ACTIVITY BASED COSTING FOR A MARBLE PLANT

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ABSTRACT

ACTIVITY BASED COSTING FOR A MARBLE PLANT

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In this thesis, activity based costing, which was developed to overcome the problems associated with traditional cost accounting systems, is examined in terms of the suitability to the marble plants. Activity based costing model is developed for the plant to obtain more accurate information about the production cost, especially about the factory overhead costs.

Besides, the model developed for the plant is not left on theoretical basis and the application of model is done numerically to control whether it works or not. From the application it is seen that constructed model is working by giving logical results about the product costs.

Key Words: Mining, Marble, Activity Based Costing

ÖZ

BİR MERMER FABRİKASI İÇİN FAALİYETE DAYALI MALİYET BELİRLEME

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Bu çalışmada geleneksel maliyet muhasebesi sistemlerinde görülen problemlerden kaçınmak için geliştirilen faaliyete dayalı maliyet sisteminin mermer fabrikalarına uygunluğu incelenmiştir.Üretim maliyeti hakkında özellikle de genel üretim giderleri hakkında daha doğru bilgi elde etmek amacıyla fabrika için bir model kurulmuştur.

Bunun yanında kurulan model teorik olarak bırakılmayıp, sayısal olarak da uygulanmıştır. Elde edilen sonuçlar kurulan modelin mermer fabrikalarında uygulanabileceğini göstermiştir.

Anahtar Kelimeler: Madencilik, Mermer, Faaliyete Dayalı Maliyet Belirleme

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURES

CHAPTER 1
INTRODUCTION

Today's competitive environment makes it imperative for producers competing globally to know their costs and many companies now recognize that their cost systems are inadequate for today's powerful competition.

As competition shifted to low cost production of commodity products, the companies had to develop a new cost system to give managers more reliable information about their production costing. Costing systems which are being used in many organizations today have been developed about fifty years ago and because of the conditions during that time production was consisting of single or limited variety of products and mainly depending on the direct labor. So important part of the production cost was consisting of labor and material costs. The other parts, actually the most important one, indirect costs are allocated to products according to some allocation bases such as direct labor hours, direct labor cost and machine hour, etc.

As the production systems became automated, structure of the production cost changed. Share of the labor in production has diminished and on the contrary, machines have taken an important place. In these days, when labor is much smaller element of product cost and overheads are very high, it leads to product costs that are seriously distorted.

So activity based costing (ABC) was developed as a practical solution for problems associated with traditional costing systems. ABC is actually an accounting system that assigns costs to products based on the resources they consume. ABC can be used in many business branch and here it was applied to mining sector. For mining sector application marble plant was selected due to product diversity, machine based operations. Besides, marble plants fit the definition of job order costing systems. ABC can be used more effectively in companies providing these conditions so, for application marble plant was selected.

The main aim of this study is to use ABC system in marble sector. A general model for marble plants is developed. The study covers the quantitative results about the cost items of marbles observed and calculated on plant production stages as well as the qualitative interpretations based on observations at the plant and on private interviews with the people dealing with the production and accounting.

Besides, by the help of constructed ABC system unit cost of product is calculated to see whether the system is working or not. ABC system was not only being used to find unit cost of a product but it was also used as a management tool for decision making.

Beyond this aim, this study covers 4 Chapters.

In Chapter 2, literature survey about the traditional cost accounting and activity based costing are stated.

In Chapter 3, the general information about the plant, production lines and present accounting system in the plant are mentioned. Development stages of the model are stated. Additionally at the end of the Chapter 3, a numerical example is given about the use of the constructed model in order to find unit cost of product.

In Chapter 4, the conclusion and further recommendations are given.

CHAPTER 2
LITERATURE SURVEY

2.1. General

This study is about the activity based costing , which was developed as a part of cost accounting.

Cost systems which are generally used in many organizations developed fifty years ago. So from that time there have been many changes in products, production environment, customer needs and structure of the cost system, etc. Production used to consist of single or limited variety of products and mainly depending on the direct labor. During this time traditional cost accounting systems were able to meet the needs of companies producing single type of product.

But when the production systems became automated, structure of the production cost also changed and a new system was needed to overcome the distortions caused by the traditional systems. So ABC was developed. (Moriarity and Carl, 1991)

In this chapter brief information about the traditional cost accounting and activity based costing will be given. Besides, fundamental differences between two systems and the application of ABC will be explained in subsequent sections.

2.2. Traditional Cost Accounting

2.2.1. Definition of the Traditional Cost Accounting

Cost systems which are used by companies working within the traditional production environment can be called traditional cost accounting systems. Traditional production environments generally consist of limited variety of products and lack of automation, that is, production primarily depends on the labor. In these environments, main objective of the cost accounting is the derivation of the cost of products produced in order to prepare financial tables and stock evaluation. (Kaplan, 1985)

According to Kaplan, present managerial and cost accounting systems were developed for a production environment which was very different from the today's environment at the beginning of 20^{th} century. But while production environment was developing, cost accounting could not renew itself appropriately. For this reason, also, these systems can be called as traditional cost accounting systems. (Kaplan, 1984)

2.2.2. Basic Concepts of Traditional Cost Accounting

In this part of the study, some important concepts will be explained which are important to be able to understand the subject well.

a) Cost and Expense

Cost reflects the organization's ability to minimize the use of resources given the objectives that it seeks. In other words, it is the monetary value of commodities and services to produce a product.

Cost is important because of the relationship between a product's cost and its price. In the long run, the price an organization receives for a product must cover its costs or it will go out of business of making that product. Since customers will buy the product with the lowest price, all other things being equal, keeping cost low provides an organization with a strong competitive advantage. (Kaplan, et al, 1995)

Expense is defined as all the expenditures made by the organization to gain a profit. Expenses related to production can be called as cost. (Uslu, 1991) In other words, every expenditure is first accepted as an expense and all expenses to produce product or service constitute cost.

b) Cost Elements

There are mainly three cost elements forming the product cost;

Direct Material Cost: Direct materials are materials that can be physically traced to a product. In any production facility one can see direct materials being converted into finished products. For example, one can observe sheet metal being shaped into automobile bodies or marble blocks being processed to tiles. Although other materials, such as tile package and wax are used in the production process, they are not accounted for as direct materials because their cost is small relative to the high cost of keeping records on them.

Direct Labor Cost: Direct labor is work that can be physically traced to a product like direct materials, direct labor can be observed. The people who assembles automobiles, or cutting marble blocks are all performing direct labor and their wages are classified as direct labor cost.

Factory Overhead Cost: Factory or production overhead includes all production costs other than direct material and direct labor. For example, factory work not performed directly on product is classified as indirect labor. The work of factory supervisor, material handler belong in this category. In addition to indirect material and indirect labor, factory overhead includes; i) depreciation of plant and equipment; ii) maintenance and insurance of plant and equipment; iii) property taxes on plant and equipment. None of these overhead costs are traceable to a particular product. The electricity that lights the plant, for example, illuminates many work areas as well as non-production related areas such as the lunch room. (Don and Gray, 1988)

The sum of factory overhead, direct materials and direct labor costs is called as the total cost of product. Period costs are those costs that expensed in the period in which the associated services have been acquired. It is assumed that period costs have helped generate revenues in the period incurred. Period costs are generally accepted as operating expenses. Figure 2.1 summarizes the classification of cost in a production firm.

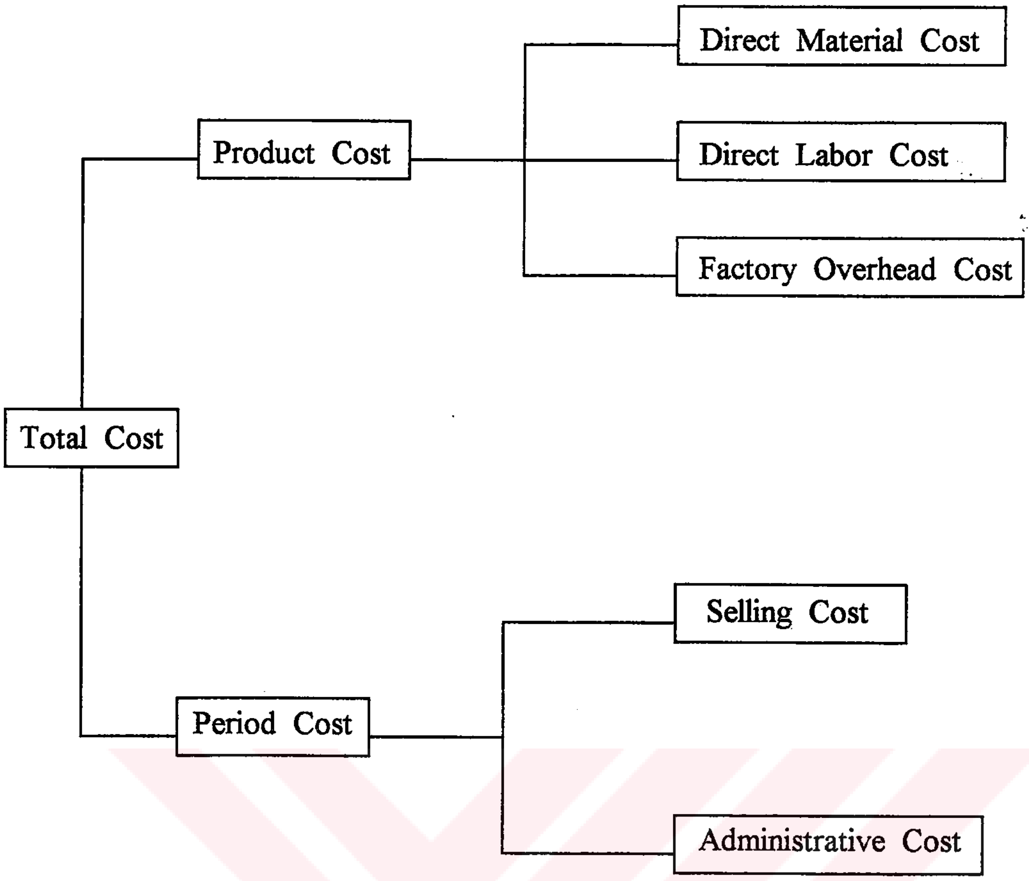

Figure 2.1 Classification of Cost

c) <u>Cost Objective and Cost Centers</u>

A cost objective is an activity or product for which the total or unit cost is to be determined. A cost objective may be the product produced or the service performed, or it may be a department, a process, or a function, all of which are referred to as cost centers. The cost center is the smallest unit for which costs are accumulated for repeating and analytical purposes. (Johnson and Kaplan, 1987)

2.2.3. Cost Systems

The main aim of the cost accounting can be accepted as to find unit cost of a product. For this reason several cost systems have been developed to cope with this problem. As it was mentioned before, the sum of direct labor, direct material and overhead cost gives the total cost of product produced. While performing this, several cost systems are used to reach the final product cost.

