EXAMINATION OF LEAN PRODUCTION WITH REGARDS TO OCCUPATIONAL HEALTH AND SAFETY: A CASE STUDY IN AN AUTOMOTIVE PLANT

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Prof. Dr. Meliha Altunışık
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Erkan Erdil
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis and for the degree of Master of Science.

Assoc. Prof. Dr. Erkan Erdil
Co-Supervisor

Dr. Burçak Özoğlu Poçan
Supervisor

Examining Committee Members

Assoc. Prof. Dr. Teoman Pamukçu (METU, STPS) _____

Dr. Burçak Özoğlu Poçan (METU, BA) _____

Assoc. Prof. Dr. Erkan Erdil (METU, ECON) _____

Prof.Dr. Gamze Yücesan Özdemir (AU, GZT) _____

Dr. Barış Çakmur (METU, ADM) _____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Esin Aytaç KÜRKÇÜ

Signature :

ABSTRACT

EXAMINATION OF LEAN PRODUCTION WITH REGARDS TO OCCUPATIONAL HEALTH AND SAFETY:

A CASE STUDY IN AN AUTOMOTIVE PLANT

Kürkçü, Esin Aytaç

M.Sc., Department of Science and Technology Policy Studies

Supervisor: Dr. Burçak Özoğlu Poçan

Co-Supervisor: Assoc. Prof. Dr. Erkan Erdil

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The objective of this study is to examine lean production and its effects on general working conditions and occupational health and safety. Lean production is considered either as a humane way of production with positive effects on workers or to have negative consequences for workers' and their job quality.

This study investigates the increasing workload of the workers as a result of the unlimited performance demands of lean production as the first hypothesis.

Secondly, there is the question of whether lean production provides a reduction in the number of occupational accidents because of the fact that occupational accidents are seen as waste, thus eliminated at all costs. The last hypothesis which will be assessed is that the number of occupational diseases increases after the implementation of lean production.

To that end, a case study was carried out in an automotive plant by a qualitative research method using tools of observation, document analysis, in depth interview and structured interview.

As a conclusion, the implementation of lean production in a plant in automotive industry has resulted in the reduction of the occupational accidents and improvement of ergonomic conditions even though the main incentive for these improvements is to reduce the wastes and costs and to increase the profitability and competitiveness. Based on the interviews, workers do not consider that their workload is increased after the implementation of lean production. Besides, workers feel work autonomy and job satisfaction. They also claim that they do not feel job stress in contrast to the literature.

Keywords: lean production, working conditions, occupational health and safety.

ÖZ

YALIN ÜRETİMİN İŞ SAĞLIĞI VE GÜVENLİĞİ AÇISINDAN İNCELENMESİ: BİR OTOMOTİV FABRİKASINDA SAHA ÇALIŞMASI

Kürkçü, Esin Aytaç
Yüksek Lisans, Bilim ve Teknoloji Politikaları Bölümü

Tez Yöneticisi: Dr. Burçak Özoğlu Poçan
Ortak Tez Yöneticisi: Doç. Dr. Erkan Erdil

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Bu çalışmanın amacı, yalın üretimin çalışma şartları ve iş sağlığı ve güvenliğine olan etkilerinin incelenmesidir. Yalın üretim hem işçileri üzerinde olumlu etkileri olan insancıl bir sistem hem de işçiler ve çalışma şartlarını olumsuz yönde etkileyen bir çalışma biçimi olarak algılanabilmektedir.

Bu çalışmada, ilk hipotez olarak yalın üretimin yüksek performans beklentisi sonucunda iş yükündeki artışı incelenmesi amaçlanmaktadır. İkinci olarak, yalın

üretimde israf olarak görülen ve her şekilde ortadan kaldırılması amaçlanan iş kazalarında azalma olup olmadığı sorgulanmaktadır. Son olarak da, yalın üretim uygulamasından sonra meslek hastalıklarında artış incelenmektedir.

Bu amaçla, otomotiv sanayinde faaliyet gösteren bir fabrikada gözlem, doküman analizi ile derinlemesine ve yapılandırılmış mülakatlara dayalı bir kalitatif araştırma çalışması gerçekleştirilmiştir.

Sonuç olarak yalın üretim uygulamasının, birincil amacı israfın azaltılması ile kar ve rekabet gücünün artırılması olmakla birlikte, iş kazalarında azalma ve ergonomik şartlarda iyileşme sağladığı görülmüştür. Mülakatlara dayanarak işçiler tarafından, sistemin uygulanmaya başlamasıyla iş yükünde artış olmadığının, iş üzerindeki kontrolün ve iş tatmininin geliştiğin, ayrıca literatürün aksine iş stresi hissedilmediğinin düşünüldüğü tespit edilmiştir.

Anahtar sözcükler: yalın üretim, çalışma koşulları, iş sağlığı ve güvenliği.

To *Mehmet*

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LIST OF ABBREVIATIONS

OHS : Occupational Health and Safety

WCM : World Class Manufacturing

TPS : Toyota Production System

ILO : International Labor Organization

SMED : Single Minute Exchange of Dies

NVAA : Non Value Added Activity

FMEA : Failure Mode and Effect Analysis

SOP : Standard Operating Procedure

KPI : Key Performance Indicator

PM : Preventive Maintenance

PPE : Personal Protective Equipment

CHAPTER 1

INTRODUCTION

The objective of this study is to examine lean production and the effects of lean production practices on general working conditions and occupational health and safety. Some researchers view lean production as a humane way of production with positive effects on workers however the others see it having negative consequences for workers' and their job quality (Womack *et al.,* 1990; Berggren, 1992). In this study, it is aimed to investigate the work intensification and controlling by stress methods, workplace design, ergonomics, and occupational accidents and occupational diseases in other words occupational health and safety conditions in lean production.

This study investigates the increasing workload of the workers as a result of the unlimited performance demands of lean production as the first hypothesis.

Secondly, there is the question of whether lean production provides a reduction in the number of occupational accidents because of the fact that occupational accidents are seen as a waste since they cause a loss of labor force, time and capital cost and lead to the interruption of the production. In lean production occupational safety is given special importance in order to prevent the occupational accidents which are eventually seen as wastes.

The last hypothesis which will be assessed is that the number of occupational diseases increases after the implementation of lean production. This will be discussed on the basis of the literature which mainly put forward that lean production led to job stress, increased risk of cardiovascular and musculoskeletal disorders. (Brenner, 2002; Landsbergis, 1999)

1.1 Evolution of Lean Production

The age of pioneering mass production methods and management rules applied by Henry Ford in his car factories has been named as Fordism. The heyday of Fordism was in 1950s and 1960s (Amin, 1994). Amin summarizes Fordism as the age of intensive accumulation with monopolistic regulation of the economy (Amin, 1994). The main source of the dynamism of Fordism is the mass production. In Fordism, based on mass production, productivity rises due to economies of scale, as productivity increases incomes/wages increase, mass demand increases due to rise of wages, so profits increases based on the full utilization of the capacity (Amin, 1994).

In the aspect of work organization, Fordism aimed to sequentially order the tasks of the production along a production line in order to save time lost by workers leaving the equipment. It involves mass production based on moving assembly line techniques operated with semi-skilled workers (Amin, 1994).

According to Ansal, transition form Fordism to lean production took place as a consequence of socio-economic conditions in Japan. Narrow Japanese markets necessitated more flexible production patterns manufacturing smaller batches of products (Ansal, 1996). Lean production is based on Toyota Production System developed by the founders of Toyota- Sakichi Toyoda and Kiichiro Toyoda- and the engineer Taiichi Ohno who targeted the implementation of Ford's continuous

material production by eliminating its disadvantages of creating excessive inventories and introduced the concept of one-piece flow in which there is a continuous production and flow of equipment into the assembly line without creating excessive stocks (Monden, 1998). The Toyota production system was initially termed as *Just-in-Time* production and diffused globally by the International Motor Vehicle Project which coined the term *Lean Production* for this mode of production. Lean production is described as a five step process[1] composed of defining customer value, defining the value stream, making it flow, pulling from the customer back and striving for excellence (Womack and Jones, 2003). The important features of lean production are the smooth flow of production through continuous improvement (*kaizen*) in productivity and quality, pull system supplied by *kanban* mechanism enables just-in-time, elimination of *wasted* time and motion and quality control circles which are the meetings of small team of workers to solve quality and productivity problems (Landsbergis, 1999; Bilgin, 2000).

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[1] *Lean thinking starts with an attempt to precisely define the value. In applying lean production, the whole production line is examined from the customers' view. Anything demanded by the customers is termed as value. Though, the whole production line can be examined and value-added processes can be separated from non-value added ones. Non-value added processes are called waste. Secondly, the value stream is defined by defining and categorizing all actions for creation, ordering and production as value-adding, non-value-adding but required (so called type one muda), and non-value-adding and to be eliminated immediately (type two muda). Third step is the continuous flow to keep inventories low and keep the process running continuously. This gives away the inefficiencies as there are no huge stocks to compensate for the inefficiencies in process flow. Fourth step is the pull system which is the ideal state of just-in-time manufacturing, is supplying the customer any product when and at the amount it is demanded, instead of keeping an inventory and "pushing" products to the customer. The one-piece continuous flow is the most ideal form of the pull system. In its ultimate implementation, the production is 100% on demand and there is neither any inventory nor any overproduction. The fundamental requirement for just-in-time production is to make all processes know when and how much their products are demanded. In order to control the level of the inventory for every item and replenish the items as they get close to stock out by customer demand, a system of signal to inform the former process is developed which is called kanban. Fifth step is the perfection which is occurred by the precise definition of the value, identification of the value stream and making value-adding activities flow, a loop of continuous improvement.*

There are some important differences in terms of the characteristics of the work organization in Fordism and lean production. The first difference is the relationship with the market. In the Fordist system, production is pushed to customers in accordance with the predetermined plans whereas in lean system, production flow is pulled by customers' needs which originate from actual market demand. The second difference is related to the workforce. In Fordism, workforce is seen as a resource which naturally tries to resist the supply of work while on the contrary in lean production workforce is seen as a resource which naturally wants to work and collaborate, to give more as regards the supply of work (Forza, 1996).

The importance of Fordism as regards labor are specialization at work, alienation of labor to production process, decrease in labor productivity due to quality of work and its strict control in production process (Arslan and Erdil, 2003).

The crisis of Fordism[2] in 1970s, have led to development of more flexible work organizations (Ansal, 1996). According to Piore and Sabel (1984), flexible work organizations are based on skilled workers who produce a variety of customized goods, in contrast to mass production which involves the special purpose machines and semi-skilled workers to produce standardized goods. In flexible work organizations, more than a narrow segment of workers' skills are utilized and for a continuous flow of production commitment to quality work, self discipline and autonomous decisions are encouraged (Thompson, 1989).

Lean production which is a kind of flexible work organization developed as a consequence of socio-economic conditions in Japan is based on some main principles such as total quality control, just-in-time production and quality control cycles (Ansal, 1996). Ansal claims that, unlike Fordist production, workers in lean

[2] *Four main factors contributed to the crisis of Fordism; firstly productivity gains decreased as a result of the social and technical limits of Fordism, secondly the expansion of mass production led to an increase in globalization of economic flows which made national economic management difficult, thirdly the grow of social expenditure and fourthly the change in the consumption pattern towards a greater variety of use values.*

production implementing total quality control should be conscious about quality and skilled enough to identify any quality defect during course of production. Hence, the expectations from the workers have been increased in lean production to carry out more than one task, to use their whole mental and physical capacity and even to do the unsaid.

Womack *et al.*[3] (1990) put forward that a real lean plant has two important organizational features which are the transfer of the maximum number of tasks and responsibilities to the workers actually adding value to the car and the detection of ultimate causes of the defects. In this sense, the working conditions of the workers changed under the lean production system are worth to investigate.

Womack and Jones (2003) define lean production as a set of principles and methods which aim to eliminate all non-value added activities, all kinds of *wastes* and costs originating from those activities in the production process. The production activities in lean production are divided into two as value added activities and non-value added activities- *wastes*.

According to Womack and Jones (2003), the elements which do not add value to the product or service from the customer point of view are considered as *waste* and must be eliminated. Since the objective in lean production is the customer satisfaction, the activities in the production which do not affect the customer satisfaction must be discarded (Drew *et al*., 2004). The main aim in lean production is to produce high quality product or service with less cost and less time.

[3] *The writers of this book are senior directors in the International Motor Vehicle Program (IMVP). This book is based on the findings of the researches of IMVP and written mainly for the employers in the auto industry to be a manual for them in applying lean production.*

Lean thinking starts with an attempt to define the *value*. In applying lean production, the whole production line is examined from the customers' view. Anything demanded by the customers is termed as *value*. Though, the whole production line can be examined and value-added processes can be separated from non-value added ones. Non-value added processes are called *waste* (Womack and Jones, 2003).

In lean production the wastes are listed as; *overproduction, waiting*, u*nnecessary transport*, o*ver processing, excess inventory*, u*nnecessary movement* and *defects.* Besides these wastes, *wasted employee creativity* and *insufficiency in occupational safety conditions* are also considered as wastes (Womack and Jones, 2003).

According to Womack and Jones (2003), in lean production, continuous improvement can only be achieved by benefiting form the creativity of the workers. It is also seen as a waste not to utilize the skills, ideas and creativity of the workers.

In lean production, the workers continuously control the running assembly line to check if there is a defect. When a defect is detected, the process can be interrupted by a worker immediately to solve the problem to prevent a waste. Since failure in one unit will stop the other units, workers should be well trained and skilled to easily detect the defect in order to prevent the waste and to solve the problem as soon as possible in order to avoid any further loss (Koukoulaki, 2009). Therefore, in lean production workers are skilled and trained contrary to mass production. Additionally, unlike mass production workers can propose their opinions to contribute to continuous improvement in lean production.

In Fordism, maintenance departments are the center of preventive maintenance, however in lean production *total preventive maintenance* seeks to involve workers in all departments and levels, from the plant-floor to senior executives, to ensure

effective equipment operation. Hence, workers are trained to become capable of carrying out maintenance activities of the equipment to prevent any failure in the equipment (Shingo, 1989).

In lean production the "multiskilled" operators organized into small teams and they are responsible for quality, continuous improvement and problem solving. The feature of team work enables employee participation in improvement and problem solving and therefore highly motivated work environment (Womack *et al.*, 1990).

The critics of lean production view it as essentially an old-fashioned speed up production system presented as a new idea; a modern version of Taylorism in the aspect of controlling the workforce and maximizing managerial control and profits on the backs of workers (Kochan *et al.,* 1997). Berggren (1992) also criticizes lean production because of the facts that the so called multi-skilling is only multi-tasking that urge people to carry out various kinds of unskilled labor, the short training periods and the oriented improvement toward further standardization of work which can be characterized as Taylorism. Berggren (1992) put forward that the difference between lean production and Taylorism is that workers cooperate on making improvements. Burawoy (1985) describes factories under lean production system as despotic. Similarly, Parker and Slaughter (1988) see lean production as a management by stress and put forward that lean production is simply a faster and a more exploitative form of Fordism characterized by an intense work pace and self discipline applied by work teams.

As a conclusion, the position of worker in lean production organization has been changed; the system targeted to benefit from the skills, capacities, mental and physical power of the worker mainly in the aspect of *continuous improvement*, *quality control* and *total preventive maintenance.* In lean production, even not to benefit enough form the workers creativity and capacity is considered as a waste.

Wasted employee creativity is the skills, ideas and improvements lost by lack of conversation with employees (Liker, 2004).

1.2 State of Occupational Health and Safety in Lean Production

As stated above, the objective of this study is to examine the effect of lean production on occupational health and safety. Occupational safety is given special importance in lean production since insufficient occupational safety conditions may cause occupational accidents which may cause loss of labor force and time and therefore additional costs, and which are eventually seen as wastes. Besides, failure of one unit due to an occupational accident leads to interruption of the whole manufacturing process in operations with no inventories as in lean production (Koukoulaki, 2009). In lean production, occupational accidents which may cause loss of labor force, time, additional costs and interruption of the whole manufacturing process seen as wastes. Therefore, lean production put emphasis on the elimination of occupational accidents to eliminate another source of waste.

Occupational health and safety is a discipline covering the scientific and systematic studies in order to provide protection from the hazardous conditions for health arising from the conditions of work at the workplace. According to the definition of International Labor Organization (ILO, 1995), occupational health is defined as a discipline of medicine aiming the maintenance of the highest degree of physical, mental and social well-being of workers in all occupations. The main objective of occupational health and safety is to protect the workers against the adverse effects at workplaces, to provide a safe work environment in other words to ensure the physical, mental and social well-being of workers by protecting them against occupational accidents and diseases[4] (ÇSGB, 1993).

[4] *Occupational disease and work-related disease must be differentiated. In occupational disease, the working conditions are the main factor whereas in work-related diseases working conditions are only facilitating or accelerating the disease to be occurred.*

There are also some other objectives of occupational health and safety which are; to provide production safety which will result in an increase in productivity and to provide workplace safety by reducing the incidence of explosion and fire (ÇSGB, 1993).