Actually, cost systems are systems to be used in transforming the cost of production factors to final product cost. Cost systems are mainly classified according to production process and cost structure.

In the classification according to production process, there are mainly two systems; job-order and process costing systems. Job-order costing systems are used by companies whose products or batches of products are treated as individual jobs. Aircraft manufacturers and part suppliers for large manufacturing companies, are examples of the users of this system. On the other hand, process costing systems are used by companies with homogeneous products such as crude oil, chemicals. Both job-order and process costing systems serve to develop unit cost of production, because of the inherent differences in the physical characteristic of products the two methods differ from each other. (Lewis, 1993)

In other classification, classification according to cost structure, there are mainly three costing systems; actual, normal, and standard costing systems. In actual costing systems, actual direct material, actual direct labor and actual factory overhead costs are absorbed into production cost. Normal costing systems absorb actual direct material and actual direct labor, but absorb estimated factory overhead into production cost. Finally, standard costing systems absorb standard direct material, standard direct labor and standard factory overhead into production cost.

2.2.4. Cost Flow

Flow of cost in production organizations depends on the physical flow of the product. This condition is showed in Figure 2.2 and Figure 2.3 considering the job-order and process costing systems. (Heitger and Matulich, 1982)

Generally direct material and direct labor costs can be directly traced to the products. But indirect costs, overhead costs, are first accumulated in the production overhead account. Since it is difficult to build a relationship between indirect costs and products, these accumulated costs in the production overhead account are allocated to products with the help of some allocation bases.

2.2.5. Cost Allocation Process

It is important to understand the conventional method that cost accounting systems have used to allocate costs among departments. Many plants are organized into departments responsible for performing designated activities. Cost accounting systems are often designated for this type of departmental structures.

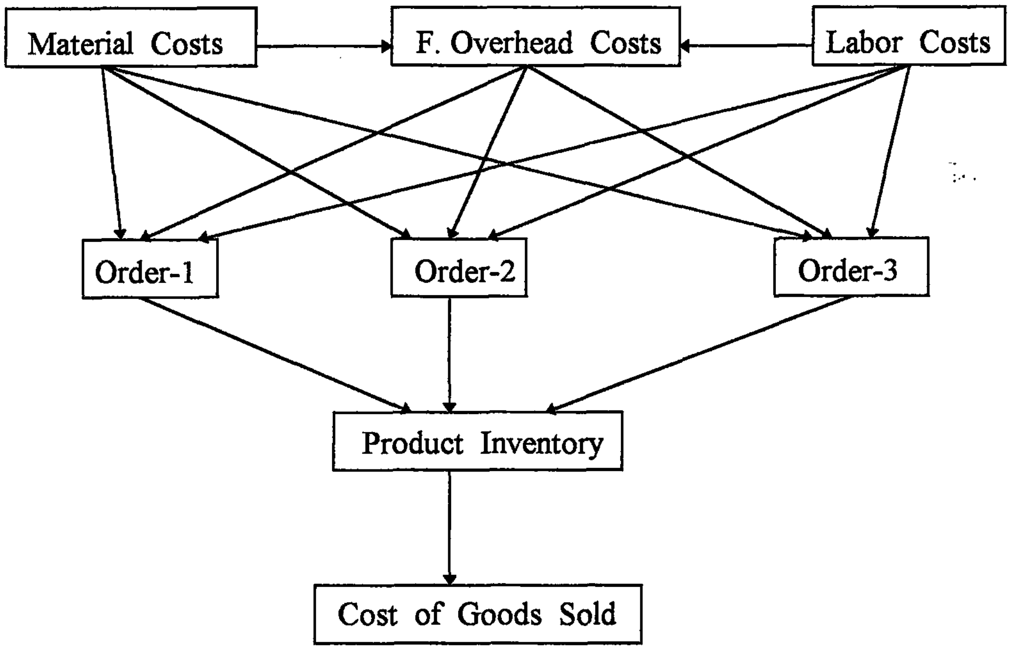

Figure 2.2 Cost Flow in Job-Order Costing (Heitger and Matulich,1982)

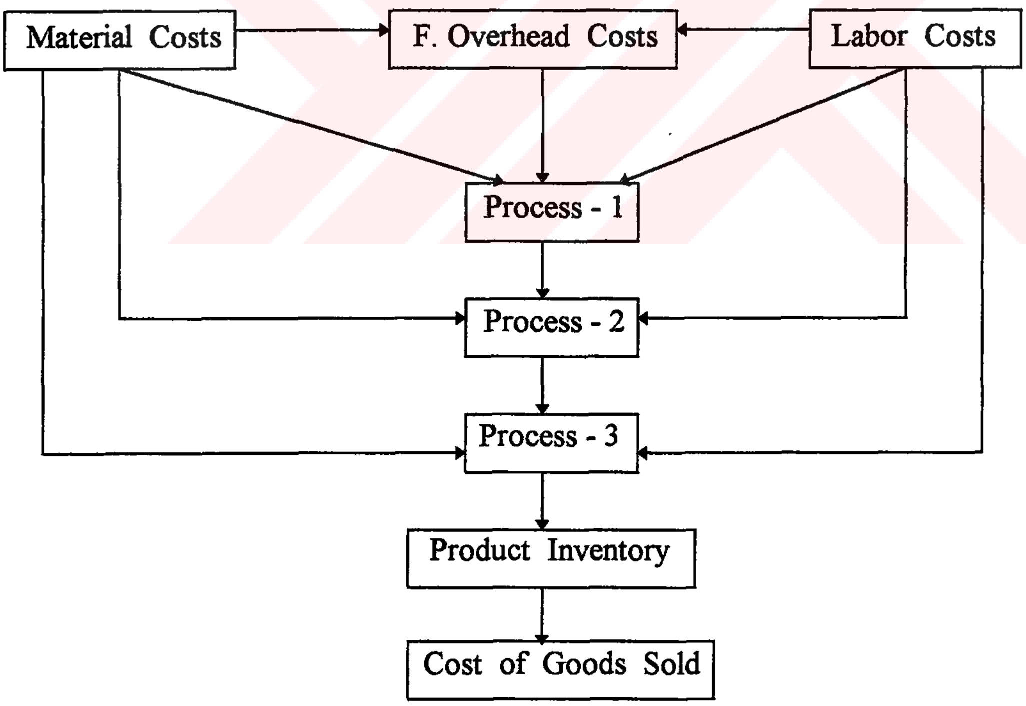

Figure 2.3 Cost Flow in Process Costing (Heitger and Matulich, 1982)

Departments directly responsible for some of the work of converting raw materials into finished products are called production departments and departments such as machine maintenance, machine set up, production engineering and production scheduling are called service departments. All service department costs are indirect (or overhead) costs because they do not arise from direct production activities. (Ketz, et al, 1991)

Traditional product costing systems assign indirect costs to job or product in three stages. In first stage, the system identifies indirect costs and these costs are assigned to various cost centers, such as; production or service departments. In the second stage all of the service department costs are allocated to production departments. In the final stage, the system assigns the accumulated indirect costs for the production departments to individual jobs or products based on predetermined departmental overhead rates. (Figure 2.4)

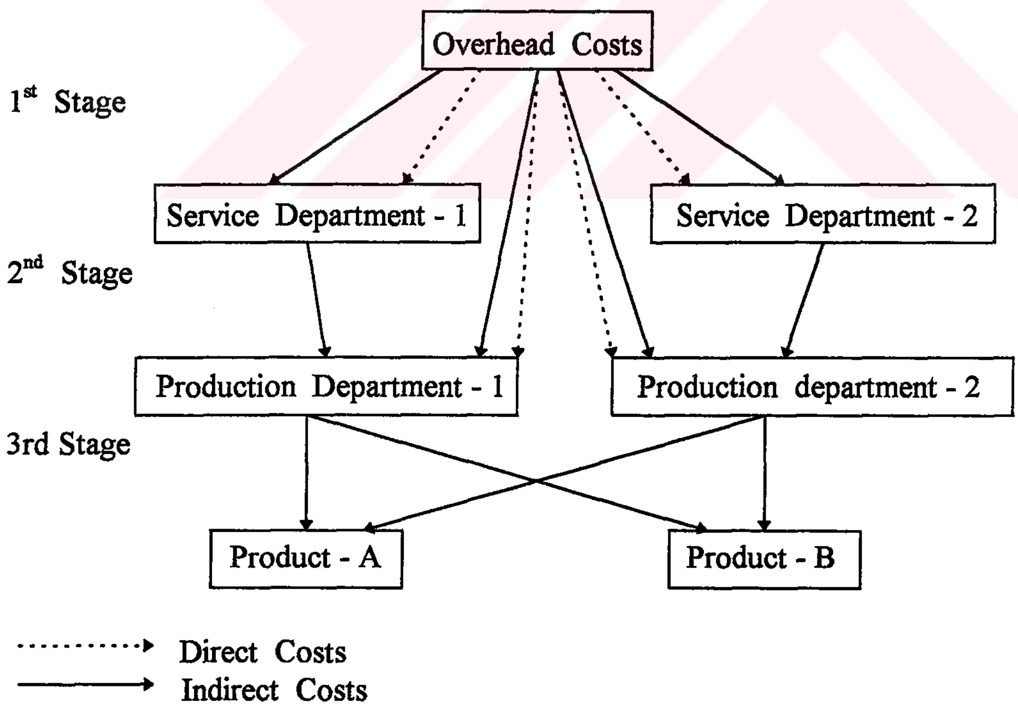

Figure 2.4 Assignment of Indirect Cost (Doğan, 1996)