Workers should be protected against the hazards for their health -both physical and mental- and safety. According to Labor Act No 4857 Article 77, employers are fully responsible to ensure occupational health and safety in their establishment. So, in order to eliminate the direct and indirect costs of occupational accidents, to establish production and workplace safety and to obey legal responsibilities, employers must put emphasis on occupational health and safety.

There are several studies on the effect of lean production on occupational health and safety. According to Berggren (1993), lean production has several advantages such as increased job security, higher quality of workforce and some disadvantages such as unlimited performance demand and working hours, increase health and safety complaints, and a strict factory.

Landsbergis (1998) claims that in lean production workers' health is under threat through some stress-related illnesses, such as cardiovascular or musculoskeletal diseases or physiological disorders.

In their literature review, Landsbergis *et al* (1999) claimed that the workers of companies applying lean production have high levels of stress, fatigue and tension because of long working hours, high pace of work and short rest periods.

Similarly, Brenner *et al.* (2002) put forward that workplace transformation, quality circles and just-in-time production in particular, might cause cumulative trauma disorders such as carpal tunnel syndrome which have their origins in repeated

pressure, vibration or motion. Likewise, in the study of Parker (2003), effects of lean production applications on workers were found to be negative.

Unlike above mentioned studies, Macintosh and Cough (1998) put forward that new work organization methods have a positive effect on OHS conditions. In their research, total quality management cycles are reported to effectively contribute to analysis and identification of occupational health and safety hazards at workplaces.

Lewchuk *et al.* (2000) point out that main factor determining overall quality of employees' life at work is more dependent on the attitude of the company rather than solely on the concept of lean production. Likewise, the empirical model study of Conti and Gill (1998) show that job stress caused by implementation of lean production is closely related to the design of work flow in a factory.

The study of Conti *et al.* (2006) reveals that there has been no direct relationship between lean practices and job stress on workers. Instead, job stress has been found to depend on management attitude in implementation of lean production.

Few studies report impacts of lean production on development of safety culture and the companies' approach to occupational health and safety. Saurin and Ferreira (2009) find out that due to lean production system, top management's commitment to OHS has increased and workers consider that their working conditions are good and have improved after the introduction lean production.

1.3 Structure of the Thesis

Within the scope of this thesis, a case study was carried out in a plant in the automotive industry so as to investigate the effects of lean production, on general working conditions and occupational health and safety conditions.

The plant which was examined during this study, was an automotive manufacturer located in Ankara, employing 1250 employees (of which 940 are blue collar) and manufacturing 35,000 vehicles per year.

The case study was based on the observation of the workplace environment, examining changes in general working conditions and occupational health and safety conditions after the implementation of lean production and interviewing with workers working in a model area where some lean production practices are put into practice. The lean production in the plant was put into effect based on the *World Class Manufacturing (WCM)*, which is a variant of lean production.

In the ongoing chapters of this thesis, definitions and literature on occupational health and safety, literature review regarding effects of lean production on working conditions and occupational health and safety are described. In the final chapter of this thesis, the case study is presented which aimed to examine the lean production applications in the plant in the name of *World Class Manufacturing*. In the case study, the effects of *World Class Manufacturing* on general working conditions and occupational health and safety conditions are presented based on observations, documents analysis, statistical data on occupational accidents and structured interviews with the workers.

CHAPTER 2

OCCUPATIONAL HEALTH AND SAFETY

2.1. The Evolution of the Concept of Occupational Health and Safety

Occupational health and safety awareness began in the time of the building of Egyptian pyramids in 3000 B.C. In about 1500 B.C., Ramses III hired physicians to care for mine workers and construction workers. In about 400 B.C. Hippocrates, called as father of medicine, described tetanus. About 200 B.C. lead poisoning was described by Nicander. Various Roman scientists from 100 B.C. to 2nd century A.D. described the ill effect of the environment on mine workers. In 1st century A.D., Pliny the Younger mentioned lead poisoning as a disease among mine workers and wrote about the primitive respirators used by workers to keep the mercury fumes away from their breathing zone. In the 7th century King Rothari codified existing laws were the origins of the basic principles of compensation for injury. In 1473 Ulrich Ellenborg, an Austrian physician, wrote to warn the goldsmiths and other metal handlers against the burning of coal in confined spaces and the inhalation of lead, antimony, silver and mercury vapor arising when heating these metals. This is considered to be the first writing on industrial metal poisoning. In 1561, Agricola's book *De Re Metallica* was published. It wrote on ventilation need in mines and illustrated the devices for ventilation, personal protective equipment such as gloves and masks. In 1567, Paracelsus distinguished

between acute and chronic poisoning in his book. In early 18th century Bernardino Ramazzini published the book *Discourse on the Diseases of Workers* in which he pointed out that in addition to the standard questions asked by doctors to a patient one more question should be added: What is your occupation? (The National Safety Council, 1988).

Until 1700s, production methods were labor intensive, the work was being done by hand in cottages. This has been changed by the development of spinning jenny in 1764, power loom in 1784 and cotton gins in 1792. These and other innovations[5] initiated the Industrial Revolution which transformed the life of man, nature of society and the relationship between people.

Because of the changes in production methods the need for masses of workers emerged which brought hazards never before encountered. In the period of Industrial Revolution, both the level of production has increased and also serious economical and social problems have emerged (Makal, 1997). The foremost social problem came up in consequence of Industrial Revolution is the severe working conditions (Makal, 1997). The most severe problems were the long working hours and low wages (Makal, 1997). Consequently, Industrial Revolution brought about adverse working conditions for the employees. Firstly the employees came across these adverse working conditions, then the people who did not subject to these working conditions and finally the international organizations and the states reacted and objected these severe working conditions. The states made provisions against the unfavorable working conditions by putting into force preventive social political precautions (Makal, 1997).

[5] *The innovations encountered in the processes and organization of production changes included; substitution of inanimate power instead of animate source of power by the introduction of steam power through the combustion of coal, substitution of machines instead of human skills and strength, invention of new methods for transforming raw materials specifically in making iron and steel and industrial chemicals, the organization of work in large units, such as factories, forges or mills.*

Beginning from the 20th century, occupational health and safety regulations were put into force. This was the age of Fordism, the age of pioneering mass production methods and management rules applied by Henry Ford. In the corresponding period in America, the state of Massachusetts leaded occupational health and safety studies through inspection of workplaces and child labor. In socialist countries, on the other hand, several training and research centers were established as a result of foundation of the system's own audit mechanism (TMMOB, 2003)

After above mentioned progress, International Labor Organization (ILO) was established as a part of League of Nations in 1919 and became an expertise organization by the agreement signed with United Nations (UN) in 1946. In cooperation with World Health Organization (WHO) and several other partners, ILO has carried out extensive research related to occupational health and safety; and recommendations and conventions of ILO, of which Turkey is a member, has significant contributions to related problems.

During the progress of above mentioned developments in the World, Dilaverpasa regulations, related to working conditions of coal mines and consisting of 100 articles, were prepared in 1865 but could not be put into enforcement. Even though the regulation was mainly about production, it is worth referencing as it is one of the earliest legal texts about OHS and contains provisions mandating employment of an occupational physician at the mines. After the administrative reforms in 1839, Maadin regulations were prepared and became one of the most important regulations because of mandating existence of a occupational physician and a pharmacy at the mines and payment of amends in case of an accident. Other important regulations in this period were regulation about shipyards and retirement of their employees, regulation about Hicaz railways and their employee's rights for accidents and regulation about military factories (TMMOB, 2003).

Although industry in Ottoman Empire began to develop in 20th century, the wars in corresponding period retarded both the industrial development and improvements in OHS. According to statistics of 1913-1915, workplaces were mainly concentrated on food, leather, wood products, textile, chemicals and metals production; and 15,000 people were employed in these workplaces. 93,9% of these workplaces used to utilize motor power, with a total capacity of 20,977 horsepower (TMMOB, 2003).

After the foundation of Grand National Assembly of Turkey, production of coal was given special importance as it is vital for the war of independence consequently heavy working conditions of workers were identified and taken into consideration of the national assembly. As a result, the laws governing the rights of coal mine workers in Zonguldak and Eregli were put into enforcement. By these acts, provident funds and registration systems were established, aids and amends were provided in case of occupational diseases and accidents, and working hours, occupational trainings and social insurances were regulated. In the following years, several other laws, comprising provisions related to OHS and constituting basis for today's regulations were put into force, such as Weekly Vacancies Act (1924), Code of Obligations (1926), General Health Act (1930), and Act of Municipalities (1930). Even though working life is regulated by these acts to a certain extent, progress of industrialization necessitated a work act (TMMOB, 2003).

Although the first Work Act (No: 3008), which was published in 1936 and remained in force until 1967, introduced a new approach, social security studies were delayed until establishment of Ministry of Labor in 1946, particularly due to World War II. Under the organization of the Ministry of Labor, General Directorate of Worker Health was established. After the adoption of ILO convention No. 81, labor inspectors were employed in order to carry out workplace inspections. Increase in OHS inspections correspond to introduction of

5-year development plans in 1963 and industrialization. The trend of industrialization can be observed from the share of industry in GDP, which is 17.5% in the first 5-year development plan period, 20.5% in the second and 22.5% in the third (TMMOB, 2003).

After the introduction of Work Act No. 1475 in 1971, provisions related to OHS were enforced. For detailed regulation of OHS issues, 11 regulations were enacted.

Beginning from 1950s, Act of Insurances for Occupational Accidents and Diseases No. 4772, Act of Foundation of Worker Insurances No.4792, Act of Illnesses and Maternity No. 5501, and Act of Old Age Insurance No. 6700 were put into effect. In order to simplify the social security applications, Act of Social Security Insurances No. 506, which also comprised regulations about OHS, was enacted. Additionally, provisions regarding OHS also take place in Act Related to Regulation of Relationships Among Employees and Employers in Press No. 5953 (1952), Mining Act No. 6309 (1954), and Act of Maritime Affairs No. 854 (1967) (TMMOB, 2003).

Besides national legislation, ILO conventions are continuously followed. In this respect, 38 ILO Conventions related to

- Occupational Health and Safety and Workplace Environment, No. 155,
- Contracts Regarding Occupational Health, No. 161,
- Health and Safety at Port Activities, No. 152,
- Prevention of Occupational Accidents (Sea Men), No. 134,
- Protection of Health and Medical Care of Sea Men, No. 164

were approved. The ILO conventions No. 155 and 161 have particular importance by means of OHS.

The Labor Act No.4857 was approved in May 22, 2003 in Grand National Assembly of Turkey and published in the Official Journal dated June 23, 2003 and

came into force. The 5th chapter of Labor Act (Article 77-89) has the title of "Occupational Health and Safety". The articles in this chapter lay down provisions regarding responsibilities of employees and employers, regulations and implementing regulations about health and safety, interruption of work and closure of workplace, council of occupational health and safety, workers' rights, prohibitions on use of alcohol and drug use, heavy and hazardous works, reporting in heavy and hazardous works, reporting for workers below the age of 18, implementing regulation for pregnant and nursing women and several implementing regulations (TMMOB, 2003)

According to Labor Act No 4857 Article 77, employers are fully responsible to ensure occupational health and safety in their establishment. Article 77 says that "Employers shall take all the necessary measures and maintain all the needed means and tools in full and employees shall comply with all the preventions in area of occupational health and safety". In order to ensure compliance with and supervision of the measures taken for occupational health and work safety at the establishment, the employer must inform the employees of the occupational risks and measures that must be taken against them as well as employees' legal rights and obligations and, in this connection, he must provide the employees with the necessary training on occupational health and safety.

The Article 78 of Labor Act is regarded to the regulations on Occupational Health and Safety. Based on this article, 28 implementing regulations have been published. These implementing regulations are harmonized from the corresponding European Union directives. "Occupational Health and Safety" directive, based on the Directive 89/391/EEC published in December 9, 2003 has been cancelled by the State Council. Instead of this Directive, at the moment the studies on the preparation of "Occupational Health and Safety Act" are ongoing.

According to the Directive 89/391/EEC (1989), the employer shall implement the on the basis of the following general principles of prevention:

- avoiding risks,
- evaluating the risks which cannot be avoided,
- combating the risks at source,
- adapting the work to the individual, especially as regards the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health,
- adapting to technical progress,
- replacing the dangerous by the non-dangerous or the less dangerous,
- developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment,
- giving collective protective measures priority over individual protective measures,
- giving appropriate instructions to the workers.

The list of some important directives on occupational health and safety published based on EU directives are given in the Table 2.1.

According to the estimations of the International Labor Organization (ILO), 270 million occupational accidents and 160 million work related diseases happen around the world annually. 210,000 of these accidents are fatal. Because of these accidents and diseases 2 million people die every year. Every day more than 500 people do not come home because they were killed by accidents at work (Saari, 1998).

The number of occupational accidents and diseases may even be greater because some of the accidents may be unreported. In studies of ILO, it is also emphasized that in the developing countries and in the sectors of agriculture, construction and mining where working conditions are dangerous and the number of unregistered workers are high, there are more occupational accidents. Also the occupational accidents and diseases are mainly seen in the small and medium sized enterprises (SMEs).

Table 2.1: Some Directives on Occupational Health and Safety in Turkey

	Name of the Turkish Directive	Corresponding EU Directive
1	Implementing Regulation on Health and Safety In Asbestos Related Works	83/477/EEC 91/382/EEC
2	The Implementing Regulation for Noise	2003/10/EC
3	Implementing Regulation for the Protection of Workers from the Risks Related to Exposure to Carcinogen and Mutagen Substances at Work	90/394/EC 97/42/EC 99/38/EC
4	Implementing Regulation on the Protection of the Health and Safety Measures from the Risks Related to Chemical Agents at Work	1998/24/EC 1991/322/EEC 2000/39/EC
5	Implementing Regulation for Personal Protective Equipment	89/686/EEC 93/68/EEC 93/95/EEC 96/58/EC
6	The Implementing Regulation for the Protection Against Risks of Explosive Atmospheres	1999/92/EC
7	Implementing Regulation for Vibration	2002/44/EC
8	Implementing Regulation of Health and Safety at Construction Sites	92/57/EEC
9	The Minimum Requirements for Safety and Health of Workers in Surface and Underground Mineral-Extracting Industries Implementing Regulation	92/104/EEC
10	The Implementing Regulation for the Minimum Requirements for the Safety and Health Conditions in the Mineral Extracting Industries through Drilling	92/91/EEC

The Conventions of ILO are guide for the Member Countries' policies on occupational health and safety and have legal force if the conventions are approved by the Parliament of the Member Country. According to the Article 90 of the Turkish Republic Constitution, the ratified ILO Conventions are in equal force as the laws. At the moment Turkey has ratified 38 Conventions among the 181 Conventions. The two most important conventions in terms of occupational health and safety are ILO Convention No.155: Occupational Health and Safety Convention and ILO Convention No.161: Occupational Health Services Convention.

According to Social Security Institution's statistics of 2008, 72.963 occupational accidents and 539 occupational diseases occurred in Turkey. 866 people died as a result of these occupational accidents and diseases, (865 people died as a result of an occupational accidents and 1 person died as a result of an occupational disease). In 2008, the duration of temporary incapacity for work is 1.855.980 days as a result of occupational accidents and 9135 days as a result of occupational diseases. Because of occupational accidents there are 1452 permanent disabilities and because of occupational diseases there are 242 permanent disabilities reported in 2008 (SGK, 2008).

Table 2.2: Occupational Accidents, Occupational Diseases and Death in Turkey in the years 2003-2008 (SGK, 2003-2008)

Years	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Occupational Accidents	76668	83830	73923	79027	80602	72963
Incidence Rate of Occ. Accidents (per 100.000 workers)	1365	1356	1068	1011	948	700
Occupational Diseases	440	384	519	574	1208	539
Incidence of Occ. Dis. (per 1000 workers)	0.07	0.06	0.07	0.07	0.14	0.07
Death	811	843	1096	1601	1044	866

Table 2.3: Occupational Accidents, Occupational Diseases and Death in manufacture of Motor Vehicles, Trailers and Semi-trailers in Turkey in the year 2008 (SGK, 2008)

Sector of Manufacture of Motor Vehicles, Trailers and Semi-trailers	**Number**
Occupational Accidents	856
Number of Permanent Incapacity as result of Occ. Accidents	5
Occupational Diseases	2
Number of Permanent Incapacity as result of Occ. Diseases	1
Death	0

In Table 2.2, only the statistics of 2008 is demonstrated since before 2008 NACE classifications (Classification of Economic Activities in the European Community) for the classification of the activities were not been used so the name of the branch activities are different before 2008 in SGK statistics which makes the comparison impossible.

In Chapter 2.2, some basic definitions in occupational health and safety that have importance in the aspect of the effects of the lean production discussions will be stated.

2.2 Basic Definitions and Principles in Occupational Health and Safety in terms of Lean Production Discussions

According to the definition made by International Labor Organization (ILO) and World Health Organization (WHO) in 1950 and renewed in 1995, occupational health is defined as a discipline of medicine aiming:

- the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;
- the prevention of workers from adverse effects of their working conditions on their health and safety;
- the protection of workers from risks resulting from factors adverse to health;
- the placing and maintenance of workers in an occupational environment adapted to physical and mental needs;
- the adaptation of work to humans.