According to Kaplan and Cooper, cost systems in production companies assign indirect factory overhead to products by a two stage procedure. The first stage of this procedure assigns indirect costs to cost centers, and the second stage assigns the accumulated costs in the cost centers to products. So actually, the three stage and two stage procedures are combined. (Cooper and Kaplan, 1991a)

Allocation of direct materials and direct labor costs is relatively easy because the physical link between materials, labor and product make it possible to measure precise quantities used on each job. Although factory overhead is a part of the cost making products, it is not physically linked to particular units. Without a physical link between overhead costs and units of products, the accountant must find another way of assigning overhead costs to products. Generally overhead costs are applied, or allocated, among the products produced throughout the year according to a ratio called predetermined overhead rate. (Don and Gray, 1988)

Overhead is applied to products according to some activity base, or measure of production activity and the most widely used base for appliying overhead cost is direct labor costs. Direct labor hours and machine hours are also commonly used. Direct labor cost is a reasonable base when most of company's costs are labor related.

Once a suitable base is chosen, the predetermined overhead rate can be established. A predetermined overhead rate is simply a ratio that relates total estimated factory overhead costs for the year to expected activity for the year.

2.3. Activity Based Costing (ABC)

2.3.1. Definition of ABC

Activity based costing is a relatively new term in accounting. It refers to the basis for cost accumulation, either direct or indirect, to products or services. The traditional approach for assigning costs to products is to attach these costs that are directly traceable to the product and allocate the indirect costs by a measure of volume, such as direct labor hours, direct labor dollars, or machine hours.

Although ideas on activity based costing can be traced back for several decades, its' current popularity emerged from its development and use in some USA manufacturing concerned in the 1980's.

Activity based costing is a part of total cost management. Direct materials and direct labor are traceable to the product regardless of the costing system. On the other hand, indirect costs, marketing, engineering and administrative costs have become proportionately greater due to the decrease in direct labor. These are the costs that are not traced to the product under the traditional costing models. ABC recognize that many of these costs, which have been assumed to be nontraceable are now traceable because of changes in the production process, or to technological changes. (Lewis, 1993)

Briefly, activity based costing can be defined as a new cost accounting system to give more reliable product cost information and to provide more accurate information to the manager for decision making.

2.3.2. ABC Concepts

Before going further, some basic concepts of ABC will be explained;

a) Activity

Any organization is formed to do things of particular objectives. Although means and ends can differ greatly, this generally requires the acqusition of resources which are used in a coordinated way to produce end results. Activities are the links between the resource inputs and the end results. (Figure 2.5)

Resource Inputs ⟶ ACTIVITIES ⟶ End Results

Figure 2.5 The Role of Activities (Innes and Mitchell, 1994)

In other words, activity is defined as the repetitive tasks performed by each specialized group within a company as it executes its business objectives.(Cotton and Ricci,1993) At the same time activity consumes the organization's resources while reaching the organization's objectives.

b) Cost Driver

Cost driver concept is new in the cost accounting literature and it was first used with the development of ABC.

As it was mentioned before, activities cause cost . In other words, activities consume resources. So these activities should be mentioned with certain kind of measures. Actually, cost driver is a kind of measure of activity. It is any factor (or factors) that causes the incurrence of costs in the designated activity. Cost drivers provide the causal relationship between the activity's total costs and the product that passes through the activity. (Lewis, 1993)

Cost driver in activity based costing system is used instead of the allocation base in traditional cost accounting system. Cost drivers provide the causal relationship between the costs and products. On the other hand allocation bases are generally used for the subjective allocation of costs.

Cost driver concept is also closely related with the level of activities. Cost drivers can be unit level activities performed every time a unit of product is produced, batch level activities performed every time a batch of product is produced, product level activities performed to support the production of a given product and facility level activities performed to sustain the production of products in general. That is the most important difference between ABC system and traditional accounting systems. Traditional systems use only unit level cost drivers to allocate indirect costs to products. But as seen, ABC system uses different level of cost drivers. (Roth and Borthick, 1991)

Some examples of cost drivers and their activity levels can be seen in Table 2.1.

Table 2.1 Cost Drivers

Cost Drivers	Level
Direct labor Hour	Unit
Machine Hour	Unit
Preparation Hour	Batch
Engineering Change Notice Number	Product

c) <u>Cost Pool</u>

Cost pool is the place where costs are accumulated. In these pools similar activities or group of activities are accumulated. So in this way, by using a single cost driver, costs can be assigned to related products.

In an organization, one can define vast number of activities. The number of activities also depend on the structure of the organization, that is, if organization is dealing with producing of many products, it is inevitable that there are many activities. On the other hand, if the number of product is limited, certainly there are much less activities.

The more activities in the organization have means, the more cost drivers there should be. This increases the complexity of the system. So if an organization have many activities, similar activities are grouped in cost pools. By this way, instead of using many cost drivers, one cost driver is used for a certain cost pool. So the system becomes more manageable.

2.3.3. Structure of the ABC System

Activity based costing systems start by assuming that support and indirect resources provide capabilities for performing activities, they do not generate costs to be allocated. The first stage of ABC systems assigns the expenses of support resources to the activities performed by these resources. ABC systems, therefore, start from the assumption that activities consume resources.

The second assumption of ABC systems is products consume activities. Therefore, in the second stage of the two stage ABC process, activity costs are assigned to products based on individual products' consumption or demand for each activity.

Figure 2.6 shows the structure of an ABC system in which the expenses of support departments are assigned to the activities performed (setting up machines, supporting direct labor, and administering parts). The expenses of each activity are then assigned to products based on the product's demand for the activities (e.g. Number of setups, direct labor hours and number of parts in the product). Even though ABC systems use a two stage procedure, just like traditional cost systems, both the nature of cost centers (or activity centers) used to accumulate operating expenses in the first stage and the method of assigning expenses from cost centers to products are quite different in activity based cost systems. (Cooper and Kaplan, 1991a)

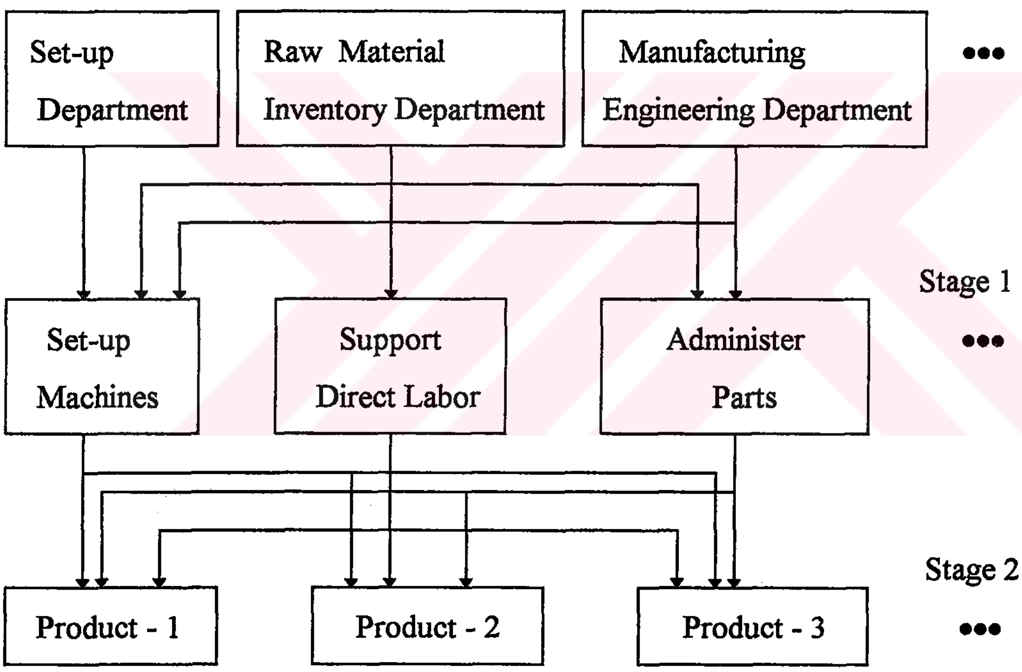

Figure 2.6 Structure of ABC System (Cooper and Kaplan, 1991a)

Activity based systems measure more accurately the cost of activities not proportional to the volume of outputs produced. So four categories of activities can be identified; Figure 2.7.(Cooper andKaplan, 1991b)

i) Unit - level Activities

ii) Batch - level Activities

iii) Product - level Activities

iv) Facility - level Activities

Unit - level activities are those whose volume or level is associated with the number of units produced or other measures, such as direct labor hour, or machine hour which are directly related to the number of units produced.

Batch level related activities, such as setting up a machine to produce a different product are performed each time a batch of goods is processed. When a machine is changed from one product to another, set up resources are consumed. As more batches are produced, more set up resources are consumed.