In other words, occupational health encompasses the social, mental and physical well-being of workers.

Occupational health and safety is a discipline covering the scientific and systematic studies in order to provide protection from the hazardous conditions for health arising from the conditions of work at the workplace.

Occupational health and safety studies have the objectives as follows;

- To protect the workers: This is the main objective of the occupational health and safety**.** To protect the workers against the adverse effects at workplaces, to provide a safe work environment in other words to ensure the physical, mental and social well-being of workers by protecting them against the occupational accidents and occupational diseases.
- To provide production safety: Providing the production safety will result in the increase of productivity therefore this is also important economically. By protecting the workers, the losses of work force and work day caused by the occupational diseases and accidents will be reduced therefore production will be protected and there will be an increase in productivity.

- To provide the workplace safety: By the precautions taken at the workplace, the incidence of explosion and fire will be reduced so the workplace safety will be established (ÇSGB, 1993)

Improvements in the occupational health and safety conditions both ensure the well-being of workers and also contribute positively to productivity. Healthy workers are more likely to have higher motivation, enjoy greater job satisfaction and contribute to better quality products and services (Allii, 2001).

2.2.1 Occupational Accidents

In the Law of Social Insurance and General Health Insurance No 5510, occupational accident is defined as an event which occurs when the worker is at the workplace, due to the work carried out by the employer, when the worker is not carrying out his main work due to the reason that he is sent on duty to another place out of the workplace, for a nursing female worker at times allocated for nursing her child or in a vehicle provided by the employer to come or leave the workplace, which causes immediate or delayed, physical or mental damage to the workers' health.

The use of term accident in the workplace is linked with personal injury. Damage to a machine is not referred as an accident but can be defined as a disruption or damage. Damage to the environment is called an incident. Accidents, incidents and disruptions which do not result in injury or damage are known as near accidents or near misses.

Occupational accidents occur from workers and objects (not only technical instruments such as work, machines and materials but also all the surrounding items such as floors, stairs, electrical current, gas, dust, atmosphere and so on) interacting with each other through the release of energy (Skiba, 1998). The cause of an accident may because of unsafe or unsuitable equipment, supervisor

receiving incomplete job instructions, trainer receiving incomplete or incorrect training or worker not capable of performing the work safely (Skiba, 1998).

In recent years, mechanization and automation of production processes have advanced. Therefore, the causes of many accidents have shifted from the human errors to those originated from the maintenance of the equipment and interaction with automated processes. In order to prevent the accidents especially in automated plants, the workers should be able to physically and psychologically work safely, providing suitable equipment, good environment and satisfactory work conditions by the employers (Skiba, 1998).

Some of the work practices generally used in the workplace in order to achieve occupational safety are;

- The working environment should be safe and healthy through the use of administrative or engineering controls for example substitution of less hazardous materials and conditions, use of personal protective equipment.
- Equipment, machinery and objects must function safely for their intended use, with operating controls designed to human capabilities.
- Workers and supervisors must be informed and aware of the dangers and potential hazards through trainings.
- Workers must be motivated to function safely which will be provided by certification procedures and trainings.

Near accidents (near misses) and minor accidents must be eliminated to avoid serious accidents (Skiba, 1998).

It is known that occupational injuries are mainly caused by working conditions especially the environment, tasks, work organization, and lack of training which result in the lack of job knowledge. Also, certain individual factors such as young age, body weight, smoking, alcoholic drink consumption, sleep disorders, and

some disabilities, have been identified as risk factors for occupational injuries (Bhattacherjee *et al.,* 2003).

As explained in Chapter 1, lean production intends to eliminate occupational accidents since they cause loss of labor force and time, interruption of the production therefore additional costs which are eventually seen as wastes. Actually, occupational accidents or diseases are very costly and can have many serious effects on the lives of workers and their families. For workers some of these are (Andreoni, 1998):

- The pain and suffering of the injury or illness;
- The loss of income;
- The possible loss of a job;
- Health-care costs

The costs of occupational accidents or illnesses to employers are also estimated to be enormous. For a small business, the cost of even one accident can be a financially catastrophic. Some of these direct costs are (Andreoni, 1998):

- Payment for work not performed;
- Medical and compensation payments;
- Repair or replacement of damaged machinery and equipment;
- Reduction or a temporary halt in production;
- Increased training expenses and administration costs;
- Possible reduction in the quality of work;
- Negative effect on morale in other workers

Some indirect costs of occupational accidents and illnesses for employers are (Andreoni, 1998):

- The injured/ill worker has to be replaced;
- A new worker has to be trained and given time to adjust;

- It takes time before the new worker is producing at the rate of the original worker;
- Time must be devoted to obligatory investigations, to the writing of reports and filling out of forms;
- Accidents often arouse the concern of fellow workers and influence labour relations in a negative way;
- Poor health and safety conditions in the workplace can also result in poor public relations

Overall, the costs of most work-related accidents or illnesses to workers and their families and to employers are very high.

It is well known that in order to create and maintain a safe and healthy workplace, it is essential to establish a strong management commitment and strong worker participation which are the main characteristics of lean production.

In literature, there are extensive researches on the effect of lean production on occupational health which are discussed broadly in Chapter 3. In these studies lean production practices are associated with the stress-related illnesses, such as cardiovascular or musculoskeletal diseases. In order to have comprehensive knowledge on the concepts discussed in Chapter 3, some information on work related stress and occupational diseases is given in Chapters 2.2.2 and 2.2.3.

2.2.2 Work Related Stress

Stress refers to a process in the body, to the body's general plan for adapting to all the influences, changes, demands and strains to which it is exposed (Levi, 1998).

Levi (1998), defines the main stressors at the workplace as follows;

- *Quantitative overload (demand)* when there is excessive work, time pressure and repetitive work-flow at the workplace.

- *Qualitative under load* when the job content is too narrow and one-sided and when there is no demands on creativity and problem-solving or low opportunities for social interaction.
- *Role conflicts* when workers occupy several roles concurrently. Conflicts easily arise among the various roles and these are often stress evoking.
- *Lack of control* when worker has no influence, no control, no say on the work pace and working methods or when there is uncertainty or lack of any obvious structure in the work situation.
- *Lack of social support* by the organization, line management and colleagues.
- *Physical stressors which* can influence the workers both physically and chemically such as the direct effects on the brain of organic solvents. Secondary psychosocial effects can also originate from the distress caused by, say, odours, glare, noise, extremes of air temperature or humidity and so on. These effects can also be due to the worker's awareness, suspicion or fear that he is exposed to life-threatening chemical hazards or to accident risks.

Karasek's Demand/Control Model (Karasek, 1976; Karasek and Theorell, 1990) was developed for work environments where stressors are chronic and there are outcomes of sophisticated human organizational decision making. The Demand/Control Model is based on psychosocial characteristics of work; the psychological demands of work and a combined measure of task control and skill use which is named as decision latitude.

The model put forwards that not just physical hazards lead to diseases and injury and stress-related consequences are related to the social organization of work activity (Karasek and Theorell, 1990).

According to the Demand/Control Model, job practices with high levels of psychological job demands will cause high job stress. The study suggests that high stress jobs are associated with high job demands and low job control. Psychological strain (fatigue, anxiety, depression and physical illness) occur when the psychological demands of the job are high and when the worker's decision latitude (worker's ability to control his/her own activities and skill variety in his/her job) in the task is low. The study also indicates that job strain, which is a combination of high demand and low decision latitude, represents a risk factor for hypertension and cardiovascular disease.

Karasek (1998) gives an example of assembly-line worker whose almost every behaviour is rigidly constrained. In a situation of increased demands such as speed up, long-lasting and negatively experienced response of residual psychological strain occurs.

2.2.3 Occupational Diseases

Depending on the ILO definition, occupational diseases are defined as the diseases affect workers directly due to his/her occupation whereas work-related diseases are diseases aggravated by work or having a higher incidence owing to the conditions of work. In Turkey, definition of occupational disease which is in accordance with the ILO definition is given in the Law of Social Insurance and General Health No 5510. However in Turkey, there is no definition for work related diseases in the legislation. In order to identify an occupational disease the exposure-effect relationship between a specific working environment or specific activity and a specific disease effect must be clearly established (Lesage, 1998)

The ILO list of occupational diseases divided in three groups; occupational diseases caused by agents of chemical, physical (noise, vibration, ionizing radiation, etc.) and biological agents, occupational diseases by target organ systems of respiratory, skin, musculoskeletal and occupational cancers (Lesage,

1998). In Turkey, the list of occupational diseases also covers the musculoskeletal disorders and cardiovascular diseases.

The most important work related diseases can be listed as, cardiovascular diseases which has the risk factors of chemical exposure, stress, physical activities or night work; musculoskeletal disorders which has the risk factors of injuries, heavy load lifting, heavy physical activities, whole body vibration, repetitive jobs or psychosocial problems (TTB, 1999).

It is scientifically evident that exposure to job stress increases the risk for cardiovascular disease (Karasek and Theorell 1990). Cardiovascular disease is one of the causes of death in economically developed societies. Diseases of the cardiovascular system include coronary heart disease, hypertensive disease, cerebrovascular disease and other disorders of the heart and circulatory system. There are also direct effects of stressful work environments on neurohormonal elevations as well as on heart metabolism. A combination of physiological mechanisms, shown to be related to stressful work activities, may increase the risk of myocardial infarction. Early epidemiological studies of psychosocial working conditions associated with cardiovascular diseases suggested that high levels of work demands increased coronary heart diseases risk. Between 1981 and 1993, the majority of the 36 studies that examined the effects of high demands and low control on cardiovascular disease found significant and positive associations (Theorell and Johnson, 1998)

There is growing evidence in the occupational health literature that psychosocial work factors may influence the development of musculoskeletal problems, including both low back and upper extremity disorders (Lim *et al.,* 1998*).* Prolonged exposure to stress may have a deleterious effect on musculoskeletal function as well as on health in general. For example, stress-related muscle tension

may increase the static loading of muscles, thereby accelerating muscle fatigue and associated discomfort (Lim *et al.,* 1998*).*

Psychosocial factors may influence the physical (ergonomic) demands of the job directly. For example, an increase in time pressure is likely to lead to an increase in work pace (i.e., increased repetition) and increased strain (Lim *et al.,* 1998*).*

CHAPTER 3

LEAN PRODUCTION AND OCCUPATIONAL HEALTH AND SAFETY

Aforementioned concepts and discussions on occupational health and safety put forward that occupational accidents, occupational diseases and work related diseases basically which are in relation to job stress are worth discussing in terms of the effects of lean production on occupational health and safety.

Womack *et al.* (1990) put forward that lean production "transfers the maximum number of tasks and responsibilities to those workers actually adding value to the car on the line, and it has in place a system for detecting defects that quickly traces every problem, once discovered, to its ultimate cause." Womack *et al.* (1990) also argue that because blue collar workers are held responsible under lean production for seeking cost reductions, zero defects and zero inventories, they will find their jobs more challenging and they will become more productive.

These arguments suggest that the workers face with the intensified work and various roles under lean production system. The principles of continuous improvement and *kaizen* in lean production may also increase the work load.

In the aspect of worker autonomy there are different considerations. Klein (1991) suggests that just in time production in lean system leads to the elimination of

buffers which reduces the job autonomy with respect to work pace. It is also stated that worker autonomy is reduced by the extensive use of standard operating procedures in lean production (Klein, 1991). However Adler and Cole (1993) claim that worker autonomy is increased in lean production due to the participation of worker in the improvement of working conditions process which is absent in Tayloristic productions.

The workload of the worker (demand) and the worker autonomy (control) discussions are important in terms of occupational health and safety since according to Karasek's model increasing in demand and decreasing in control causes work related stress.

According to Womack *et al.* (1990) the freedom to control one's own work replaces the "mind numbing stress" of mass production. They put forward that workers think actively to solve workplace problems, increase their skills and have authority on decision making which makes work "humanly fulfilling".

Conti *et al.* (2006), have examined the effects of lean production on worker job stress. It is stated that lean production operates with balanced and synchronized material flow with minimum *wastes* of material, people and machinery which improves performance but increases the intensity of work (the proportion of work time spent performing production tasks) which results in the increase of potential for job stress. In the study, a positive relation between job stress and,

- work pace[6],
- intensity,
- long working hours,
- decreasing cycle time,
- ergonomic difficulties experienced in performing tasks are expected.

[6] *Work pace is defined as how fast a person works on production tasks.*

Also a negative relation between job stress and

- opportunity for team working,
- level of buffer inventories between work stations,
- level of work pace control,
- level of autonomy for making process changes,

- ability to comment on proposed work changes,
- degree of participation in improvement programs,
- frequency of job rotation are expected.

Conti *et al.* (2006) expect a positive relation between job stress and lean production since it is claimed that by systematically eliminating *waste* lean production increases work intensity and associated job demands, reduces autonomy and decreases worker control; increased demand and reduced control results in increase of stress by the Karasek model. Depending on the results of the questionnaire carried out by 1391 workers, Conti *et. al.* concluded that lean production is not inherently stressful and worker well being is not deterministic. They also concluded that the worker well being under lean production is mainly depending on management in designing and operating lean production system and it is not necessary to have stressful practices to achieve the benefits of the lean production system.

Conti and Gill (1998) in their study assessing the stress in lean production based on Karasek Demand/Control Model describe the lean production as a high value added continuous material flow which avoids the delays that result in excess inventory, high costs and long delivery times. This continuous flow is provided by the elements of total quality management eliminates quality problems, total preventive maintenance avoids machine breakdowns, *poka-yoke* ensures that parts fit properly and continuous improvement (*kaizen*). Large inventory buffers are

avoided in lean production since they are the major form of non value adding *wastes*. In lean production job security is provided in order to gain worker commitment. Any problems that interrupt the flow are immediately solved. The study put forward that in lean production workers are faced with high job demands because of the speeding up the production. In terms of job control, the study claims that because of tight control of the process there is a tight control of workers which consequently increase the stress. On the other side the study states that lean production has a favorable side; continuous improvement practices as quality circles which provides workers some degree of autonomy (control) and enables workers to influence their work task, to utilize creativity and knowledge and help to solve workplace problems. Conti and Gill (1998) states that there is high psychological job demand in lean production associated from "delaying production by taking too long to complete a task and not passing the component to the next station when needed and shutting down the line by producing a defect". If there are no inventory buffers between the stations the worker has no alternative but to wait which consequently increase the stress. It is also stated that stress level would be increased in the lack of social support which can be solved with the use of work cells and work teams which is generally applied in lean production practices.

Schouteten and Benders (2004) concluded in their study assessing the lean production by Karasek Demand/Control Model based on a survey in a lean plant that the work is monotonous and repetitive whereas decision latitude is high, not because of continuous improvement, but because of routinized work. The job satisfaction and job commitment were found to be low.

In the study of Parker (2003), effects of lean production on work characteristics such as job autonomy, skill utilization and participation in decision making have been examined. The outcomes of the implementation of three lean production

practices which are lean teams[7], assembly lines and workflow formalization/standardization have been discussed based on the results of 3 year quasi-experimental field study. At the beginning, a decline in job autonomy because of the standardization of procedures which remove control over work; a decrease in skill utilization because of the simplification of the procedures which means unskilled assembly work; a decline of participation in decision making for the assembly line workers and production workers affected by workflow formalization but not lean team members; a reduce in organizational commitment, an increase in job anxiety and job depression because of the reduce job autonomy, skill utilization and participative decision making have been expected.

The findings of the study put forward that workers reported poorer quality work designs, a decline in organizational commitment but no change in role overload or job anxiety. This study also suggests that assembly lines -which are central to both mass and lean production- are associated with severe negative effects on work characteristics as well as increased job depression and lowered job commitment. Another result of this study is that the workers in lean teams report lower autonomy and use of skills which is in accordance with the arguments suggest multiskilling in lean teams is more like multitasking. (Berggren ,1992)

Another discussion on the effects of lean production in literature is the health outcomes as a result of the high workload demands and high pace of work and in lean systems. In literature lean production is associated with the cumulative trauma disorders, musculoskeletal disorders and cardiovascular diseases which was also discussed in the previous chapter.

[7] *Lean teams take responsibility for support tasks such as quality management and improvement and involved in systematic activities to reduce waste. Lean team members work together as a cell to complete their tasks.*

Landsbergis *et al.* (1999) have reviewed studies published between 1976 and August 1998 related to the effects of lean production on workload, decision authority, job control, skill use, job stress, job satisfaction, cumulative trauma disorders and etc. In the light of studies examined it is claimed that, compared to workers of other companies, the workers of auto manufacturing companies applying lean production have high levels of stress, fatigue and tension because of long working hours, high pace of work and high demands and short rest periods. Reviewed studies have also shown that implementation of lean production has led to an increase in injuries, musculoskeletal disorders and cumulative trauma disorders, due to increased working speed. Moreover, workers are reported to work with pain, as they refrain from consulting physicians because of heavy workload and competitive working environment. The auto workers in lean companies reported elevated job demand, heavier workload and fast work pace. Low or decreasing decision authority is also reported in many studies. It is also stated that the idea of producing highly trained, multiskilled workers was also challenged by the survey.