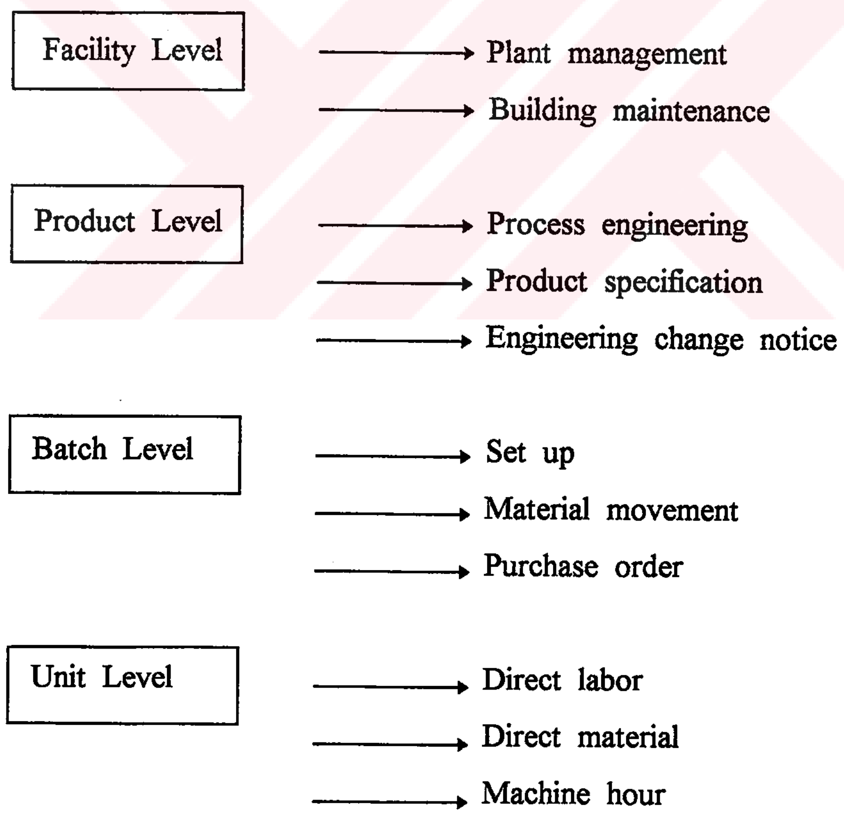

Figure 2.7 Activity Levels (Cooper and Kaplan, 1991b)

Product level activities are performed to enable individual products to be produced and sold. The expenses of these activities can be traced to the individual products, but the resources consumed by these activities are independent of how many units or batches of the product are produced. Example of resources used for product level activities include the information system and engineering resources.

Other additional category is the facility level activities. Many facility level activities are administrative , such as managing the plant and personnel and accounting for the shop floor. Other examples include the taxes, maintenance, security and lighting for the factory building. Facility level activities are necessary to provide a factory that can produce products, but these activities are unrelated to the volume of individual products. Facility level expenses are treated as an expense of operating the facility for the period and not allocated to products but sometimes according to desire of the manager they can be allocated to products.

2.3.4. Construction of the ABC System

The development of an ABC system involves four major steps;

i) Identification of the activities performed to produce outputs.

ii) The identification and assigning of resource consumption to these activities.

iii) The selection of a cost driver for each activity cost pool.

iv) Application of cost drivers to product lines to generate product cost information.

Activity identification involves finding out what is done with the resources consumed in the organization. This must be done in a systematic way to provide that all relevant activities are captured. One way is the following physical flow of product. The other way is the interwiev.

After activities have been identified, resource costs must be mapped to the activities. Organizational resources include indirect labor, materials and supplies, capital, equipment and buildings. The cost of the resources can be assigned to activities in three ways; direct charging, estimation and arbitrary allocation. In direct charging, the actual usage of resources by activities is measured. Lacking direct measurements, cost of resources used by each activity is estimated through surveys and interviews. Finally, when no meaningful way exists to estimate the resources used, one can also use arbitrary allocations. (Cooper and Kaplan, 1992)

Link between activity costs and outputs is estimated with different cost drivers. ABC designers use several types of activity cost drivers. For example, transaction drivers capture the number of times an activity is performed. Transaction drivers can be used when all outputs make essentially the same demands on the activity. Duration drivers capture the length of time an activity is performed on an output. Duration drivers should be used when significant variation exists in the amount of activity required for different outputs.(Innes and Mitchell, 1994) By the help of these cost drivers product cost information can be obtained accurately.

2.4. ABC versus Traditional Cost Accounting

Generally, there is a direct relationship between the calculation of product cost and production structure. If this relation is disappeared, it is difficult for cost accounting to do its job as expected. Besides, traditional cost accounting systems that are still used today were developed a long time ago considering the needs of that time. (Kaplan, 1984)

Because of the new technologic improvements and new production techniques, production environment has changed very differently. Especially the computer usage and increase in automation has effected the new manufacturing environment. As it is known, before these, production was based on the labor but after the automation both production techniques and cost structure has changed. (Brunton, 1988)

Today organizations are forced with a new production environment and a new cost structure for the product while the ratio of direct costs are diminishing and the rate of indirect costs are increasing. So, indirect costs became more important today. (Schwarzbach and Vangermeersch, 1985)

Dr. Goldratt expressed the weakness of traditional cost accounting systems in certain points as follows; (Howell and Savay, 1987)

a. Being too limited to meet management's need.

b. Not reflecting the production process.

c. Not accurately measuring resource consumption or realistically assigning resource costs.

d. Producing information too late.

e. Producing unreliable information.

f. Performing unrealistic cost allocations.

g. Not providing a basis for planning and scheduling future production.

h. Evaluating performance based on the wrong goals.

Traditional cost systems use a two-stage procedure to assign an organization's indirect costs to outputs.(Cooper, 1990) Indirect costs are assigned first to cost centers and second, to the outputs of the production process.(Figure 2.8)

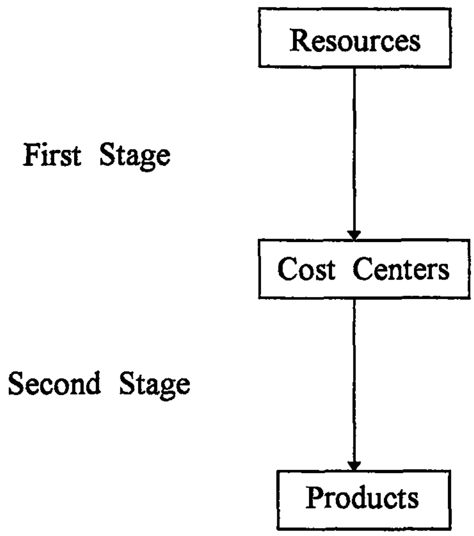

Figure 2.8 Traditional Cost System

These traditional two-stage assignment procedures, however, distort reported costs considerably. The traditional systems assign costs from cost centers to outputs using volume based drivers such as labor, machine hours and units produced. Because many indirect and support resources are not used in proportion to the number of output units produced, these systems provide highly accurate measures of the costs of activities

Activity based cost systems differ from traditional systems by modeling the usage of all organizational resources on the activities performed by these resources and then linking the cost of these activities to products, services, customers and etc. (Figure 2.9)

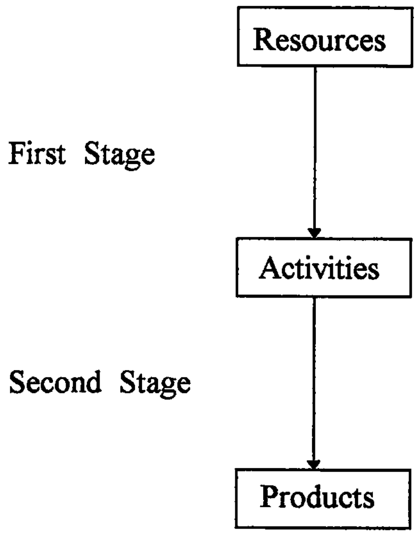

Figure 2.9 ABC System

Activity based cost systems differ from traditional systems in two ways; (1) Cost pools are defined as activities rather than as production cost centers, and (2) the cost drivers used to assign activity costs to outputs are structurally different from those used in traditional cost systems. These modifications to the two-stage procedure allow well designed activity based cost systems to report more accurate costs than traditional systems because they identify clearly the costs of the different activities being performed in the organization and they assign the costs of these activities to outputs using measures that represent the types of demands that individual outputs make on those activities. (Cotton and Ricci, 1993)

In activity based costing four categories of activities can be identified;(1) unit level activities, (2) batch level activities, (3) product level activities, (4) facility level activities. By these categories ABC introduced batch level and product level activities which were not found in the traditional systems.

2.5. Examples of Activity Based Costing Applications

Ideas on activity costing can be traced back for several decades. Its current popularity and contemporary formation emerged from its development and use in some USA manufacturing concerns in the 1980's.In these organizations, it was developed as a means of overcoming the systematic distortions which traditional costing systems created in their product cost information. The organizations became the subject of series of Harvard Business School cases (Cooper and Kaplan, 1991b) and the case authors termed the approach "ABC" which USA academics have since developed their advocacy of ABC at both conceptual and practical levels and so provided the publicity which fostered its dissemination to Europe where its adoption has proceeded and further empirical research has been undertaken.

Table 2.2 lists a diverse range of organizations from the manufacturing and service sectors which have reported their experiences of ABC at conferences or published case studies. (Innes and Mitchell, 1994)

For example, IBM has been reducing its work force and learning to do more with less reliance on the hierarchical organization, moving towards a matrix marketing structure.(Carreon,1995) So ABC was determined to be applied in IBM to measure and improve its sales force automation project. IBM has already implemented ABC in its plant to improve design and manufacturing. But the method of costing activities in the selling process for a downsizing project has not been done before. Finally, IBM decided to implement and ABC pilot with some key objectives. After construction of the model, it became easy to analyze activities. Activities were labeled as value added, business value added, or non value added. In this way, it was understood that the cost for each activity to help prioritize how automation could improve the process.

By the help of ABC pilot, IBM found that by reducing non-value added activities, they can be more responsive to their customers and produce higher quality proposals . (Carreon,1995)

Other example is the US Airways which is one of the world's leading air carriers and one of its largest. US Airways determined to apply ABC in its powerplant department due to need for more detailed information to manage the business, drive improvement, manage costs and support third party pricing. The lack of detailed operational and financial information did not allow management to fully understand the costs associated with producing or overhauling on engine, and, to a lesser extent, the costs of each modules making up an engine. ABC was chosen as a solution and an ABC team was formed at US Airways to implement ABC in the powerplant department. ABC project was divided into four main phases. The phases consisted of introduction to ABC, data collection and information gathering, model building, and data analysis and reporting. After the model was built and the ABC data was available results began to be taken. The ABC model output provided US Airways with operational and financial data to support strategic and operational decision making. Besides, it became possible to see the activities' cost by labor classification and by shift. Also, expensive non value added activities could be seen. For example, one work team found they spent about 80 % of their effort or $85,000 per year reinspecting due to the use of an older piece of inspection equipment. The ABC information justified the purchase of the new piece of inspection equipment. Finally, power plant management made the decision to update the cost model on a periodic basis to obtain accurate and timely data. (Dommelly, 1997)

Chicopee, a Johson&Johnson subsidiary has also applied ABC to obtain continuous improvement, elimination of non value added activities and more accurate process and product cost data. Company's cost structure needed a major overhaul. One of the problems was the traditional use of variance numbers as a performance measure. There were problems related to scheduling and efficiency due to long set up times. There was also the matter of high plant inventories . Under the old system, overhead was allocated based on machine hours. This practice was providing distorted product cost information. So an ABC team was formed to develop a model. Finally, ABC was used to determine non value added activities and cycle efficiency. (Osthaul, 1991)

Another company, Slade, applied ABC in its automotive business group. Business lines included engine components, transmission components and assemblies, exterior body panels and rubber products. Competition was increasing and customers more and more demanding higher quality, lower price and more reliable delivery. So ABC was applied to address both product and customer profitability. Product costing was the primary objective of Slade ABC model. The activity based model found that 30 % of the products, representing 80 % of the sales volume, generated 150 % of the profits. The middle 60 % of products were break-even and the least profitable 10 % of the products lost 50 % of the profits. In the year following the development of the ABC model, 13 % of the customers and several production items were eliminated, and 20 % of the service parts were phased out of productions. (Cooper and Kaplan, 1992)

While implementing ABC to several organizations, implementation plan was used consisting of seven steps; (Cooper and Kaplan,1991b)

1. Seminar on ABC;
2. Design seminar;
3. Design and data gathering;
4. Progress meeting;
5. Executive seminar;
6. Results meeting and
7. Interpretation meetings.

First phase includes the short lecture for members of the plant management team about ABC. Second phase, design seminar, also serves to create a strong team identity. During this seminar, computer based training exercises are used. The design and data gathering phase was broken into two parts. First, the direct material and direct labor standards were examined. Then overhead was analyzed to identify the activities that were driving it. Progress meetings are held to keep the plant's management informed about progress made throughout the entire design and data gathering phase. An executive seminar was held for the plant's management to explain ABC in more detail than had been possible in the first seminar. In the sixth phase, when the activity based costs become available, a select group of managers and engineers was assembled to analyze the results. Interpretation meetings were held after the results meeting. These meetings focused on how to interpret the activity based product costs. (Cooper and Kaplan, 1991b)

Table 2.2 ABC Users

ABC Users	
IBM (Electronics)	DHL International (Messenger Service)
Hewlett-Packard (Electronics)	Royal Bank of Scotland (Banking)
Cummins Engine Co. (Engineering)	John Deere (Engineering)
Lucas Industries (Engineering)	Siemens (Electronics & Engineering)

CHAPTER 3
MODEL DEVELOPMENT AND APPLICATION

3.1. General Information

3.1.1. Information About the Plant

The selected plant; Ertaş Marble Co. is located in Kütahya, dealing with both strip and tile production. The major products of the plant are free length or dimensioned strips and marble tiles. The company buys raw material (marble blocks) directly from the quarries and applies all the production steps at the same plant.

Plant exports almost all its products. United States and Israel are the major buyers of these products. Products that are not suitable for the foreign market, are utilized in domestic market.

3.1.2. Marble production and Production Lines

The products of a typical marble plant can be classified into three main groups;

- Marble slabs
- Free length or dimensioned marble strips
- Marble tiles

Slabs are the marble plates with thickness of 2 or 3 cm and different widths and lengths according to the dimensions of the block. They are cut by means of gangsaws and can be dimensioned by bridge cutting machines. In selected plant slab production is not done.

Free length strips (F/L) may be either in 2 or 3 cm thickness according to the place where they are used. Their lines generally begin with block cutting machines. Their front and end sides are perfectly cut by the cross cutters. According to the market demand, they may be polished or sold as they are.

Marble tiles are polished and chamfered plates with square shape. They are generally 12" (305mm x 305mm x 10mm) or 16" (407mm x 407mm x 15mm) in dimension. (Akbilgic, 1997)

The free length strip and tile production lines can be seen in Figure 3.1 and Figure 3.2.

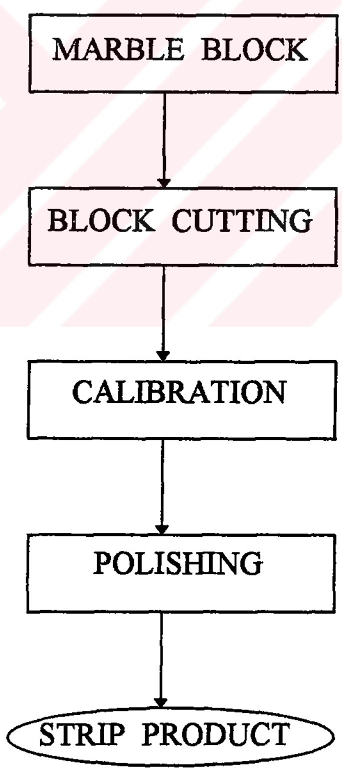

Figure 3.1 Free Length Strip Production

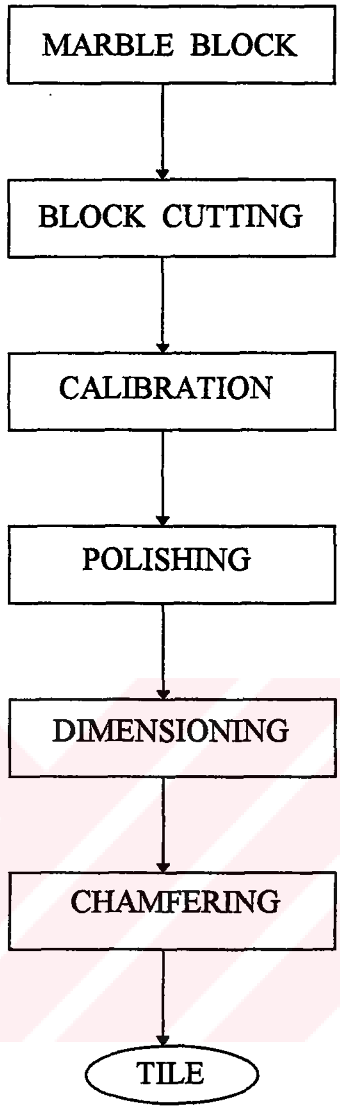

Figure 3.2 Tile Production

At the first step of production of free length strips, the blocks are unloaded from trucks to the plant raw material site. According to the general acceptance " Block " is marble mass with regular six rectangular faces. " Rubble " is an irregularly shaped marble mass produced from the quarries with no regular face. Rubbles are generally smaller than blocks in terms of size. Although rubbles can not reach to the efficiency of the same tonnage regular blocks, it is a common practice in the world to cut them with the same machines. The unloading work is done by the 20t - 50t bridge cranes in the plant.

At the second step the blocks are loaded to the block cutters by the help of bridge crane. The block cutting step is handled by two different machines. The first machine is block cutter (BC) and the second is cross cutter (CS). Block cutting machines cut the marble blocks and produce marble strips by the help of a vertical steel wheel with diamond segments welded on the periphery. The diameter of the cutting wheels varies between 100cm to 300cm. Although there are several types of block cutting machines, the most common types are 2 column and 4 column block cutters and in the plant all of the four block cutters are 4 column. While getting a marble strip from the marble block, first the vertical wheel cuts the face of the strip and the horizontal wheel cuts the bottom. After than, the strip is removed by the operator and transported to the cross cutting machine. Ends of the strips are cut by the help of this machine.

The next step is the calibrating and polishing. The first one is the calibrating part. There are five vertical shafts over the conveyor belt. Three of them are for the calibration which a diamond disk is connected to the bottom of each shaft and an electrically driven motor is placed at the top. Two of them consist of abrassives that are connected to the bottom of the shaft. The marble strips are fed to the calibrating part by the help of conveyor belt. Calibrating and thickness reducing processes take place by the first three shafts (head) and other two heads are used to smooth the calibrated surfaces.

The marble strips then move to the polishing part. The general working principle of polishing part is similar to calibrating part. At the bottom of each shaft different numbered abrassives are used. The number of heads vary between 6 to 24 and ten heads polishing machine is used in the plant. The clean water flow should be available both at the calibrating and at the polishing part.

The tiles which are different from the strips are faced with more processes. All the steps above are also used for the tiles. But due to the market demand the marble tiles should be cut in squares and this action is achieved by multi-disk dimensioning machine consisting of six cutting disks. In the factory, strips are dimensioned right after the polishing line in order to remove the not properly polished zones from tiles and take the tiles from the convenient parts of the strips to remove the unwanted colored or textured parts from the final tile product.

The next stage for the tile is chamfering. Chamfering machine has the diamond disks for opening channel at the back of the tile and for perfect dimensioning of tiles, abrassives for chamfering process. Finally tiles are dried for selection and packaging operation.

3.2. Present Accounting System in the Plant

Plant in that study was established in 1996 to deal with the marble production. Since it can be accepted as a new plant, structure and policy of the plant is newly developing.