The review study of Landsbergis states that in a survey dated 1992, workers in lean teams reported greater opportunities for skills training than other workers. However, the follow-up survey indicated that training opportunities is declined and these jobs had become similar to traditional jobs. However according to Murphy and Olthius (1995) many workers continued to see lean practices positively, as "better" than other manufacturing jobs on "satisfaction, work pace and health and safety"

In conclusion the review study of Landsbergis *et al* (1999) claims that surveys confirms that lean production in auto manufacturing creates intensified work pace and demands whereas increases in decision authority and skill are very modest or temporary, and decision latitude remains low. Therefore such work can be considered to have job strain. In jobs with physical ergonomic stressors (such as manufacturing), intensification of labor may lead to increased rates of

musculoskeletal disorders. The increase in work pace and the limitation in autonomy which is job strain will cause an increase in the incidence of hypertension and cardiovascular diseases. Landsbergis *et al.* (1999) suggest that a cost-benefit analysis is necessary to compare the benefits of the lean production in terms of productivity, quality and efficiency and the costs of the chronic diseases such as hypertension, musculoskeletal disorders and cardiovascular diseases associated with lean production practices to create an incentive to moderate the stressful features of lean production.

In another study of Landsbergis (1998), worker health is shown to be increasingly under threat through some stress-related illnesses, such as cardiovascular or musculoskeletal diseases or physiological disorders. It is urged that increase in occupational diseases could be attributed to recent trends in work organizations.

Similar finding have been reported by Brenner *et al.* (2002), who claim that workplace transformation, quality circles and just-in-time production in particular, have a potentially increasing effect on cumulative trauma disorder conditions such as carpal tunnel syndrome which have their origins in repeated pressure, vibration or motion. They indicate that just-in-time systems "prevent workers from building stocks or working up the line so as to secure periods of rest during production" (Brenner *et al.*, 2002, pp.5) This study also puts forward that components are frequently supplied from subcontractors with certain defect problems, which needs higher physical power in installation leading to strain on muscles, joints, tendons and nerves. They claim that these conditions increase the risk of cumulative trauma disorders.

The study of Berggren (1992) presents a compact summary of pros and cons of lean production. According to Berggren (1992), lean production offers several advantages such as increased job security in some applications, more egalitarian approach compared to most American companies, higher quality of workforce, motivating effect of product quality on workers, and management culture. The

emphasis on team-based problem-solving is evaluated as a social advantage at work. Berggren (1992) states that management values worker' proposals for improvements, in spite of the fact that they primarily aim to improve efficiency. Continuous problem-solving, finding the root cause and systematic testing of the best solutions, are evaluated by Berggren (1992) as important features of the production culture.

On the negative side, Berggren (1992) lists unlimited performance demand and working hours, growing health and safety complaints, and a rigorous factory regime. Berggren (1992) states that in lean plants there is unlimited performance demand since waiting of a worker without contributing to the production is not only seen as a *waste* but also a lack of motivation to continuously make proposals for improvement. In many lean plants, production quotas must be reached independent of what happened during the shift, such as interruption of the assembly line, so working hours extends. Another factor cause overtime work is the voluntary quality circle meetings. Berggren (1992) puts forward that lean plants place considerable emphasis on safety and the avoidance of accidents which can interrupt production. However, the repetitiveness of the jobs, which are designed according to very Taylorist principles, combined with the intense pace and long working hours, lead to significant health risks, such as cumulative trauma disorders or repetitive strain injuries. By eliminating buffers, lean production increases management's dependence on workers and their contribution which may result in highly principled factory regime, “detailed conduct and discipline codes, absolute demands for attendance, minute regulation of the workplace and elimination of all personal attributes”.

Lewchuk *et al.* (2001) states that lean production is a model of production implementing “the just in time, kaizen, teams and elimination of wastes offers a model of production dependant on reconfiguration of methods of labor control” (Lewchuk *et al.,* 2001, pp.85). The study carried out on factories of different companies implementing lean production concludes that outcomes of lean

production on workers, main factor determining overall quality of employees' life at work is more dependent on the attitude of the company rather than solely on the concept of lean production. In other words, in companies with highly aggressive productivity and performance demands, decline in workers' job satisfaction and increase in frequency of strikes have been observed (Lewchuk *et al.,* 2001).

Moreover, the responses to the questions dealing with health and safety including the days working in pain, portion of each day working in physically awkward position, tension and exhaustion suggests that "working conditions in automobile assembly plants continue to expose workers to serious health and safety risks" (Lewchuk *et al.,* 2001, pp.79).

Unlike above mentioned studies, Macintosh and Cough (1998) have put forward that new work organization practices such as employee involvement, team working and flexible labor practices have a positive effect on OHS conditions. In their research, partially carried out on a company supplying equipment for Australian automotive assemblers, total quality management cycles have been reported to effectively contribute to analysis and identification of occupational health and safety hazards at workplaces. Implementation of novel work organizations like total quality management cycles have been found to result in significant reductions in occupational injuries and work days lost. This success has been attributed to influence of employees on the management actions and constructive relationships with unions (Macintosh and Cough, 1998)

Few studies report impacts of lean production on development of safety culture and the companies' approach to occupational health and safety. For instance, Saurin and Ferreira (2009) assessed the impacts of lean production on working conditions in a harvester assembly line. In the study, which was carried out as a qualitative assessment based on interviews with managers, supervisors, safety specialists, safety engineers and assembly line workers, the workers have stated

that job insecurity was a source of stress but they considered their working conditions were fairly good and improved after introduction of lean production. In terms of occupational health and safety, based on the interviews with the safety specialist the most dramatic health and safety changes have been found out as the culture of safety. Due to lean production system top management's commitment to OHS had increased. OHS is no longer seen as the concern of health and safety department alone; it is rather a matter for all employees from all departments. Accidents are considered as extreme forms of inefficiency and must be avoided at all costs, which is fully in line with lean philosophy. Health and safety management applies the lean production principle of investigating the root causes of defective production. Safety specialist in the firm reported strong interest in identifying the root causes of accidents and occupational diseases. It is also emphasized that by the introduction of lean production system, there is an improvement in housekeeping. Storage areas are kept clean in the context of the philosophy of visual management. By the introduction of lean production, weight and size of materials to be handled manually is limited in operating the kanban system. The paper work is increased since all preventive measures have to be registered and standardized. However this is a positive change because every thing is under control. Managing health and safety in the departments, in which lean system is better developed, is easier since lean production implementation implies detailed planning which also includes health and safety planning. Workers also think that health and safety was improved in lean production compared to the old system, mostly because housekeeping is improved. Workers have high satisfaction with health and safety, primarily about safety rather than health and ergonomics. As a result the workers considered that their working conditions are good and had improved after the introduction lean production (Saurin and Ferreira, 2009)

There are also some studies in Turkey investigated the effects of lean production on working conditions.

Ansal (1996) puts forward that unlike Fordist production, workers in lean production implementing total quality control should be conscious about quality and skilled enough to identify any quality defect during course of production. Hence, the worker should be able to carry out multiple tasks (instead of doing only one task as in Ford's system) and take responsibility for solving any quality problem. Ansal (1996) defines the role of workers in lean production as a major deviation from Fordism. In implementing quality control cycles, labor efficiency is significantly improved by referring to workers' intellectual skills and mental potential. The new role of workers in lean production is accepted to be an advantage for them, as their work enables them to improve their skills. However in lean production workers capacities and experiences, and mental potentials are used in the upper limits to eliminate of all waste and producing with zero defects.

Ansal (1996) also claims that overtime work without any extra payment is mandated in Japan unless the daily quotas are fulfilled. Japanese workers are found to work overtime, compared to European workers and work under more stress and hurry to fulfill the quotas which has resulted in a major increase in occupational accidents in Japan. Moreover the productivity achieved by lean production and workers' contribution was not reflected to workers' reel income. Besides 117.3% productivity increase in Japan, reel income of workers increased only by 5.9%.

Yücesan-Özdemir (2001) stated that working hours has not shortened upon the productivity increase achieved by lean production. Particularly in Japan, where lean production is developed and implemented, many activities of workers, such as quality control cycles meetings, warming up machines and cleaning up working area are not considered as a part of regular work. Yücesan-Özdemir (2001) also states that as well as accidents, excess workload is also considered to increase the risk of occupational diseases. In addition to overtime work, another point mentioned by Yücesan-Özdemir (2001) is that, lean production creates competition among workers by means of contribution to work practices and self-

improvement. This is claimed to force workers to behave individually and damage the solidarity among them. This competitive working environment also results in varying worker wages, which restricts trade union activities. In brief, worker-employer relationship in lean production can damage organization and solidarity among workers. Besides workers' enthusiasm for self-improvement and participation in development of the work practices, their motivation in their job may also drop, as they may think that the competition in the work causes too much stress and damage their social relations at work.

In conclusion, above discussed literature represents that lean production is associated with high job stress because of the high demands, high work pace and intensified work in lean plants. Some authors claim that lean production reduces job autonomy and worker's control over his/her work however some authors claim that worker's control increases due to the participation of worker to continuous improvement activities which provides the worker a say on his/her working conditions.

It is admitted by many of the authors that lean production is stressful and the work related stress is associated with the occupational diseases such as hypertension, cardiovascular diseases and musculoskeletal disorders.

Another point is that lean production places considerable emphasis on safety and the avoidance of accidents that can interrupt production. This aspect of lean production is favorable in terms of occupational health and safety since emphasis on safety will reduce the number of occupational accidents.

In consideration of the abovementioned discussions in literature on the effect of lean production on occupational health and safety, the case study was intended to seek whether there is an increase in the workload of the workers, a reduction in occupational accidents and an increase in occupational diseases.

CHAPTER 4

CASE STUDY

The underlying reason inspiring this case study is the intention to investigate the discussions in literature on the impact of lean production on occupational health and safety by a field research. It has been learned that the plant where the case study was undertaken has started implementing lean production practices. Since the company belongs to the automotive industry, in which lean production was born, it was thought that identifying lean principles and applications would be practically possible in the company. Besides there was some chances to study with the company in some past studies on occupational health and safety and the company's attitude on academic studies was found to be very positive. In March 2010, contact with the company was started and necessary official permission was received from the Human Resources Department of the company in April 2010. In May 2010, the case study was started actively. The plant was visited several times between the period of May-November 2010. In the case study, qualitative research method was used based on the tools of observation, document analysis, in depth interview and structured interview.

In the first visit to the plant, an interview was carried out with the occupational health and safety expert and the production engineer who is responsible for lean production. In the interview with the production engineer, it is learned that the company's perception of lean production is *World Class Manufacturing.* Thereby

the term *World Class Manufacturing (WCM)* was firstly encountered. The production engineer interviewed has the title of *WCM* Office Leader and some basic principles of *WCM* were told by the office leader. *World Class Manufacturing* is defined as identical as the *Toyota Production System* by the company and the group plants. After the interview, a manual on *WCM* was supported by the company to understand the system completely. Depending on the company's perception and written manual on *WCM*, it was clearly decided that *World Class Manufacturing* is an identical variant of lean production.

Lean production studies in the plant have been started in 2007 by the application of *kaizens.* In September 2009, *WCM* has been initiated within the plant. The incentive to apply lean production in the name of *WCM* is attributed to the broad application of lean production in group plants and in automotive industry in general. It was learned in the interview that lean production in the name of *WCM* was applicable only in some model areas in the plant, not in the whole plant. As the experience gained, lean production is planned to be expand to the whole plant. Until then, each of 11 pillars of *WCM* has been applied in one model area. One of the pillars of *WCM* is named as safety pillar and it has been decided to carry out the case study in this pillar in order to evaluate the impact of lean production on general working conditions and occupational health and safety.

After the paper based study on the principles and applications of *WCM*, the case study was initiated with the observations of the workplace environment and model area. After the observation of the plant, structured interviews were carried out with the workers in the model area. Besides these structured interviews with workers, detailed interviews were also carried out with the occupational health and safety expert, and worker representative for health and safety.

As described above, the case study was carried out in a plant in the automotive industry, so as to investigate the effects of lean production, which is named as

World Class Manufacturing, on general working conditions and occupational health and safety conditions

4.1 Definition of the Plant

The plant where the case study undertaken is;

- Located in Ankara, Turkey on 282,800 m^2 land with a covered area of 82,126 m^2,
- Employing 1250 employees (of which 940 are blue collar), and
- Manufacturing 35,000 vehicles and 25,000 engines per year.

The management system certificates owned by the plant are;

- ISO 9001 Quality Management System Certificate
- ISO 14001 Environment Management Certificate
- ISO 18001 Occupational Health and Safety Management Certificate
- ISO 27001 Information Security System Management Certificate

There are 940 blue collar workers in the plant. Blue collar workers are classified as "direct workers" and "indirect workers". Indirect workers, such as forklift operators or control staff, are the workers who are not obliged to process a certain number of parts in a limited period of time. Direct workers, on the other hand, have to complete a task or process a definite number of parts in a specified period of time.

Weekly working duration is 45 hours. At the sections where production is carried out in two shifts, day shift is between the hours 07:00-15:00 and night shift is between the hours 15.00-23.00. There are also units working three shifts. The day shift in these units is between the hours 07.00-15.00, 15.00-23.00, 23.00-07.00.

Workers shift between day and night every week. In case it is necessary, overtime work is between 17.00-19.00. Rests of 10 minutes are taken twice a day.

The factory is organized as 23 units, the workshop being 5 units. These workshops are heat treatment, machining, body production, engine production and paint shop.

4.1.1 Occupational Health and Safety Studies at the Plant

One occupational safety expert, one full time occupational physician and two occupational nurses are employed at the factory. Occupational health and safety council is managed by the factory manager and consists of occupational physician, occupational safety expert and workers' representative for health and safety. The OHS council has a past of 35 years. Workers' representative for health and safety is the worker selected among the workers and responsible for providing technical assistance to occupational safety expert and occupational physician during their duties. With the directions of the OHS council, health and safety issues are particularly considered in order to reduce number of occupational accidents at the workplace.

Noise, indoor air quality, ergonomics and occupational accidents are major OHS problems at the workplace. Noise is present at the areas where workbenches used for more than 50 years, through the assembly line where air compressors operate and at the heat treatment section where metal equipment is finished with hammers. Every year, 3-4 noise measurements are carried out by OHS team chief under the control of the OHS expert at 300 point throughout the plant. The sandblasting area and engine test rooms are isolated for noise. Eye protection is provided to all workers. Workers employed in the noisy areas are directed to occupational disease hospital for their medical check twice every year. In order to determine the concentration of hazardous chemicals at the workplace atmosphere measurements are carried out regularly. In the heat treatment unit, carbon dioxide, nitrogen oxides and ammonia; in the painting unit volatile organic compounds such as

benzene, xylene and toluene are measured at least once in a year. In terms of ergonomic problems many projects including the redesign of the workbenches have been carried out within the company to reduce the health outcomes of these problems.

Since 2000, 33867 worker-hours OHS training was provided to the employees. Since 2001, risk assessment is done regularly.

No fatal accidents have taken place at the factory so far, but there have been three major incidents, all of which are falls from height. The occupational accident records of last five years are shown in Table 4.1.

Table 4.1: Statistical data on employees, working hours, accidents and disability at the plant between 2004-2009.

Year	Number of Employees	Working Hours (avg/person/year)	Number of Accidents	Disability (Days)
2004	1067	2032	41	515
2005	975	1936	17	172
2006	961	1856	31	248
2007	1239	1936	28	341
2008	1475	1856	38	299
2009	1240	1936	14	142

In accordance with the Labor Act No.4857 Article 80 which mandates the Occupational Health and Safety Council in the industrial companies with permanent jobs lasting more than six months and employing permanently 50 employees, the plant has established the OSH Council. The plant also employs full time occupational physician and occupational safety expert in pursuant of the Article 81 of Labor Act No.4857.

4.2 Method of Research

The case study was based on the document analysis of the *WCM* system, observation of the workplace environment, examining changes in occupational health and safety conditions by the application of the safety pillar, in depth interviews with the occupational health and safety expert and the workers' representative for health and safety and structured interviews with the workers working in the safety model area of the plant, where *WCM* is implemented.

Within the course of the case study, both multiple choice and open-ended questions are asked to 6 of 7 workers, employed in the model area before the introduction of *WCM*. The questionnaire and the workers' answers are given in Appendices B and C, respectively. A in depth interview was also carried out with the workers' representative of health and safety.

The initial 32 questions are multiple-choice and related to general occupational health and safety conditions in the factory. These questions are about general experience of the workers in their job, their occupational accident record, their job satisfaction, and their opinions about health and safety conditions.

The questions from 33 to 43 are open-ended and related to the workers' opinions about *WCM*. The purpose of the open-ended questions is to investigate workers' opinions about impacts of *WCM* on their working conditions, frequency of occupational accidents and occupational diseases, and their workload and job stress to complement the observations in the factory.

It is expected that occupational accidents have been reduced after *WCM*, since emphasis put on the elimination of occupational accidents in lean production as any failure in safety would result in interruption of the process. Here, although the

primary purpose is to provide the production safety, a reduction in the number occupational accidents is favorable in terms of occupational health and safety. Hence, one of main question in the case study is whether occupational accidents are decreased after the implementation of *WCM*.

In contrast to occupational accidents, the number of occupational diseases is expected to increase, in accordance with the literature discussed in Chapter 3, which point out that lean production might lead to job stress and increased risk of cardiovascular diseases and musculoskeletal disorders. Consequently, another important question in the case study is whether the occupational diseases are more common after the implementation of *WCM*.

Since the workers have additional tasks especially in continuous improvement activities in lean production, the workload of the workers and in conjunction with this the work related stress are expected to increase. Hence, other questions in the case study are whether workload and work related stress of the workers are increased after the implementation of *WCM*.

4.3 Work Organization in WCM

4.3.1 Definition of WCM

WCM is defined as a system designed to reach world class performance in operations by cutting out wastes and losses, enhancing standards and methods, and involving all employees in continuous improvement. *WCM* principles apply to all aspects of plant organization, from quality and cost reduction to maintenance and logistics in a perspective of continuous improvement. The *WCM* system defines methods and techniques not only for eliminating the wastes but also for eliminating the sources of the wastes (WCM Manual, 2006).

The *WCM* system approach aims to align the level of performances of the occupational safety, quality, maintenance, cost deployment and logistics in the group plants to those of world's leading companies manufacturing in the same field.

The principles of *WCM* are as follows;

- The system does not accept any kind of losses. The goal is zero accident, zero quality and service defect, zero inventories, and zero breakdown. The basic principle of *WCM* is to combat any type of waste and loss.
- Involvement of people in *WCM* who are employed in all segments of production and teamwork is aimed.
- Application of all the *WCM* instruments and methods definitely which provides the elimination of wastes and losses is targeted.
- Outputs are to be standardized and disseminated (WCM Manual, 2007).

The aim of the system is to maximize the workplace performance in the competition factors such as quality, cost, delivery time and flexibility. Hence, *WCM* is essentially an integrated model that optimizes the processes of production and logistics, and enables the continuous development of factors of quality, efficiency, safety and delivery. The application of *WCM* is supported by an audit system with objective evaluation criteria such as key performance indicators to evaluate the improvement (WCM Manual, 2007).

In the guidelines of *WCM*, it is stated that the essential element in order to have everything working well is the human component, since without full involvement of the workers nothing could be made. In this sense, the effects of *WCM* on workers are worth to investigate.

WCM is defined as a variant of *Toyota Production System*. *Kaizen* approach and lean production tools are the backbone of the *WCM* especially in terms of the

widespread involvement of employees in improvement projects and elimination of wastes and losses (WCM Manual, 2006).

WCM system is structured in ten activity pillars. These are:

1. Safety
2. Cost Deployment
3. Focused Improvement
4. Autonomous Maintenance
5. Professional Maintenance
6. Early Equipment Management
7. Quality Control
8. Logistics / Customer Service
9. Environment
10. People Development

WCM system is structured in ten managerial areas, to qualify progress to *WCM* across all activities:

1. Management Commitment
2. Clarity of Key Performance Indicators and Targets
3. Assignment of most highly qualified personnel to model areas and machines
4. Commitment of Organization
5. Competence of the Organization Towards Improvement
6. Time & Budget planning
7. Level of Detail
8. Operator motivation
9. Level of Expansion
10. Route Map to *WCM*

Each of these ten activity pillars are applied in one model area in the plant, where the case study has been carried out. Since the objective of this study is to investigate the effects of lean production on occupational health and safety, the safety pillar which has the goals of "zero lost time injuries and zero medical treatment incidence" has been decided to be examined.

4.3.2 WCM Applications in the Plant

Application of *WCM* is coordinated by the Deputy General Director of Production, of the plant. The organization of Deputy General Directorate of Production and that of *WCM* application in the plant are shown in Figures 4.1 and 4.2, respectively. Application of *WCM* in the plant is under the management of Deputy General Director of Production.

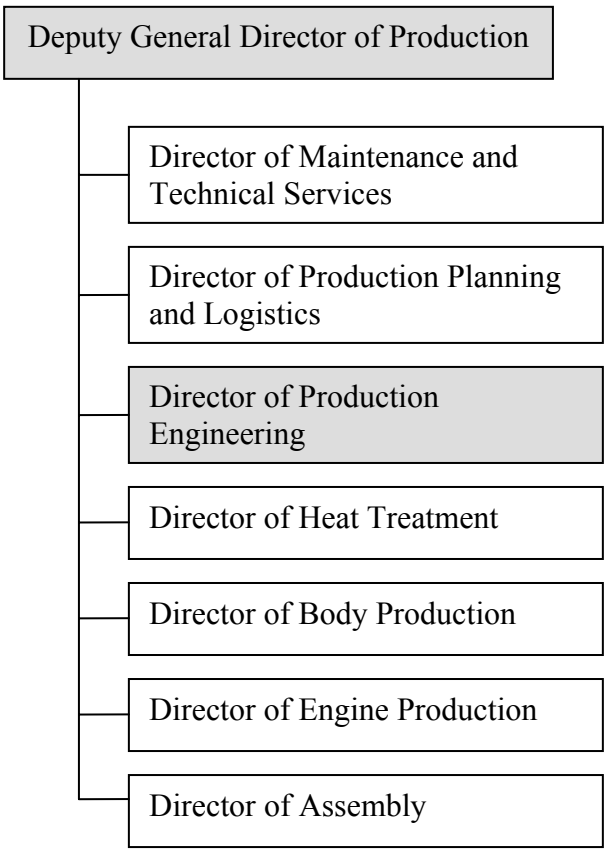

Figure 4.1: Organization of Deputy General Directorate of Production in the plant.

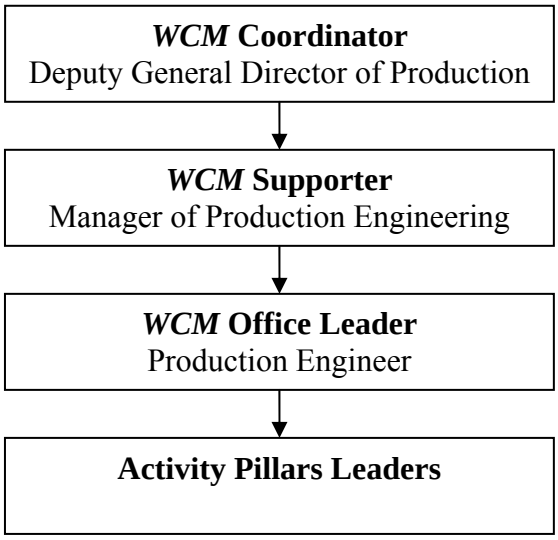

Figure 4.2: Organization of *WCM* in the plant.

Coordination of the *WCM* studies by the Deputy General Director of Production and involvement of the Manager of Production Engineering implies top management's commitment to *WCM*.

As stated above, application of *WCM* in the plant was started in September 2009. The application of lean philosophy has not yet began in the whole plant; it has only been applied in the model areas. The pillars of safety, environment, workplace organization, autonomous maintenance, professional maintenance, quality control and logistics are applied in one model area.

4.3.3 Safety Pillar

The safety pillar of *WCM* is applied in order to improve the occupational safety conditions in the plant. Herewith, it is intended to eliminate the likelihood of potential occupational accidents, improvement in the working conditions, establish a safety culture within the company and to improve the ergonomic conditions in the plant. Its ultimate goal is to have zero occupational accidents and injuries, compliance with the law, minimizing risks at their sources and to establish a safety culture within the plant. The main activities to achieve these are periodical in-

house inspections in terms of safety, identification of risks and risk assessment, systematical analysis of risks, technical improvements in machinery and processes, training, control, and supervision. The expected results for the safety pillar are improvement in the working conditions and elimination of likelihood of potential occupational accidents (WCM Manual, 2007).

The safety pillar team consists of 9 employees including manager of production engineering, manager of assembly, manager of maintenance, occupational safety expert, occupational physician, 2 maintenance engineers, a body manufacturing engineer and a technician from the process engineering. In every shift, one worker in the model area is responsible for the *WCM* activities.

The model area for *WCM* safety pillar is the area where engines and gear boxes are combined prior to assembly. The function of safety pillar model area consists of following operations:

- Engine storage,
- Gear box storage,
- Installation of engine and gear box,
- Loading to assembly line.

In the plant, in order to achieve an effective management of safety six key points, which are defined in the safety pillar of *WCM,* have been put into practice. These six key points are as follows;

- ***Company Commitment and Policy*:** Company commitment is defined as the main underpinning of a successful safety plan. It is stated that all levels of the company management must be convinced, share the importance of the topic and compliance with rules. Managers must provide sufficient support for the activities carried out by co-workers. It is emphasized that workers must be committed to comply with safety rules, remembering that

effective deployment of a culture of prevention stems from their behavior. The company safety policy defines the company's approach to maintaining and improving operating conditions and workers' health, and to continuous reduction of hazards. The company applying the *WCM* system aims to eliminate the accidents. They emphasize that working in a safe environment contributes in workers' satisfaction and well-being.

- ***Organization:*** Effective application of the objectives and the policy established by the safety teams always requires the active involvement of all workers. The success of the activities on occupational safety depends on enhancing workers' awareness that they are responsible for their own safety and for that of their co-workers. Supervisors encourage workers to participate and cooperate in improving working conditions through suitable training, stimulation of a pro-active approach, analysis and problem-solving activities. Workers must be aware of workplace risks and the measures to be adopted to reduce them. They must be involved in improvement activities. Safety is also forged by correct communication (worker training and information). Workers are adequately trained with regards to safety legislation and safe methods of work.

- ***Planning and Application:*** Planning is seen essential to promote effective application of safety policies with regard to monitoring of workplace risks, ability to react and to apply corrective measures as the risks identified change. Identification of main hazards, assessment of the risks, identification of the reduction measures, reduction of residual risks, continuous monitoring of activities and introduction of a self-sustaining system provides a correct management of workplace safety conditions.

- ***Auditing and Review of Performance:*** The audit and performance review system closes the continuous improvement cycle and makes it possible to direct energy towards implementing the activities. Auditing activities are

carried out daily and structured on several levels of review. This is seen as the only way to maintain constant effectiveness of the improvement system (WCM Manual, 2007). In the audit activities the if the management considers safety to be a priority issues, if there is a managed risk control system, if residual risk reduction actions are maintained and used and if each weak point in the system is highlighted are audited. Audit activities by senior management are of essential importance in all *WCM* activities, including safety.

- ***Safety Improvement Tools:*** The WCM techniques applied for the safety pillar are 4M, 5S, 5W1H, 5Why, Failure Cards, Failure Prevention, One Point Lesson, Six Sigma (WCM Manual, 2007). The main tools that can be used in improvement activities are:
  - Safety Emergency Work Order (Accidents Root-Cause Analysis)
  - Heinrich Pyramid, Green Cross, S Matrix
  - PPE Icons
  - Visual control of critical areas (Activity board)
  - Awareness campaigns

- ***Measurement of Performance and Indicators:*** System performance indicators are used in order to maintain and improve safety. There are two types of measurement systems: Pro-active systems permit monitoring of company improvement plans and achievement of standards, and reinforce company commitment. Re-active systems permit monitoring of accidents and application of the related corrective measures (WCM Manual, 2007).

Besides these six points of safety management, another application in the company by the *WCM* Safety Pillar is the seven steps of safety. The plant where the case study was conducted has completely finished the 3rd step of safety and they have

fully implemented the applications given in the 1st, 2nd and 3rd steps of safety in the model area. These seven steps of safety are defined in Chapter 4.3.3.1.

4.3.3.1 The Seven Steps of Safety

These steps of safety define the applications of the *WCM* Safety Pillar implemented at the company to improve the occupational safety conditions.

1st Step: In this step analysis of accidents followed by an analysis of the causes of accidents are done. In this step, activity board in the model area used as a tool to document the key performance indicators and activities of *WCM*. Actually it is an information point but around the board safety pillar team and workers meet to discuss and improve the occupational safety conditions in the model area. Each accident or incident is analyzed by using an analysis of accident report.

In this analysis of accident report, accidents and incidents are analyzed using the tool 5W1H. The question *what* is asked to learn the location and severity of the injury, *when* is asked to learn the when the accident happen, *where* is asked to learn the location of the accident, *who* is asked to learn the task of the worker exposed to the accident, *which* is asked to learn type of the work in which the accident take place, *how* is asked to learn how the accident happen. Then 5Why tool is used to clarify the cause of the accident. The question *why* is asked sequentially 5 times to identify the cause of the accident. The cause of the accident can either be unsafe conditions (inappropriate equipment, insufficient maintenance, insufficient environmental conditions, insufficient illumination, deficiency of operation card, insufficient procedure, insufficient occupational safety norms, inappropriate personal protective equipment (PPE), etc.) or unsafe act (insufficient training, insufficient experience/competence, lack of attention, breaking the occupational safety rules, misuse of PPE, insufficient training given management, inappropriate supply of PPE by management, personal conditions such as family, health, psychological, alcoholism or drug addiction problems, etc.)

2nd Step: After identifying the cause/causes of the accident, countermeasures such as training of the workers, improvement of the work environment, improvement of the equipment, improvement of the PPE, sufficient maintenance of the equipment, etc. are identified and planned to eliminate the root cause of the accident. The countermeasures are carried out and each countermeasure is checked for at least 3 months to verify the effectiveness. The countermeasures are also expanded through the plant into the similar areas.

3rd Step: All the safety problems are listed; the problems are prioritized by severity and potential consequences. All the facilities must be in compliance with the occupational health and safety legislation in Turkey. In all work stations, visual warnings are posted at the eye level and as close as the work station where workers can every time see them. Risk assessments are carried out in whole plant for example for the risks of explosive atmospheres, electromagnetic waves, vibration, hazardous chemicals, noise, ergonomic risks. After the assessment safety procedures and work instructions are created. Also after worker's operations analysis, all safety critical operations are described in detail with Standard Operating Procedure (SOP). The SOPs are also posted and visualized clearly in each workstation at eye level. In this step another activity is the weekly meeting announcing the notes including Heinrich Pyramid (represents the number of fatal accidents or number of accidents with lost days, number of first aid cases, number of near misses, number of unsafe acts or conditions), Green Cross (represents the number of days without an accident), injuries and near misses and general safety training by the safety manager to his workers.

Another tool is One Point Lesson (OPL). This tool is used to train the worker on one subject. This is also used to document improvements or activities coming from a root cause analysis of injuries.

4th Step: A general inspection for safety is introduced. The perception that safety is the Safety Manager's job is removed. People are trained in their understanding of safety and how they can affect their safety. Also an integrated system of audit is developed. The issues audited are; risks evaluation of workplaces, inquiries about accidents, substances and chemical compositions, ergonomics, safety devices, transport, noise in working environment, machinery and electric devices, safety warnings, personal protective equipment, safety document, evacuation and emergency plan, exit routes, medical exams, tiding and cleaning. The safety specialist audits the work area in every two weeks through the above mentioned issues.

5th Step: In this step all the people are involved in the audit system. Team leader performs daily audit. Workers also perform audit daily at the beginning of the shift. Audit is carried out via a checklist. Items are defined based on level of responsibility. Besides, all workers can report near misses, unsafe conditions and unsafe acts at anytime. All the people actively look for ways to improve the safety of their working environment.

6th Step: In this step, autonomous safety standards are introduced. The workers in teams work to define their own standards for a safe and secure working environment.

7th Step: Safety management system with the achievement of zero safety incidents is implemented fully.

It has been observed that these steps are fully implemented in the plant in accordance with the procedures above stated.

4.4 Safety Applications in the Workshop

4.4.1 Model Area

As stated above, the model area for safety pillar is the area where engines and gear boxes are combined prior to assembly. There are four substages in the area. The first substage is the waiting stage of the engines, second is the waiting stage of gear boxes, third is the combination of engine and gear box and forth stage is loading to the assembly line. The number of workers per shift is 7. The work in the model area is based on two shifts. The reason for the selection of the area as the model area for safety pillar is that the area was the most problematic workshop in terms of safety. Most of the occupational accidents have taken place in this area. However, the model area is not very problematic in terms of occupational diseases such as musculoskeletal disorders that are common in automotive industry.

With the implementation of *WCM* Safety Pillar in the model area, analysis of accidents followed by an analysis of the causes of accidents is done. Each accident or incident is analyzed by using an analysis of accident report. Activity board in the model area was used as a tool to document the key performance indicators and activities of *WCM*. After identifying the causes of the accident, countermeasures such as training of the workers, improvement of the work environment, improvement of the equipment, etc. are identified and planned to eliminate the root causes of the accidents. Then, all the safety problems are listed; the problems are prioritized by severity and potential consequences. In all work stations, visual warnings are posted at the eye level and as close as the work station where workers can every time see them. Risk assessments are carried out in model. After the assessment safety procedures, work instructions are created. Also after worker's operations analysis, all safety critical operations are described in detail with Standard Operating Procedure (SOP).