Like in all organizations, firstly to provide official requirements and to provide information about the financial situation, traditional accounting system was begun to be used in the plant. This is the most widely used system in organizations dealing with production or other sectors. It was designed to meet the formal demands and as the plant developing it was seen that it could not catch up with the desired needs. In that type of accounting system, primary aim is the fulfilling of the official requirements. On the other hand, to obtain reliable information about the production cost, a separate accounting system should be employed. Of course, this does not mean the replacement of the system. Actually two system are complementary to each other.

In the plant, there are mainly two accounting systems. They can be separated as financial accounting and cost accounting. In financial accounting system, expenses related to both production and supporting activities are followed by several accounts. There are mainly four accounts consisting of several sub-items. Production, management, marketing-selling and direct material accounts are the name of main accounts and all the expenses are followed under these accounts.

Production account includes all items related to production. Every expenditure made for production is recorded to this account. Actually this account can be called as a factory overhead account. During the examination of accounts, it was seen that some of the items which actually belonging to factory overhead account was being kept under the direct material account such as abrassives, wax, polishing bricks etc. Since all these items are used in the production process and it is difficult to assign to a product directly, items related to production under the direct material account were moved into the factory overhead account. Actually direct material account comprises the items directly traceable to a product and in this case only block cost and direct labor are directly traceable to the product. So production and direct material accounts were rearranged for this study. Other accounts, management and marketing-selling were not changed.

Cost accounting was tried to be developed by the plant management and actually it is similar to financial accounting. Like in financial accounting all expenses are recorded but not in regular accounts. In fact, this system aroused due to need for detailed information about production but it could not surpass the financial accounting. Finally, it can not be said that this system provided the desired information about the production to the management due to misuse.

Records in financial and cost accounting are kept by computers. For this purpose a program that is called LOGO is used. Expenses are recorded to related accounts and by this way necessary information is obtained when needed. Program enables user to open or cancel a desired accounts and items so it can be arranged according to the need of organization. All necessary information required for financial accounting and cost accounting are obtained by the help of this program.

Accounting records of the factory are kept by one person and this cause difficulty in holding accurate records. Because at the same time, a hotel is run by the same organization and hotel's records are also kept by the same person. In this situation there can be some confusions due to the hard working conditions.

In addition, in the plant there is not a proper inventory control system. Only coming blocks or rubbles are recorded to stock cards but when they are given into production, necessary procedures are not being applied and this cause absence in records. Inventory is generally being followed from the invoices, that is at any time one needs to review all the invoices to control the stock level.

The most important thing for a plant dealing with production is the calculation of unit cost of a product. Only by this way it can establish a strong market strategy, price policy etc. In the plant, it was seen that there was not a specific way of finding unit cost. To find unit cost of a product all the expenses related to production, labor, management and marketing-selling are taken into consideration. Expenses related to these items are summed and then divided to total number of product to find the unit cost of a product.

It is obvious that finding unit cost by this way is not an accurate method and it does not provide reliable information to management.

Product Type: As it was mentioned before, plant mainly produces two kinds of products; dimensioned or free length strips and marble tiles. Generally, plant works depending on the orders and production planning is done according to these orders. Calculation of the cost of a product in organizations producing single product is easy because there is just one product and all expenses are made for this product. On the other hand, if there is more than one kind of product it becomes intricate to find the cost of a product. In that case, sources are shared by several products and it becomes difficult to differentiate the expenses related to each product. So ABC is suitable for this kind of organizations producing several kinds of products.

Production Technology: A study of the history shows a steady trend of substituting technology for human labor. Advanced production technologies are changing the basis of competition in the market place and companies need to reorganize themselves to compete with the changing situations. Production in the plant is suitable for the nowadays condition's and production is continued by the modern machinery. Plant has four block cutters which are home products and an Italian made tile line. As a result, it was thought that the production environment appropriate for the ABC system.

Cost Structure: As the production technology increases, cost structure of the production also changes. Share of labor diminishes as the production depends on the machinery and this cause indirect costs to become important. Traditional accounting systems became insufficient to provide necessary information in this case.

Distrust to the Present System: To sustain its economic life plant needs usable and reliable information. With the present system plant management is not satisfied and they are willing to find something better to plan their future.

3.3.2. Identification of Activities

The first step in the construction of ABC system is the identification of activities. In a broad sense activities actually represent the process beginning with production order and ending with the reaching to the customer.

In practice, one can identify a very large number of activities performed to produce outputs. This can be done with the detailed process description but it is rarely useful to calculate more accurate output or activity costs. If too many activities are defined, the cost of measurement for the ABC model grows disproportionately high. (Romano, 1988).Activity identification involves finding out what is done with the resources committed in the overhead area of an organization. This must be approached in a systematic way to ensure that all relevant activities are captured. System flowchart is the most widely used and preferable one to obtain information about activities. In that chart all the activities performed to produce an output are specified with a diagram. Figure 3.3 shows the production flowsheet of the plant.

To be able to get information about activities, mainly two types of departments were identified. These were the production department and supporting departments. Production department includes the activities related to production and activities were defined according to the production flowsheet. Supporting departments are not directly related to production but they are required for production to continue.

Activities related to production and support department can be seen in Table 3.1 and Table 3.2. These activities were selected from the production flowsheet in Figure 3.3. This flowsheet shows the production steps beginning from the stocking and all the necessary steps to produce outputs. Since activity is defined as the repetitive tasks performed to produce a unit product, all activities defined here accomplish the definition.

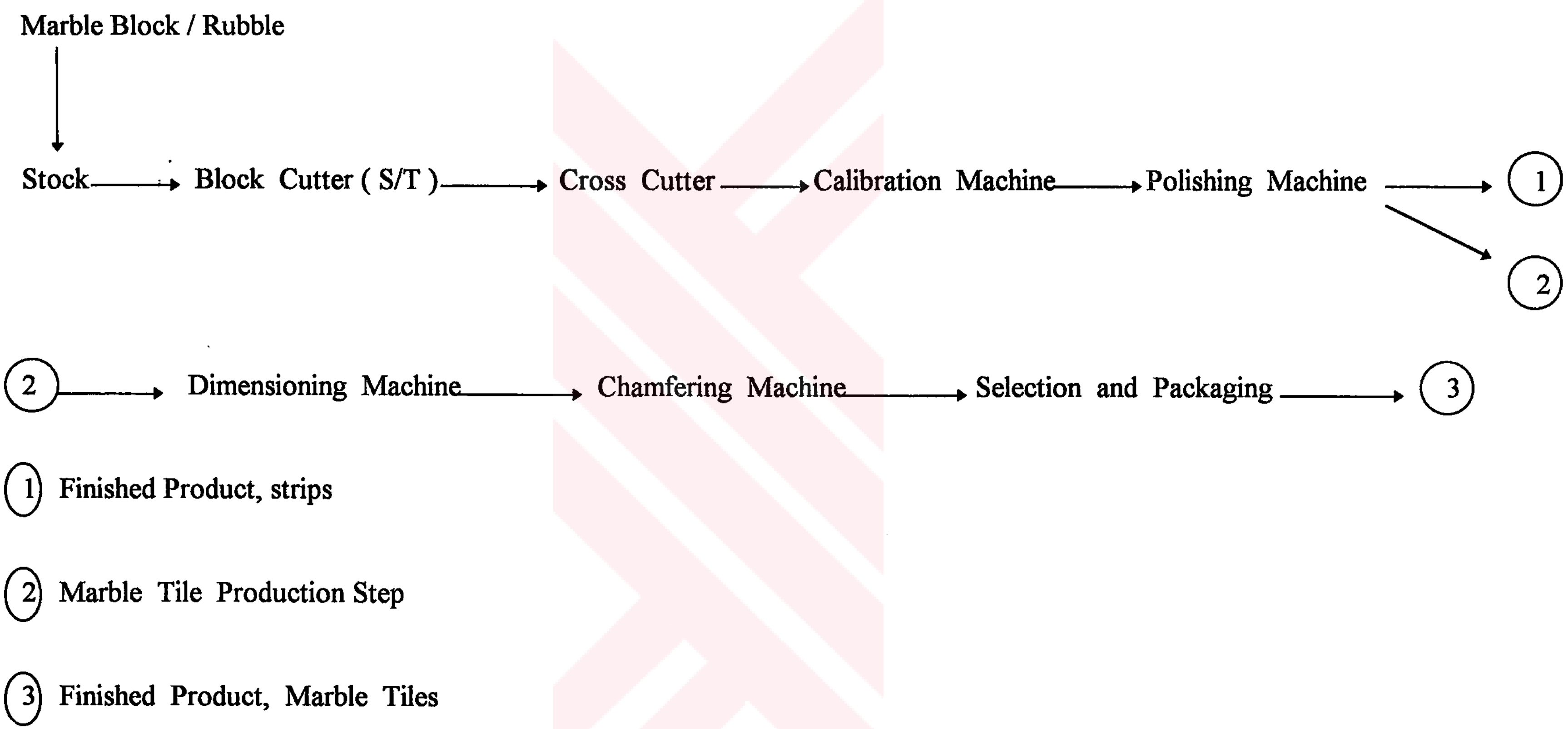

Figure 3.3 Production Flowsheet of the Plant

Table 3.1 Production Activities in the Plant

Activities	Level
Stocking	Batch
Preparation	Batch
Block Cutting	Unit
Transportation -1	Unit
Cross Cutting	Unit
Transportation - 2	Unit
Calibration	Unit
Polishing	Unit
Dimensioning	Unit
Chamfering	Unit
Waxing and Selection	Unit
Packaging	Batch

Table 3.2 Support Activities in the Plant

Activities	Level
Repair and Maintenance	Facility
Management	Facility
Marketing-Selling	Facility
Depreciation	Facility

Activities were also classified into a hierarchy. There are mainly four activity levels used in the organizations; unit level, batch level, product level and facility level activities.