4.4.2 Improvements in the Model Area

Improvements in the model area were observed with the guidance of the worker representative of health and safety. The observations in the plant have been compared to the conditions before *WCM*, based on the information gained from the worker representative of health and safety and the senior workers. Implementation of *WCM* provided significant changes in the workplace environment. Engineers involved in the safety pillar participate in identification of problems with OHS. These problems were also identified by workers. Then, the solutions were defined and possible solutions were proposed. It has been observed that, after evaluation of workers' suggestions by the safety pillar team, following changes, which are called *quick kaizen*, have been done upon the recommendations of the workers in the model area. The photographs demonstrating the changes and improvements in the model area in terms of occupational health and safety which have been implemented by the studies *WCM* safety pillar are given in Appendix A. These changes are:

1. The yellow-black markings were put on the floor in order to draw the attention of the workers (Figure A.1).
2. A barrier was put in front of the working area in order to avoid the risk of a forklift crash to the operator (Figure A.2).
3. With the 5S, application tool of *WCM* and LP, the instruments are put in order (Figure A.3).
4. Before the improvement, the engines and gear boxes were waiting on the wooden plates which were broken easily and on which there were pins that can hurt workers. After *WCM*, they are waiting on wheeled metal scaffolds to ease transportation and cleaning (Figure A.4).
5. The workers carry the components of the product by a wheeled aparatus which is suitable for safe transport (Figure A.5).
6. The workers put the components inside the apparatus under the bench to carry out their tasks to ease it (Figure A.6).

7. Before the improvement the equipment called the “ceraskal” was not able to turn to all the directions and worker had to carry some items manually. After *WCM*, the remote controlled systems carry the engines or gear boxes to the desired point, without excessive human effort (Figure A.7).

4.4.3 The Opinions of Workers about WCM

As the changes in working conditions after *WCM* primarily affect workers, they were interviewed in order to investigate the effects of *WCM* application on occupational health and safety conditions in the model area.

The workers were interviewed alone so that they would not feel under influence when they are delivering their statements. The voice recordings, which are given in the Appendix C, were taken based on their permission after describing the objective of this academic study. The questions asked to the workers are also given in Appendix B.

Profile of Workers

Brief profile information about the workers interviewed is given in Table 4.2.

Table 4.2: Brief profile information about the workers interviewed

	Worker 1	Worker 2	Worker 3	Worker 4	Worker 5	Worker 6
Age	In between 25-30	In between 30-40	In between 25-30	In between 20-25	In between 25-30	In between 20-25
Level of education	General high school	General high school	University	Technical high school	Technical high school	Technical high school
Duration of employment in the plant	In between 2-5	In between 10-15	In between 2-5	In between 2-5	In between 2-5	In between 2-5

Job Experience and Trainings

Among the workers interviewed, only one worker has had another job in the past. All workers told that they were given occupational health and safety, and first aid trainings. However, whereas five workers told that they were provided training related to the job, only one worker stated that he was not given any training related to his job at the beginning of his employment.

Smoking Habits and Diagnosed Diseases

Five of six workers claimed that they have been regularly smoking (4-20 cigarettes per day) for 5-15 years, and one worker rarely takes alcohol. One worker reported that he had chronicle disease. He had problem with his back, which he claimed to begin before employment. However, he told that he carried out repetitive work. Repetitive work may cause musculoskeletal disorders.

Regular Work Duration and Overtime Work

Regular working duration is 6 days per week and 8 hours per day. The work is done in two shifts. Salaries of all workers were claimed to be above the base wage and they are paid 100% increased wage for overtime work.

Personal Protective Equipment

Although personal protective equipment (PPE) is provided to all workers, two workers said that they are not using their PPE, as the risk assessment in their sections indicated that use of PPE in those sections is not mandatory.

Past Accidents

Among the six workers interviewed, one worker has had an occupational accident. He has slipped on the frost on the ground outside the building, fallen down and hit his face. The accident has not resulted in a serious injury.

Job Satisfaction

All workers told that they were satisfied with their job. One worker said:

> ***"I was not pleased in the past, but now I am pleased after the improvements. For instance, they dismounted the shelves and provided carrier cars. Our task got easier. We used to take the equipment ourselves; now the worker in the kit area is bringing the equipment. The working area got clearer. There was even oil on the ground in the past, now there is not".***

In fact, five of the six workers are in their first job. Due to this fact and general employment conditions in Turkey, the workers' might keep their expectations from their work low. This might also be one of the reasons for their job satisfaction.

Job Selection Criteria

The factors, which made workers choose this job, are shown in Table 4.3.

Table 4.3: The factors, which made workers choose this job

	Worker 1	Worker 2	Worker 3	Worker 4	Worker 5	Worker 6
Job security		√	√		√	
Satisfying income					√	√
Social security	√	√			√	√
Good OHS conditions		√			√	
Social services		√		√	√	
Ease of transport		√		√	√	

The table shown above points out that only two of six workers have chosen to work in this plant owing to good OHS conditions. Four of six workers have chosen their job for social security, whereas only two workers have chosen their job for

satisfying salary. This points out that the primary concern of the workers is social security.

OHS Conditions

Regarding occupational health and safety conditions, all workers told that they were satisfied with the OHS conditions in their workplace. Two of the workers said that OHS conditions improved compared to past. Another worker supported this argument and told that *WCM* led to some improvements, even though the OHS conditions were also good before *WCM*. One other worker told that, besides improvements achieved by *WCM*, there were still some areas to be improved. He said that:

> ***"For example I have to pick up parts from the palette. There are free palettes on the ground. The area is in a mess."***

There are many improvements done in the model area in order to improve the working conditions that are described in section 4.4.2. These improvements are done based on either engineers' suggestions or workers' suggestions. It is seen that workers are satisfied with these changes.

In general, workers attribute several changes in OHS conditions to implementation of *WCM*. These are cleanliness and tidiness of the working environment, relief of unsuitable working conditions and unsafe practices, more frequent OHS trainings, and training of operators directly. One worker said:

> ***"We have a better working environment, by Kaizen. For example, the components I mount used to be in the palettes on the ground. I had to bend to pick them up. Now they are loaded on the cars with ceraskals and I can pick them up quite comfortably."***

All workers claimed that OHS conditions in their working environment have changed positively after *WCM*. They thought that number of occupational

accidents decreased since trainings and measures against occupational risks were effective. One worker said:

> ***"Measures have been taken against risks. I think these measures are effective as they are decided based on workers' suggestions. They are asked through failure cards and proposal forms, because workers know the work directly."***

This can be seen from the occupational accident figures of the plant, which will be discussed in section 4.4.4.

Continuous Improvement

All workers stated that they were pleased with delivering their recommendations, because they thought that they knew the problems better than engineers or management and felt job satisfaction when their recommendations were taken into account.

Workload and Responsibilities

The workers were asked if they thought that their workload and responsibilities increased after *WCM*. Four of the workers thought that their responsibilities did not increase. One worker stated that his responsibilities increased, but he was allocated enough time for his task. The same worker also told that when he carries out his extra duty, such as filling failure cards, etc. another worker is doing his work. He also stressed that he does not carry out his tasks in tea or lunch breaks. Another worker, who puts forward that his workload remained same, claimed:

> ***"For example, we complete work at 2:40 and we do the cleaning until 3:00, which is the end of work. When we have time, we fill failure cards in working hours."***

Teamwork

When the workers were asked if they were pleased with participating in teamwork, four of them told that they were pleased. In fact, participation in teamwork means

working in solution teams to make suggestions in the problems in all parts of the plant, including those were *WCM* is not applied. However, one worker said:

> ***"It is voluntary, of course. But it has monetary aspect. They give us shopping tickets. It also affects our performance grades. I think it affects continuity of our employment."***

This indicates that workers might feel obliged to attend teamwork to improve their performance grade.

Occupational Diseases

Five workers told that occupational diseases became less frequent after *WCM*, owing to studies related to ergonomics. Only one worker stated that they had no such a problem. Another worker said:

> ***"For instance, one colleague says "We are bending too frequently." Then the work is organized to reduce frequency of this movement in work."***

In fact, there are no occupational diseases diagnosed in the plant, so far. This is contrary to the literature, as lean production is claimed to result in some work related diseases, such as musculoskeletal disorders, cardiovascular diseases or cumulative trauma disorders. Since an effective diagnosis system for occupational diseases has not been established in Turkey, the statistical data of Social Security Institution on occupational diseases is not reliable. For instance, the number of occupational diseases is 2 in 2008, in the whole sector of manufacture of motor vehicles, trailers and semi-trailers.

Trainings

Workers were asked if they were trained by the trade union, as well as the employer. Three workers told that they were trained by the trade union. However, it is known that the trainings provided by the trade union covers general topics, such as hazards of smoking, etc. One worker told that the training given by the employer was enough but he thought that it would be better if the trade union

would have also given training. Another worker stated that training of workers is the responsibility of the employer. The last worker said, he was trained by the employer but the training was not sufficient. This worker also put forward that they were trained after working hours between 15 and 18 o'clock, and they were paid for this overtime work.

Management Control and Job Stress

Five of the workers told that the control exerted by the management did not increase after *WCM*. One of them said:

> ***"I consider this as cooperation with the management. This gave a chance to exchange ideas. They are asking our ideas. Because the workers know better, as they do the job."***

Only one worker said that the control of management increased, but this did not lead to any stress, instead he believed that regular audits by management are necessary. This implies that the control exerted by the management on the workers is increased.

4.4.4 The Opinions of Workers' Representative of Health and Safety about WCM

An interview was also carried out with the workers' representative of OHS. According to him, participation at the workers' level was achieved by *WCM*. Before *WCM*, engineers used to come, think and comment on the situation, but now they ask the workers, who work most. The workers felt self-confidence and motivation as they are asked about these issues. They tried to their best as they thought that they are involved in the process and could really contribute. Involvement of the lowest level in the hierarchy was the key point; the workers thought that their ideas were given importance.

The workers' representative of OHS also claims that *WCM* did not introduce any extra workload for the workers. As they already observe working environment,

they just shortly deliver their recommendations to the management, in a short period of time. Besides workload, workers consider this practice as a respect to their knowledge.

When the workers' representative of OHS was asked if the workers might feel obliged to participate in teamwork, he urged that participation in teamwork constitutes only a minor fraction in overall performance of a worker, thus, workers would not feel obliged to attend teamwork. It is also stated by the representative that, the workers who participate in solution teams have to work overtime, but get paid for overtime work. It is told that workers consider overtime work as an opportunity for extra income, since their wages are low.

The representative declared that there have been positive changes after *WCM*, He said:

> ***"There are definitely positive changes after WCM. At least, I think that there is certainly an extra effort and improvement at the end. This is enough to think that WCM positively contributed to our work." Regarding the significance of the changes with WCM, he said "Previously we used to solve the problems we see. Now, we are trying to see the probable problems. We are searching for them in WCM. We would like to contribute with pleasure."***

Although the workers' representative of OHS is a worker in the plant, his arguments are constantly in favor of *WCM*.

4.4.5 The Opinions of WCM Office Leader and Safety Pillar Team Leader

In the interview with *WCM* Office Leader and Safety Pillar Team Leader who is also occupational health and safety expert) stressed that the plant already has a 40 year-old OHS committee and achieved significant improvements in OHS. However, past efforts to improve OHS conditions were project based studies rather than standardized systems. They claim that as *WCM* is a system, not a project, OHS issues are handled systematically in a continuously improving pattern. They

also point out that *WCM* contributed to top management's commitment to improvement in OHS. For instance, it used to take too much time for procurement of any equipment upon the suggestions of workers before the system but after *WCM*, management provides suggested equipment more quickly and easily, within the context of *WCM*.

4.4.6 Data on Changes in Frequency of Occupational Accidents

The performance of the safety pillar is evaluated by well-defined key performance indicators, which are evaluation tools of improvements achieved by *WCM*. In this thesis study, these performance indicators have been used to investigate the effects of *WCM* on occupational safety in the plant. In this aspect, incident frequency rate, which defines frequency of occupational accidents, and gravity rate, which expresses ratio of work days lost, was defined as key performance indicators. These two parameters are defined as follows:

Incident frequency rate, $F = (\Sigma \text{ \# of incident}) / (\Sigma \text{ working hours} \cdot 1{,}000{,}000)$
Gravity rate, $G = (\Sigma \text{ \# of lost days}) / (\Sigma \text{ working hours} \cdot 1{,}000)$

Change of incident frequency rate and gravity rate between 2006 and 2010 are shown in Table 4.4.

Table 4.4: Change of incident frequency and gravity rates between 2006 and 2010

	2006	**2007**	**2008**	**2009**	**2010 (Until May)**
F	15.45	11.67	12.25	5.13	4.28
G	0.124	0.142	0.190	0.050	0.035

Table 4.4 evidently shows that, incident frequency rate and gravity rate began to decline sharply in the year 2009, in which implementation of *WCM* began. The decline in incident frequency rate appears to be 58.1% in 2009 and 17.0% in 2010, compared to preceding years. Gravity rate declined by 73.6% in 2009 and 30.0%

in 2010, compared to preceding years. These figures indicate that implementation of *WCM* resulted in significant reduction both in the frequency of occupational accidents and working days lost.

The change in accidents with regard to both accident type and number, between 2006 and 2010 are given in Table 4.5.

Table 4.5: The change in number of accidents in the model area between 2006 and 2010

Type of Accident	**2006**	**2007**	**2008**	**2009**	**2010 (Until May)**
Hand	7	8	6	5	0
Foot	3	3	1	1	0
Head	2	1	2	0	0
Chest & Back	0	0	0	0	0
Arms & Shoulder	0	0	1	0	0

Table 4.5 also indicates that implementation of *WCM* resulted in significant reduction in the number of occupational accidents.

In examining 2009 data, the root causes of accidents were determined to be lack of competence and knowledge, problems in attitude behaviors, such as unsafe acts in work. By the precautions taken with *WCM*, no accidents stemming from lack of precaution, deficiency of management, and deficiency in procedures and systems have taken place in 2009.

4.5 Results and Findings

Depending on the case study, some results on the effect of lean production on occupational health and safety have been found out. Based on the performance indicators given in the Chapter 4.4.4, it is certainly concluded that implementation of *WCM* has led to a reduction in number of occupational accidents. Moreover, the workers and their representative claimed that *WCM* application had a positive effect on occupational health and safety conditions in the plant.

The majority of the workers do not think that their workload and responsibilities are increased after *WCM*. Also, the majority of the workers are pleased with participating the teamwork however although participating to teamwork is voluntary the workers might feel obliged to participate teamwork. Almost all the workers think that the control exerted by management did not increase after *WCM* and they do not feel job stress due to *WCM* practices.

Almost all the workers told that occupational diseases became less frequent after *WCM*, owing to studies related to ergonomics. In fact, there are no occupational diseases diagnosed in the plant, so far. Although, this seems contrary to the literature, as lean production is claimed to result in occupational diseases, such as musculoskeletal disorders, cardiovascular diseases or cumulative trauma disorders, it should be noted that there are some deficiencies in the diagnosis of occupational diseases in Turkey. The problem about the diagnosis of the occupational disease is that it is not easy to decide whether the diseases are due to the job. Moreover, there should be a certain level of disability due to the disease in order to be diagnosed as an occupational disease. The problem of the diagnosis of occupational diseases in Turkey can easily be understood if it is considered that the number of occupational diseases is 2 in 2008, in the whole sector of manufacture of motor vehicles, trailers and semi-trailers.

In the whole plant in 2009, occupational physician diagnosed 40 musculoskeletal disorders however none of them became definite to be an occupational disease since the relation of job were not proved. It is worth to saying that in the safety model area, occupational physician never diagnosed an occupational disease since the model area is not problematic in terms of ergonomic problems which may cause occupational diseases. The safety model area was selected because the area is problematic in terms of occupational accidents. Although the reduction of occupational accidents and the studies on ergonomic problems after the implementation of *WCM* is favorable, the selection criteria represents the main focus of lean production; decrease of the occupational accidents to avoid any interruption of production. Improvement in OHS conditions in the plant is rather a concern of productivity, profitability and competitiveness; as it aims to reduce the workdays lost and cost of any OHS failures in the plant.