Unit level activities are performed at each time a unit is produced. So block cutting, cross cutting, calibration, polishing, dimensioning and chamfering activities were accepted as unit level activities. Transportation-1 activity defines the taking of strips from block cutting machine to cross cutting machine and transportation-2 activity defines the taking of strips from cross cutting machine to calibration machine. Unit level activities vary proportionately with production. As more units are produced, more block cutting, calibration, polishing, etc. activities will be consumed.

Batch level activities are performed for each batch produced but are independent of the number of units in the batch. Stocking defines the unloading of blocks from trucks to the raw material site and this is done for each block coming to the stock area. Since it is independent of the number of units produced resources consumed by this activity depends on the number of blocks coming to the stock area.

Preparation activity is also a batch level activity. Taking of block from the raw material site, placement of it to the block cutter table and preparing it for cutting defines the preparation activity. This activity is also done for each block . Packaging was also accepted as a batch level activity. Units produced are separated according to the order and then packed. So it is done for every batch and independent from the number of units produced. Actually selection and waxing activities were combined due to measurement difficulties.

Facility level activities are necessary to provide a plant that can produce products, but the extent of these activities is unrelated to the volume of individual products. The activities are common or joint to many different products and their costs must be considered common costs to all products made in the facility. So repair-maintenance, management, depreciation and marketing-selling activities are generally treated as an expense of operating the facility for the period and not allocated to products. On the other hand, management may want to allocate all plant expenses to products. In this case, facility level expenses are allocated, in some arbitrary manner, to individual products.

Product level activities are performed to support different products in a company's product line. These activities are done more often or with greater intensity as the number of products in the plant increases. Examples of product level activities include performing engineering change notices, developing special testing routines etc. But in the selected plant no activities could be defined matching the product level activity.

3.3.3. Allocation of Resource Costs to Activities

After activities have been defined, second step is the allocation of resource costs to activities. So, in this way, cost of activities can be found. According to the ABC, activities consume resources and here resource means all the expenses related to the plant.

Organizational resources include direct labor, materials and supplies, utilities, equipment, etc. The company's general ledger is the starting point for information about the cost of resources deployed to perform activities. Unfortunately, most general ledger systems report the cost of the different types of resources such as labor, electricity, equipment and supplies, but do not report the cost of activities performed. So, to find the cost of activities financial information in the general ledger is assigned to activities. This assignment determines the cost of resources used by each activity.

Cost of resources can be assigned to activities in three ways; direct charging, estimation and arbitrary allocation. In direct charging, the actual usage of resources by activities is measured. For example, energy used to operate a machine, if metered, can be charged to that machine's operation.

Direct charging accurately captures the cost of resources used by activities but is expensive because it requires measurement of the actual usage. In estimation cost of resources used by each activity can be found through surveys and interviews. Interviews can be relatively fast and inexpensive. For example, in this study electricity cost is estimated since it is not possible to measure the electricity consumption of each machine. When no meaningful way exists to estimate the resources used by an activity, arbitrary allocations are used. For example, the cost of plant management support might be allocated to activities using headcount, even though plant management support is unlikely to be proportional to the number of persons performing a given activity. In this study water cost is allocated arbitrarily since the plant has not a meter for water. Fuel cost in packaging activity is also arbitrarily allocated.

As mentioned, resource allocation begins with the financial information in the general ledger. Plant's general ledger was examined and rearranged to provide necessary information. According to inspection, factory expenses are grouped under four main accounts; direct material, factory overhead, management and marketing-selling. In addition to these accounts, in the Section 3.3.2 depreciation, repair and maintenance accounts were added. Actually, in the original records, repair and maintenance was under the factory overhead account but since the difficulty in assignment of this resource to activities it was separated from the factory overhead account. In Table 3.3 arranged accounts and main resource items can be seen.

After these accounts have been specified for this study, it was determined that which activity consumes which resource. Also the type of allocation method was determined. Direct material and direct labor can be directly assigned to the products. For every order, amount of block used and the labor hour can be measured by the help of observation forms. The Table 3.4 indicates which resources are used by which activities.

Table 3.3 Main Accounts and Sub-items

Direct Material Block / Rubble	
Direct Labor	
Factory Overhead Electricity Abrasive Polishing Brick Wax Strofor Tile Package Nylon Diamond Wheel Cutter Disk Mat Propane Gas for Dryer Wood Box Transportation	Repair -maintenance Labor Spare parts Depreciation Production related Building related
Management Telephone Cleaning Stationery Fuel Taxes Personnel Consulting	Marketing-Selling Cargo Fuel Custom Commission Accommodation Personnel Transportation

Table 3.4 Resource Consumption by Activities

Activity	Resource Used	Assignment Type
Stocking	Electricity	Estimation
	Labor	Direct
Preparation	Electricity	Estimation
	Labor	Direct
Block Cutting + Transportation-1+ Cross Cutting	Electricity	Estimation
	Diamond Wheel Cutter	Direct
	Labor	Direct
	Water	Arbitrary Allocation
Calibration + Transportation-2	Electricity	Estimation
	Labor	Direct
	Diamond Disk	Direct
	Abrasive	Direct
	Water	Arbitrary Allocation
	Propane Gas	Direct
Polishing	Electricity	Estimation
	Labor	Direct
	Abrasive	Direct
	Water	Arbitrary Allocation
	Mat	Direct
Dimensioning + Chamfering	Electricity	Estimation
	Labor	Direct
	Diamond Disk Cutter	Direct
	Abrasive	Direct

Table 3.4 (Continued)

Activity	Resource Used	Assignment Type
Packaging	Labor	Direct
	Nylon	Direct
	Wood Box	Direct
	Tile Package	Direct
	Fuel	Arbitrary Allocation
Waxing + Selection	Labor	Direct
	Wax	Direct
Management	Telephone	Direct
	Cleaning	Direct
	Stationery	Direct
	Fuel	Direct
	Taxes	Direct
	Personnel	Direct
	Consulting	Direct
Marketing-Selling	Cargo	Direct
	Fuel	Direct
	Custom	Direct
	Commission	Direct
	Accommodation	Direct
	Personnel	Direct
	Transportation	Arbitrary Allocation
Repair-Maintenance	Labor	Estimation
	Spare parts	Direct
Depreciation	Production related	Direct
	Building related	Estimation

As given in Table 3.4 cost of electricity was estimated since the plant has only one meter for the electricity. Consumption of electricity for every machine or activity should be calculated. For example, for block cutter the electricity consumption is calculated from the ampere-meter scale of vertical wheel power motor and horizontal wheel power motor. As they are operating during the time collected from the operating hour meter, it is easy to obtain the electricity to saw each block.

Consumption of electricity for other machines such as; calibration, polishing, dimensioning is also calculated in the same way. Ampere-meter values of each machine for each order are read and by a simple calculation electricity consumption for each machine can be found. After finding kWh of each machine, cost of electricity for each activity can be easily found by multiplying the unit cost of electricity with the kWh. To find the kWh of each machine;

Watt = Ampere x Volt (380 V in the factory)

kW of machine x operating hour per block/order = KWh per block/order

Water cost is allocated arbitrarily, since there is not a meter for water in the plant. Cost of water is calculated according to electricity consumption, that is, cost of electricity to run water pump is accepted as the cost of water because of the difficulty in finding water consumption. For calibration and polishing activities clean water is required and for the block cutting recycled water is used.

Labor and personnel costs include the cost of transportation and meal of staff. These costs can not be directly assigned to activities since it is impossible to build a one to one relation between products and these costs. So, for easiness, costs of labor, meal and transportation were combined. After combining these costs, cost of labor is directly assigned to activities by considering the working hour of labor.

Allocation of other resources such as; abrassives, diamond disk cutters and etc. is done mainly depending on the financial information in the general ledger. Since most of the resources are specific to a certain activity, there was not any difficulty in assigning these resource costs to activities. For example, diamond wheel cutters are only used in block cutting activity, abrassives are used for polishing activity , etc.

3.3.4. Selection of Cost Drivers and Allocation of Activity Costs to Products

Cost driver actually was explained in the Section 2.3.2 so here, a brief repetition of it will be enough to explain the subject.

Cost driver is a kind of measure of activity. That is, it is any factor (or factors) that causes the incurrence of costs in the designated activity. Causal relationship between the activity's total costs and the product that passes through the activity is provided by cost drivers.

In ABC design, several different types of cost drivers are used. Transaction drivers capture the number of times an activity is performed. Transaction drivers can be used when all outputs make the same demands on the activity. Duration drivers capture the length of time an activity is performed on an output. Duration drivers should be used when significant variation exists in the amount of activity required for different outputs. Duration drivers more accurately assign activity costs to products than transaction drivers, but they are more costly to measure.

Cost drivers are also closely related to level of activities. This means they can be unit level, batch level, product level or facility level. For activities in the plant, suitable cost drivers were tried to be chosen and during that time it was benefited from the management and production staff also. During the selection of cost drivers for each activity, the need for keeping extra data for some information was appeared but the management wanted to use present information due to difficulty in keeping these data. So some of the activities were combined and assigned to outputs by a single cost driver and it was tried to gather data about production as much as possible.

Table 3.5 shows the selected cost drivers for activities;

Table 3.5 Cost Drivers

Activity	**Cost Driver**
Stocking	Stocking Time
Preparation	Preparation Hour
BC + T-1 + CC	Machine Hour
T-2 + Calibration	Machine Hour
Polishing	Machine Hour
Dimensioning + Chamfering	Machine Hour
Waxing + Selection	Labor Hour
Packaging	Packaging Time
Repair - Maintenance	Labor Hour
Management	Labor Hour
Marketing-Selling	Labor Hour
Depreciation	Machine Hour

In stocking activity the important thing is the time passing during the unloading of blocks from trucks to raw material site. Stocking activity consumes mainly two resources; labor and electricity. At the same time, consumption of these resources depends on the time spending on this activity. So stocking time was selected as a cost driver for that activity.