Even though, company has a culture of safety before and the main incentive of *WCM* is to provide productivity, profitability and competitiveness, *WCM* has contributed to OHS conditions such as the reduction of occupational accidents and improvement of ergonomic conditions after all which is favorable for workers. The main discussion in literature on increasing of workload, job stress, cumulative trauma disorders and cardiovascular diseases associated with lean production practices have not been found out due to the deficiencies in the diagnosis of occupational diseases and very recent application of *WCM* in the plant.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

In lean production, many of the tasks and responsibilities are conveyed to the workers who are in fact adding value to the product on the assembly line (Womack *et al.*, 1990). Supporters of lean production claim that blue collar workers will find their job more challenging so become more productive in lean production since they are held responsible for seeking cost reductions, zero defects and zero inventories. In lean production, workers are organized in small teams and they are responsible for quality control, continuous improvement and total preventive maintenance (Womack *et al.*, 1990; Liker, 2004). There also critics on lean production that view the system as a modern version of Taylorism in the aspect of controlling the workforce and maximizing profits benefiting from the workers (Kochan *et al.*, 1997). The difference between lean production and Taylorism is that workers cooperate on making improvements (Burawoy, 1985). The main critics about lean production are its character of intense work pace and high speed which potentially create job stress.

In the literature the negative effects of lean production on occupational health and safety are described as; decrease of worker autonomy/control (Klein, 1991); increase of work related stress because of long working hours, high pace and high demands; increase in the incidences of musculoskeletal and cumulative trauma disorders (Landsbergis *et al.*, 1999); high job demands and tight control hence

high work related stress (Conti and Gill, 1998); monotonous and repetitive work (Schouteten and Benders, 2004); increase of the cardiovascular and musculoskeletal disorder due to work related stress (Landbergis, 1998); cumulative trauma disorders which have the origins in repeated pressure, vibration and motion (Brenner *et al.*, 2002); unlimited performance demand, long working hours, cumulative trauma disorders and repetitive strain injuries and rigorous factory regime (Berggren, 1992).

The positive effects of lean production on occupational health and safety stated in literature are; some degree of autonomy based on participation of continuous improvement practices such as quality circles that enables workers to influence their work task (Adler and Cole, 1993; Conti and Gill, 1998); increase in the culture of safety of management, continuous problem solving and finding the root-cause of the problems (Berggren, 1992); implementation of total quality circles reported to contribute to identification of occupational health and safety hazards by reducing the occupational accidents (Macintosh and Cough, 1998) and increase in the culture of safety and top management commitment to occupational health and safety and workers high satisfaction of improvement in working conditions and safety conditions after lean production (Saurin and Ferreira, 2009).

Whereas, some of the researches put forward that workers' well being under lean production is mainly depend on the management attitude in implementation of lean system. (Conti *et al.*, 2006; Lewchuck *et al.*, 2001).

The discussions in the literature on the position of worker, the change of the work organization under lean production and mainly the occupational health and safety conditions under lean production have led to an incentive for this thesis study.

The main purpose of this thesis study is to examine lean production and the effects of lean production practices on general working conditions and occupational

health and safety. The hypotheses of the study are the increasing workload of the workers as a result of unlimited performance demands of lean production, the reduction of the occupational accidents because of the fact that occupational accidents are seen as waste and to be eliminated at all cost in lean production and the increase of occupational diseases based on the literature states that lean production led to cardiovascular and musculoskeletal disorders (Berggren, 1993; Brenner, 2002; Landsbergis, 1999).

To that end, a case study was carried out in a plant in automotive industry to investigate the hypotheses empirically depending on a qualitative research method using tools of observation, document analysis, in depth interview and structured interview. The plant is applying lean production in some model areas in the form of *World Class Manufacturing* which is a variant of lean production.

In terms of workload of the workers, depending on the observation and structured interviews with the workers it is found out that there are new tasks for the workers such as contributing to the continuous improvement through suggestions on the improvement of their working environment and working conditions. Before the implementation of lean philosophy, workers also used to make suggestions but participation of the workers in continuous improvement is being done systematically in lean production. In the aspect of continuous improvement, workers are also participating in the solution teams that are working identically to quality control circles and recommending *kaizen*s for the improvement of their working conditions. The structured interviews with workers reveal that workers do not consider that their workload and responsibilities are increased after the implementation of *World Class Manufacturing*. Based on the interviews with the workers, it is found out that workers are much more satisfied with their jobs after the implementation of *WCM* and feel satisfied to contribute in continuous improvement. These results reveal that workers feel job autonomy because of the fact that based on their participation to the continuous improvement practices and their suggestions on their working environment their working conditions have

been improved; incidence of occupational accidents has decreased, unsuitable working conditions have been relieved and ergonomic work designs have been developed. However, one fact must be emphasized that in these continuous improvement practices workers mental and physical power is used to the most possible extent. Another point that is worth saying that workers feel job autonomy and satisfied with their jobs however lean production has been implemented recently and these results must be reconsidered in future studies when the lean philosophy is extended.

Based on the results of case study the hypothesis that lean production provides a reduction in occupational accidents seems to be empirically confirmed. After the implementation of *WCM*, the occupational accidents in the model area have been significantly reduced. In lean production the past accidents are examined, the root causes of the accidents are determined and the accidents are eliminated at all costs by eliminating the unsafe practices and unsafe acts mainly by redesign of the workplace and trainings of the operators. This result was expected since in lean production occupational accidents are seen as waste since they cause a loss of labor force, time and capital cost and lead to the interruption of production. The emphasis on the reduction of the occupational accidents in lean philosophy can also be seen from the selection criteria as the safety model area in the plant; the model area which was chosen as the *WCM* safety model area was a problematic work area in terms of occupational accidents. Although reduction of the occupational accidents is favorable in terms of occupational health and safety and for workers, it must be stated that the actual objective on the emphasis on the occupational safety in lean production is to reduce all kinds of costs and wastes and eventually contribute to the productivity.

Moreover the case study investigates whether the occupational diseases increase after the implementation of lean production. Depending on the observations and interviews it is worth saying that *WCM* has a contribution on the ergonomic design

of the workbenches and workers are also satisfied with the improvement of their working conditions in terms of ergonomics. Improvement in ergonomics may have contribution in the reduction of work related musculoskeletal disorders. In the interviews workers also claimed that the occupational diseases became less frequent after *WCM* owing to studies related to ergonomics. However, the situation of the occupational diseases has not been verified by statistical data because of the inefficiency in the diagnosis of the occupational diseases. It is worth saying that the safety model area is not very problematic in terms of ergonomics which may lead to occupational diseases as stated above the reason for selection to be a model area is the problems with occupational accidents.

In the aspect of work related stress, workers are also asked if they feel job stress in order to assess the job stress potential of lean production which may cause stress related occupational diseases such as the cardiovascular diseases depending on the limited performance demands in the lean system. The workers claimed that they do not fell job stress and the control exerted by management did not increase after the implementation of *WCM*. However since the implementation is very recent the job stress of the workers must be investigated in the future as only a short period of time passed after the beginning of the implementation.

As a conclusion, the implementation of lean production in a plant in automotive industry has been resulted in the reduction of the occupational accidents and improvement of ergonomic conditions even though the main incentive for these improvements is to reduce the wastes and costs and to increase the profitability and competitiveness. Based on the interviews, workers do not consider that their workload is increased after the implementation of lean production. Besides, workers feel job autonomy (control) and job satisfaction. They also claim that they do not feel job stress which is in contradiction with the literature. However, as the implementation of lean philosophy is quite recent in the plant, its impacts on work related stress and associated occupational diseases is worth investigating in the future studies.

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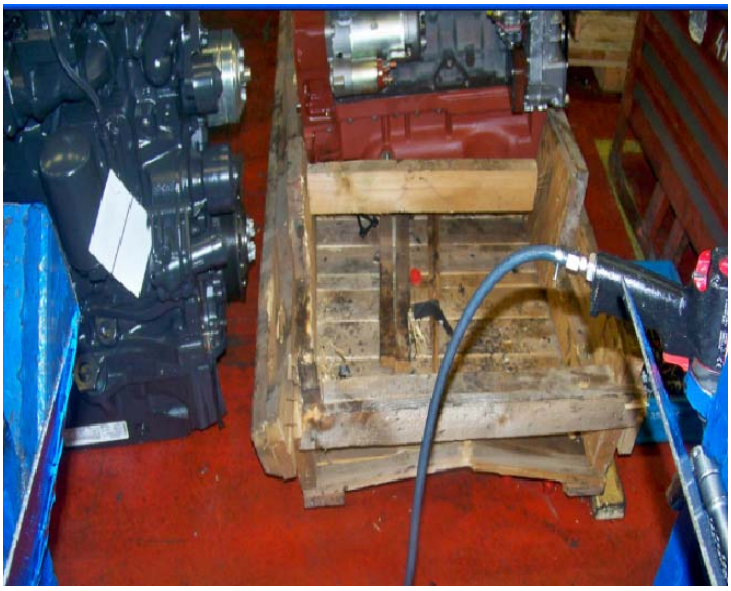
APPENDIX A

CHANGES AND IMPROVEMENTS IN THE MODEL AREA

Figure A.1: The yellow-black markings on the floor draw the attention of the workers

Figure A.2: The barrier in front of the working area in order to avoid the risk of a forklift crash to the operator.

Figure A.3: The instruments put in order by application tool of WCM, 5S.



Before the improvement

After the improvement

Figure A.4: The wheeled scaffold to handle and carry engines and gear boxes.

Figure A.5: The wheeled apparatus utilized for carrying components.

Figure A.6: The apparatus, in which workers put the components

Figure A.7: The remote controlled system carrying the engines or gear boxes to the desired point.

APPENDIX B

EVALUATION OF HEALTH AND SAFETY CONDITIONS OF WORKERS IN AUTOMOTIVE INDUSTRY

1. What is your age?

2. What is your martial status?

(1) Single (2) Married

3. Your level of education?

(1) Illiterate (2) Literate (3) Primary school graduate
(4) Secondary school graduate (5) General high school graduate
(6) Technical high school graduate (7) University graduate

4. Total duration of your employment at your current job?

5. The unit you work? …….

6. What is your task?

(1) CNC bench (2) Assembly (3) Painting (4) Cleaning
(5) Operation of work equipment (6) Other (please specify)……

7. What is your title at your workplace?

(1) Foreman	(2) Co-foreman	(3) Craftsman
(4) Worker	(5) Machine operator	(6) Crane operator
(7) Welder	(8) Engineer	(9) Technician
(10) Electrician	(11) Other (please specify)……	

8. Did you take training related to your job before being employed?

(1) Yes (2) No

9. Before this job, did you work in a similar job or similar industry?

(1) Yes (2) No

If Yes, please state its duration ..... and type of work .....

10. Your monthly income,

(1) Base wage
(2) Above base wage

11. How long are your working hours?

..... hours/day
..... days/week

12. Are you working in shifts?

(1) Yes/Always (2)Yes/If needed (3) No

13. Did you have a medical report before you start your job?

(1) Yes (2) No

14. Were you provided occupational health and safety training at the beginning of your employment?

(1) Yes (2) No

15. Were you provided any training related to your job at the beginning of your employment??

(1) Yes (2) No

16. Were you provided first aid training?

(1) Yes (2) No

17. Does the machine you use have a protection?

(1) Yes (2) No

18. Are you using personal protective equipment (PPE)? (helmet, eyeglasses, eye protectors, hand gloves, masks, protective shoes) If no, what is the reason?

(1) Any PPE has not been provided
(2) Using PPE retards work
(3) PPE disturbs me
(4) I do not believe PPE saves me
(5) Using PPE seems funny/shaming
(6) I do not know how to use PPE
(7) I do not need PPE at my job
(8) Other (Please specify)……..

19. Have you ever had any accident in this workplace?

(1) Yes (2) No

20. Did you have any accident in this workplace in the last one year?

(1) Yes (2) No

If your answer is No, please proceed with 26th question.

21. The place or section the accident took place:

……

22. How did your last accident occur?
(You may give multiple answers)

(1) Falling
(2) Dropping items
(3) Pressing, crashing
(4) Burning, welding burn
(5) Electrical shock
(6) Poisoning
(7) Eye injury
(8) Head trauma
(9) Cuts
(10) Break/dislocation
(11) Dismemberment
(12) Explosive materials
(13) Mechanical handling
(14) Hand tools

(15) Material handling

(16) Other (Please specify)……..

23. What was the reason of the accident, in your opinion?
(You may give multiple answers)

(1) Absence of PPE

(2) Not using PPE

(3) Lack of safety measures at the machines/Unsuitable machines

(4) Incompatibility of work and workers

(5) Personal reasons (tiredness, sleepiness, illness, use of alcohol or drugs, stress, unawareness of risks, etc.)

(6) Carelessness

(7) Noisy working environment

(8) Too hot or too cold working environment

(9) Problems with illumination

(10) Lack of audits

(11) Other (Please specify)……..

24. Your organs affected in the last accident

(1) Head
(2) Eyes
(3) Face
(4) Neck
(5) Shoulders and arms
(6) Hands and wrists
(7) Elbow
(8) Fingers
(9) Feet and ankle
(10) Toes
(11) Knees
(12) Body (Chest, Back, Abdomen)
(13) Bal bone (Spine or vertebra)
(14) Internal organs
(15) Other (Please specify)…….....

25. What was the consequence of the last accident?

(1) I was not injured at all

(2) I had small damage

(3) Disability for 1-2 days

(4) Disability from 3 days to 1 week

(5) Disability from 8 days to 1 month

(6) Disability from 2 months to 1 year

(7) 1 Disability for longer than 1 yean

(8) Other (Please specify)……..

26. Do you smoke?

(1) No

(2) Yes…….cigarettes/day for ……years

(3) Gave up……..months/years ago

27. Do you take alcohol?

(1) No

(2) Yes

(3) Gave up……..months/years ago

28. Do you have any chronical disease diagnosed by a physician and lasting for at least 1 year? (If Yes, please specify)

(1) Yes…….for……years

(2) No

29. If you have a diagnosed disease please mark its type?

(1) Cardio-vascular disease

(2) Hypertension

(3) Lung diseases

(4) Infection by chemical agents

(5) Hearing loss

(6) Musculoskeletal disorders

(7) Joint disorders

(8) Dermatitis

(9) Mental disorders

(10) Other (Please specify) ……..

30. Are you pleased with your current job?

(1) I am not satisfied at all

(2) I am not satisfied

(3) I am neither dissatisfied nor satisfied

(4) I am satisfied

(5) I am highly satisfied

31. Are you pleased with the occupational health and safety conditions at your workplace?

(1) Yes (2) No

32. Which of the below factors made you prefer this job, in your opinion? (You may give multiple answers)

(1) Job security

(2) Satisfying income

(3) Social security

(4) Good occupational health and safety conditions

(5) Social services (Accommodation, dining hall, restroom)

(6) Ease of transport

(7) Other (Please specify) ……..

33. In your opinion, which changes took place in your job after WCM?

(1) Negatively ……

(2) Positively …….

34. Are you pleased with delivering your recommendations regarding your working environment?

35. Do you think that your responsibilities increased?

36. Are pleased to be involved in team work?

37. Besides your task, you are also responsible for tidying up your working area and filling up failure cards. Are you considering this fact as an increase in your workload?

38. How did WCM affect the occupational health and safety conditions in

your working environment?

39. Do you think occupational accidents increased or decreased after WCM? Why?

40. Do you think occupational diseases increased or decreased after WCM? Why?

41. Are you only trained by the management? If yes, do you think that the trade union you were involved should provide training related to occupational health and safety?

42. Do you think that the control of management on you increased after WCM? Do you feel more influence or stress on you?

43. Are you working with extra performance after WCM? Did your workload increase?

APPENDIX C

WORKERS' ANSWERS TO QUESTIONS

	Worker 1	***Worker 2***	***Worker 3***
1. What is your age?	*In between 25-30*	*In between 30-40*	*In between 25-30*
2. What is your martial status?	*Single*	*Married*	*Single*
3. Your level of education?	*General high school graduate*	*General high school graduate*	*University graduate*
4. Total duration of your employment at your current job?	*In between 2-5*	*In between 10-15*	*In between 2-5*
5. The unit you work?	*Body 1 Main Lines (Model Area)*	*Body 1 Main Lines (Model Area)*	*Body 1 Main Lines (Model Area)*
6. What is your task?	*Assembly*	*Assembly*	*Assembly*
7. What is your title at your workplace?	*Assembly Operator*	*Assembly Operator*	*Assembly Operator*
8. Did you take training related to your job before being employed?	*No. I was trained after employment*	*Yes.*	*Yes.*
9. Before this job, did you work in a similar job or similar industry?	*No.*	*No.*	*No.*
10. Your monthly income?	*Above base wage*	*Above base wage*	*Above base wage*
11. How long are your working hours?	*8 hours/day, 6 days/week*	*8 hours/day, 6 days/week*	*8 hours/day, 6 days/week*
12. Are you working in shifts?	*Yes/Always*	*Yes/Always*	*Yes/Always*
13. Did you have a medical report before you start your job?	*Yes*	*Yes*	*Yes*
14. Were you provided occupational health and safety training at the beginning of your employment?	*Yes*	*Yes*	*Yes*

15. Were you provided any training related to your job at the beginning of your employment?	*No*	*Yes*	*Yes*
16. Were you provided first aid training?	*Yes*	*Yes*	*Yes*
17. Does the machine you use have a protection?	*No*	*Yes*	*No. I do not use machinery, I only do assembly*
18. Are you using personal protective equipment (PPE)? (helmet, eyeglasses, eye protectors, hand gloves, masks, protective shoes) If no, what is the reason?	*No. Risk assessment was carried out at the model area. Based on the assessment, PPE use did not appear to be necessary. PPE were provided to the workers but using them was left to their initiative.*	*Yes. I am using eyeglasses and ear protector. They are not necessary but we are using them anyway.*	*Yes. Eyeglasses, ear protector, working clothes and footwear.*
19. Have you ever had any accident in this workplace?	*No. I have never had an accident but one of my colleagues working in the same area had one. His finger was pressed when he was combining the engine and the body. In my opinion the accident took place since there was no machine guard. Thus, an audit was carried out just after the accident and the machine guard was installed*	*No.*	*No.*
20. Did you have any accident in this workplace in the last one year?	*No.*	*No.*	*No.*
21. The place or section the accident took place:			
22. How did your last accident occur?			
23. What was the reason of the			

accident, in your opinion?			
24. Your organs affected in the last accident			
25. What was the consequence of the last accident?			
26. Do you smoke?	*Yes. 10 cigarettes/day for 10 years*	*Yes. 4 cigarettes/day for 15 years*	*Yes. 20 cigarettes/day for 6 years*
27. Do you take alcohol?	*Yes. Rarely.*	*No.*	*No.*
28. Do you have any chronical disease diagnosed by a physician and lasting for at least 1 year? (If Yes, please specify)	*No.*	*No.*	*Yes*
29. If you have a diagnosed disease please mark its type?			*Musculoskeletal disorders. I have problem with my back, but I used to have it before I was employed here. It is common in my family.* ***It may be related to job. Does the physician know?*** *It was present before the work. I am medically checked every 6 months.* ***Do you have to bend too often in your job?*** *No, I do not do heavy work.* ***Do you carry out repetitive work?*** *Yes* ***What is your task exactly?*** *Preparation for assembly. I am preparing the equipment, my colleagues assemble them.* ***Don't you complain about repetitive work? How about rotation?*** *No, I am pleased with my task. Rotation is sometimes done in*

			the factory.
30. Are you pleased with your current job?	*I am satisfied*	*I am satisfied*	*I am satisfied*
31. Are you pleased with the occupational health and safety conditions at your workplace?	*Yes. Compared to past, i am pleased with the occupational safety conditions. Safety is improved.*	*Yes. I am pleased. I was also pleased before WCM, but WCM provided further improvement*	*Yes.*
32. Which of the below factors made you prefer this job, in your opinion?	*Social security.*	*Job security, Social security, Good OHS conditions, Social services, Ease of transport*	*Job security. There is no job security, but it's OK.* ***Is firing too often?*** *Yes. I had to leave during the crisis, later they called me back.*

33. In your opinion, which changes took place in your job after WCM?	*As we know the working conditions in the past, we see that the conditions are improved now. Our working environment is clearer. Our tools and equipment are in their place. A 5S study has been done. We were trained and informed as well. Unsuitable conditions originating both from us and the workplace were relieved. Our unsafe practices were observed. We received feedback about them. They tried to eliminate the risks threatening us. We also participated in these studies. We already have failure cards. We fill in them and solved many problems. On the negative side, I can say that none of the improvements is enough. The improvements should be continuous. They should be continuously supported by the management and audited.*	*Positively. We took occupational health and safety training after WCM.* ***Weren't you getting training previously?*** *We used to take trainings, but with WCM we are trained more frequently.* ***Do you think the accidents were reduced?*** *I think they decreased apparently.* ***Why?*** *People got more conscious. Measures were improved.* ***How about negatively? Do you think your workload increased? Because you are responsible for cleaning up the working area and filling the failure cards.*** *No. Because, time is allocated for this task. It's included in the working hours.* ***When are you attending the trainings? Within or out of the working hours? If out of the working hours, are you paid for overtime work?*** *Yes, out of working hours. But we are paid for the overtime.*	*Occupational safety has improved. Operators have taken more training and have been better informed.* ***There were occupational health and safety studies and training before. What has changed?*** *Operators were not directly informed. For example, I was not instantly informed about an improvement. I am now actively involved. The operators are more active and conscious about improvements.*
34. Are you pleased with delivering your recommendations regarding your working environment?	*We know that our recommendations and failure cards are taken into consideration. We are pleased with this. We are proposing recommendations for our own safety and better working conditions, and they are taking them into account.*	*Yes, definitely.* ***Why?*** *Because every recommendation is turned into a measure.*	*I am absolutely pleased.*

35. Do you think that your responsibilities increased?	*We are not considering increase in responsibilities as negative. We have to take responsibility when working. If you adopt your work, you have to take responsibility.*	*Yes, but time is provided for it.*	*Risks are eliminated. We get less stressful with improvements.*
36. Are you pleased to be involved in team work?	*Team work is always better than individual work.*	*Yes, I am pleased.*	*I am pleased.*
37. Besides your task, you are also responsible for tidying up your working area and filling up failure cards. Are you considering this fact as an increase in your workload?	*It is not possible to take this as an increase in workload. As we work at this place, we know its negatives and positives better than anyone else. Therefore, doing these tasks is reasonable. We do not consider them as an extra work. This is our normal job and we see here like our home.*	*No, as I said these are included in the working hours. Another operator is doing my task when I am filling the failure cards, etc.* ***Are you supposed to do this in your tea or lunch break?*** *No, of course.* ***When do you fill failure cards?*** *When we notice any problem during work.* ***You are tidying up the work area after 5S. Did you use to tidy up the work area before 5S or were here other workers for it ?****We tidy up the working area ourselves.*	*I do not have any extra work. I fill them in when I see a problem.*
38. How did WCM affect the occupational health and safety conditions in your working environment?	*Positively.*	*In my opinion, the work became safer.*	*Safety has been improved.*

39. Do you think occupational accidents increased or decreased after WCM? Why?	*There is a reduction in occupational accidents, however their reasons are different. Some of them originate from the environment, some from people. You cannot identify when a person gets careless, but you can eliminate other factors causing accidents. WCM provides a safe environment, but accidents due to people cannot be eliminated totally.*	*I think decreased. Because trainings are more frequent.*	*I think decreased. There are many improvements and trainings.*
40. Do you think occupational diseases increased or decreased after WCM? Why?	*No, it did not increase, because WCM is a system applied to eliminate them. If we notice a problem about this, we can report this and start a study.*	*I think decreased. Because there are more measures. For instance, one colleague says "We are bending too frequently." Then the work is organized to reduce frequency of this movement in work.*	*I think decreased*
41. Are you only trained by the management? If yes, do you think that the trade union you were involved should provide training related to occupational health and safety?	*Yes, we received teamwork training from the trade union..*	*The trade union gives training.*	*We are trained by the trade union as well.*
42. Do you think that the control of management on you increased after WCM? Do you feel more influence or stress on you?	*Yes, the control increased.* ***Doesn't this cause stress on you?*** *I do not feel stress, because I think the workplace should be regularly audited for ensuring safety.*	*I don't think so. I consider this as a cooperation with the management. This gave a chance to exchange ideas. They are asking our ideas. Because the workers know better, as they do the job.*	*I do not feel stress, I just write down when I see a problem.*

43. Are you working with extra performance after WCM? Did your workload increase?	*Our performance is improved because we are working in a more comfortable environment.* ***Then, Are you pleased with the increase in your workload?*** *By means of performance, I attribute this improvement to better safety conditions and efficiency. I do not think I am working more.*	*As I am responsible for WCM at the shift, I am allocated time for the task.*	*No.*

	Worker 4	***Worker 5***	***Worker 6***
1. What is your age?	*In between 20-25*	*In between 25-30*	*In between 20-25*
2. What is your martial status?	*Single*	*Married*	*Single*
3. Your level of education?	*Technical high school graduate*	*Technical high school graduate*	*Technical high school graduate*
4. Total duration of your employment at your current job?	*In between 2-5*	*In between 2-5*	*In between 2-5*
5. The unit you work?	*Body 1 Main Lines (Model Area)*	*Body 1 Main Lines (Model Area)*	*Body 1 Main Lines (Model Area)*
6. What is your task?	*Assembly*	*Assembly*	*Assembly*
7. What is your title at your workplace?	*Assembly Operator*	*Assembly Operator*	*Worker*
8. Did you take training related to your job before being employed?	*Yes.*	*Yes.*	*Yes.*
9. Before this job, did you work in a similar job or similar industry?	*No.*	*Yes. 3 years in elevator repair and maintenance.*	*No.*
10. Your monthly income?	*Above base wage*	*Above base wage*	*Above base wage*
11. How long are your working hours?	*7.5 hours/day, 6 days/week*	*8 hours/day, 6 days/week*	*7.5 hours/day, 6 days/week*
12. Are you working in shifts?	*Yes/Always*	*Yes/Always*	*Yes/Always*
13. Did you have a medical report before you start your job?	*Yes*	*Yes*	*Yes*
14. Were you provided occupational health and safety training at the beginning of your employment?	*Yes*	*Yes*	*Yes*
15. Were you provided any training related to your job at the beginning of your employment?	*Yes.*	*No*	*Yes*
16. Were you provided first aid training?	*Yes.*	*Yes*	*Yes*

17. Does the machine you use have a protection?	*Yes.*	*No. I am not using machinery, I am doing assembly with hand tools.*	*No. I use a ceraskal. I take the component and mount it on the engine. Then I put it on the assembly bench by the other ceraskal*
18. Are you using personal protective equipment (PPE)? (helmet, eyeglasses, eye protectors, hand gloves, masks, protective shoes) If no, what is the reason?	*I do not use. I used to use previously, but as our risk of accident was reduced to zero, it was considered to be unnecessary. Noise measurements were done, then noise was reduced. The employer provided ear protectors, hand gloves and eyeglasses. Whoever wants to use them can use them, it's free. But this only valid in our area. I am using hand gloves but no eyeglasses or ear protectors.*	*Yes, I always use ear protector.*	*Yes, I use ear protector and eye glasses. It is compulsory to use PPE on the assembly line. In our section it is not compulsory, as there is little risk.*
19. Have you ever had any accident in this workplace?	*No.*	*Yes.*	*No.*
20. Did you have any accident in this workplace in the last one year?	*No.*	*No.*	*No.*
21. The place or section the accident took place:		*Rubber area.*	
22. How did your last accident occur?		*The floor was slippery at the outside, there was frost on the ground. I fell down and hit my face.*	
23. What was the reason of the accident, in your opinion?		*Slippery floors.*	
24. Your organs affected in the last accident		*Face.*	

25. What was the consequence of the last accident?		*I had small damage.*	
26. Do you smoke?	*No.*	*Yes. 20 cigarettes/day for 10 years*	*Yes. 10 cigarettes/day for 5 years*
27. Do you take alcohol?	*No.*	*No.*	*No.*
28. Do you have any chronical disease diagnosed by a physician and lasting for at least 1 year? (If Yes, please specify)	*No.*	*No.*	*No.*
29. If you have a diagnosed disease please mark its type?			
30. Are you pleased with your current job?	*I am satisfied. I was not pleased in the past, but now I am pleased after the improvements. For instance, they dismounted the shelves and provided carrier cars. Our task got easier. We used to take the equipment ourselves, now the worker in the kit area is bringing the equipment. The working area got clearer. There was even oil on the ground in the past, now there is not.* ***Is everyone responsible for cleaning the working environment?*** *Everyone is responsible for cleaning his working area. We are given enough time for cleaning*	*I am highly satisfied*	*I am satisfied*
31. Are you pleased with the occupational health and safety conditions at your	*Yes. I am pleased now. I began working here in 2007. At that time,*	*Yes, but there are still areas to be improved. For example I have to*	*Yes.*

workplace?	*we had metal pallets here, which potentially presented risk of accident. They were on the ground, where we could hit them. Now we have plastic shelves, where we keep our equipment*	*pick up parts from the palette. There are free palettes on the ground. The area is in a mess.*	
32. Which of the below factors made you prefer this job, in your opinion?	*Social services and ease of transport.*	*Job security Satisfying income Social security Good OHS conditions Social services Ease of transport*	*Satisfying income and social security*
33. In your opinion, which changes took place in your job after WCM?	*We are filling failure cards for the problems we detect. Maintenance staff is solving the detected problems. Sometimes we are doing ourselves.* ***How about negatively?*** *Sometimes solution of the problems takes too long time, when we have limited source.*	*There are many positive improvements. For instance the workbenches were changed. They were previously whole iron. Now, they are we have new systems with arms, we use them.* ***How is change of benches related to WCM? Is it proposed by someone?*** *We did not propose them. They decided themselves and that was a precise decision.* ***How about negatively?*** *No, nothing.*	*We have a better working environment, by Kaizen, etc. For example, the components I mount used to be in the palettes on the ground. I had to bend to pick them up. Now they are loaded on the cars with ceraskals and I can pick them up quite comfortably. The workplace is now more tidy.* ***How about negatively?*** *No.*

34. Are you pleased with delivering your recommendations regarding your working environment?	*Yes I am pleased. Because they are doing what we say. We can say what we want. That is very good.*	*We propose through failure cards, in ca we need..*	*Yes, of course. Improving something is always good. Workers know better. We do brain storming for an improvement. Eventually it is improved.* ***Are you involved in a solution team?*** *No.* ***Why not?*** *My colleagues work overtime. I do not prefer overtime work, even though we are paid for it. We can propose solutions without being a team member.* ***Are your recommendations realized?*** *Yes, of course.* ***So, you are pleased with making suggestions?*** *Yes, sure, it is good, not bad.*
35. Do you think that your responsibilities increased?	*No.* ***For example, do you feel obliged to make suggestions?*** *We are proposing with pleasure.*	*No.* ***So, you have some extra work?*** *These extra works are beneficial for us. We are proposing solutions for identified problems. You feel you own the job. It is good to feel that your ideas are respected.* ***Did you use to make suggestions in the past?*** *Yes, but now we are delivering our proposals in written form; this is better.*	*No.*

36. Are you pleased to be involved in team work?	*Yes. We have a positive dialogue here. We are deciding on the improvements together here.* ***Are you given time for these improvements? Are you doing within the working hours?*** *We are working overtime.* ***Do you complain about his?*** *No.* ***Why not?*** *Because we have to do it and we cannot do it in regular working hours.* ***Are you paid for this overtime work?*** *Yes, of course.*	*We do teamwork whenever necessary. We have solution teams, 5 colleagues from different departments of the factory.* ***What kind of studies did you use to do?*** *We used to have stairways bad in ergonomics. We now have shelves.* ***Are you pleased to attend this kind of work? Are you voluntary?*** *It is voluntary, of course. But it has monetary aspect. They give us shopping tickets. It also affects our performance grades.* ***Does it influence your salary? What is happening at the end?*** *I think it affects continuity of our employment..* ***Are you participating because of this?*** *No, it's totally voluntary. But personally think it affects.*	*I am not participating in teamwork, as I am not a solution team member.*
37. Besides your task, you are also responsible for tidying up your working area and filling up failure cards. Are you considering this fact as an increase in your workload?	*They are already giving time for these.* ***Out of the working hours?*** *No, within working hours. For example, we complete work at 2:40 and we do the cleaning until 3:00, which is the end of work.* ***For filling failure cards?*** *When we have time, we fill them in working hours.*	*No.*	*No, we are filling failure cards, but it takes 5 minutes.*

38. How did WCM affect the occupational health and safety conditions in your working environment?	*We are more careful now. Risks of accidents were minimized, based on past accidents. For instance, if the team notices a defect with the ceraskal, they fix it immediately. We work in a safe environment.*	*Highly positively. We are pleased with it..*	*Positively.*
39. Do you think occupational accidents increased or decreased after WCM? Why?	*It is reduced. Because the risk is reduced as everyone got more conscious and well trained.*	*They have been reduced. Measures have been taken against risks. I think these measures are effective as they are decided based on workers' suggestions. They are asked through failure cards and proposal forms. Because, workers know the work directly.*	*Significantly reduced.*
40. Do you think occupational diseases increased or decreased after WCM? Why?	*We do not have any problem because we are doing assembly, lifting with ceraskal.* ***What if you have such a problem?*** *I would recommend a solution. For example, there was a section where our colleagues used to bend too frequently. Now they are working sedentarily.*	*They have been reduced owing to the studies related to ergonomics.*	*I think reduced, because many changes are done to this end.*
41. Are you only trained by the management? If yes, do you think that the trade union you were involved should provide training related to occupational health and safety?	*The trainings provided by the factory are enough but it would be better if the trade union also gives us training.*	*No. This is the duty of the employer.*	*The management does, but I do not find it sufficient.* ***When are you attending trainings, within the working hours?*** *Generally after working hours, between 3-6 o'clock.* ***Are you paid for overtime work?*** *Yes, sure.*

42. Do you think that the control of management on you increased after WCM? Do you feel more influence or stress on you?	*No.* ***Do you feel obliged to make suggestions?*** *I feel responsible when I issue a failure card. When I notice that oil has dropped on the ground, I have to report it. We have to avoid it.*	*No.*	*No, but we feel excited as we contribute to work.*
43. Are you working with extra performance after WCM? Did your workload increase?	*No.*	*No.*	*No.*