Preparation activity actually consists of two parts. One is the taking of block from raw material site to block cutter table and second is the preparation of block for cutting. Time that is spent on both activities was examined and for the first part, it was seen that for each block loading time the block cutter table was the same. However, preparation time was changing according to the shape of blocks, that is, for some blocks especially for rubbles preparation time was longer than regular blocks. In this case more resources such as electricity and labor were being consumed. For this reason preparation time was chosen as a cost driver for the preparation activity.

Block cutting, cross cutting and transportation-1 activities were combined due to difficulty in keeping data about cross cutting and transportation-1 activities. Block cutting and cross cutting machines are used by the same worker. These two cutting activities mainly consume the electricity and diamond wheel cutter as an indirect resource. These activities are done for every unit produced so cost driver also should be a unit level driver. It was thought that selection of machine hour as a cost driver can explain the relationship between activity and resource consumption best.

After cross cutting step, products are transported to calibration machine. Since it was difficult to follow transportation-2 activity, (from CC to Calibration) that activity was combined with calibration. Calibration activity is also done for every unit and like calibration and block cutting activities, polishing, dimensioning and chamfering activities are also unit level activities and they can be best explained by unit level drivers. Main consumption items in these activities are electricity, abrasive, diamond disk, water and labor. It is difficult to build a direct relation between abrasive, diamond disk consumption and products. For example consumption of abrasives change depending on the belt speed, head pressure, kind of marble, cutting process etc. So machine hour was selected as a cost driver for these activities. Cost of these activities, block cutting, calibration, polishing, etc. varies with the number of hours the machine is running (e.g. Power - the longer the machine is running the more power that is consumed by that product). In this way more proper relation can be built between products and resource items.

Waxing and selection activities mainly depend on the labor. Actually waxing activity is not done for every unit and for every kind of marble. Only if it is required this activity is done but selection is done for every unit. These two activities were combined because of the difficulty of keeping data separately and labor hour was selected as the cost driver.

Facility level activities are joint activities so they can be either assigned to products according to some bases or they are accepted as operating expenses. In that study management, marketing-selling and repair-maintenance costs will be assigned by using labor hour as a cost driver. Besides, depreciation is divided into two parts; production related and building related. The costs associated with machinery and equipment are assigned to the activities and then by machine hours to the products. Depreciation cost related to building are assigned to activities according to square meter and then again by machine hours to the products.

After selection of cost drivers, next step is the assigning of costs allocated in activities to products. Cost of activities are assigned to each product by the help of cost drivers. The detailed application will be explained in Section 3.4.

3.4. Application of ABC to the Plant

ABC model which was developed for the plant was explained in Section 3.3. In this section, it will be explained how to apply this model to the plant.

ABC is actually a kind of information system. ABC differs from traditional systems because it provides the necessary information accurately by collecting and arranging data in a desired way. It needs a detailed data collection to work properly but this does not mean that all the time it works. Data collection brings extra expense and load to the organization so data keeping activity should be done with the minimum expense and maximum benefit.

First, the data keeping of the plant was examined and searched for sufficiency for the ABC system. Actually, data collection in the plant is limited to certain activities. Especially for block cutting regular data collection is done and for this purpose an observation form in Table A.1 is used.

This form is filled by foremen at the end of each shift and the total amount for each block cutter is recorded to a form which is shown in Table A.3 in Appendix A. With these forms only production amount for each shift and for each block cutter (S/T) can be seen and can be arranged daily, weekly or monthly. In this form "Type" defines the product obtained from block cutters and "Q" indicates the meter square of this product.

Of course, only keeping data related to block cutting activity is not enough. These observation forms just provide the information about cutting activity, but information about the polishing, dimensioning or other activities is also required. In the plant, there is no data collection about other activities except cutting.

Raw material stock is followed by the form shown in Table A.2, but as it was explained in former sections it was not followed properly. Blocks or rubbles coming to the plant are recorded to this form but when it goes to the production it is not debited from the stock. This form is also kept by the foremen and there is no connection with the accounting service.

As mentioned there is no connection between the production and accounting service. Stock card is only kept for blocks and rubbles. In accounting service there is no data keeping about stocks such as; block, abrasive or packaging material. Stock levels are followed from the invoices when needed. For this study also, invoices were taken into consideration since the management wanted to use the present information.

To be able to apply ABC to the plant; first data collection about activities should be extended since ABC mainly depends on the detailed data gathering. Also present observation forms should have been rearranged. For this purpose new observation forms have been prepared to obtain information about activities. For block cutting activity, there was an observation form but it was not providing the necessary information for ABC. It was just giving the information about the product produced. On the other hand, information about the electricity consumption, working hour or preparation time could not get from that form. To be able to construct an ABC model, needed information was inspected and new observation forms were prepared for cutting and other activities.

Table A.4 in Appendix A shows the prepared form for block cutting activity. Different from the ex-form preparation time, pause time and ampere values of vertical and horizontal wheels were added to this form to avoid extra load and time. Stopping time and ampere values were added to obtain information about the working time and electricity consumption respectively. Observation forms were used to be filled by the foremen at the end of each shift but it was decided to have them filled by workers during the operation. In addition, before and during the cutting process, simple notes were taken indicating the crack situation, breakdowns or stopping reasons.

In order to find the diamond segments consumption, an observation form can be prepared showing the operating hour per each block for each diamond wheel cutter. But by the help of the data obtained from this observation form, it is not quite probable to calculate the exact diamond consumption for each block. As the factories are commercial places, most of the cases it is not possible to use one diamond wheel for only one type of marble. An other conventional method, measuring the thickness of the segment heights also has no practical use. The height difference before and after cutting a block of a diamond segment is generally impossible to measure.

The situation for the diamond disk cutters used in cross cutting is also the same. To find the consumption of diamond segments for each block is impractical and again data were collected from the manufacturer or from the cutting tests. Although diamond segment consumption was tried to be found by an experimental study which was performed by Akbilgic in 1997, it could not give definite results.

There is a single line in the plant which calibration, polishing, dimensioning and chamfering activities are done by this line. Both free or dimensioned strips and tiles are processed in this line. And both products are completed at the end of the line. So a single observation form was prepared for these activities which enables multi-task using. For example, it can be used both for strips and tile products. (Table A.5) Observation form includes the information about marble type, dimension of product and classification part. In classification part, products are grouped under three names; export, wax and faulty. Export products are products that can be accepted as first quality products . Some marble types require waxing and these are recorded into this column and finally faulty products that can not be sold abroad are recorded to this column. From the form labor hour worked can also be obtained.

To find the abrasive consumption for different types of marbles observation form can be prepared. To be able to assign abrasive cost to the each order, cost of abrasive consumption for each order should be known.

This might be followed by recording the operating hour for each order for each polishing head. However, in practice it is very difficult and impractical to apply this. Since the plant is a commercial place, every order can not be produced continuously. In this case it becomes complex to separate abrasive consumption for each order.

Electricity consumption of polishing line is followed by the observation form in Table A.6 As mentioned in former sections, plant has a one meter for electricity consumption. So electricity consumption of each machine is calculated with a simple formula by observing the ampere values of machines. For block cutting ampere values of cutting wheels are recorded to observation form as seen in Table A.4 but for calibration, polishing and dimensioning a separate form was prepared to record ampere values of each head. (Section 3.1.2) After collecting ampere values for each head and for different type of marbles by a simple calculation, electricity consumption can be found. Table A.6 shows the form prepared for this purpose.

In Table A.6, first part of the form shows the calibration (D_1, D_2, D_3, L_1, L_2).D_1, D_2, D_3 are diamond disks for calibration and L_1, L_2 are abrasives. Second part shows the polishing consisting of ten heads (L_1, L_2,…,L_{10}) and the last part shows the dimensioning consisting of six cutters.(L_1, L_2,…,L_6) Consumptions for chamfering such as electricity consumption, abrasives for different type of marbles were accepted as negligible. (Akbilgic, 1997) For waxing+selection and packaging activities separate observation forms were not prepared due to difficulty and impracticality of keeping data about these activities. Data related to these activities are obtained from the Table A.5 accepting that these activities consume two times more labor hour than the labor hour consumed in the line since two workers are assigned for each of these activities.

Above tables are related to production and also, for the accounting service some arrangements were done. Sub items of accounts were rearranged to make it suitable for ABC and to get right information. (Table 3.3)

3.4.1. Steps to Find the Cost of Product

Below, the necessary steps to find the cost of product will be explained;

As mentioned before, production is carried on according to orders so important thing is to find the total cost of each order. In this way unit cost of product can be found and in further productions or orders, pricing can be done more effectively.

Production begins with the stocking activity so first, coming blocks to the stock site are recorded to stock card in Table A.2 . After stocking, the next step is the preparation and block cutting activities. For both product type, tile and strip, these two activities are done then according to order necessary steps are followed as shown in Figure 3.3. While performing these steps required data are kept by forms prepared in Table A.4, Table A.5, and Table A.6 for each order. In this way it can be seen the consumption of activities as defined in Table 3.1 for each order. By arranging these data kept in prepared forms consumption of activities by each order can be seen. (Table A.7) Consumption of activities in Table A.7 are stated as total hours such as total machine hour or total labor hour.

Stocking time is found approximately 30 to 45 minutes for each block from simple observations. In the preparation activity also loading time of blocks from raw material site to block cutter table was found approximately same for each block so preparation time was taken as a determining factor. Because according to the shape of block preparation time was changing. There are not separate forms for each activity due to difficulty in following these forms. Instead of this required data is acquired from the existing forms.

Besides, stocking time and loading time is combined for practicality. For example, data related to calibration, polishing, dimensioning, chamfering and waxing selection is obtained from the form in Table A.5.

After finding the consumption of each activity for each order, the next step is to find resource consumption of activities. Since each activity is consuming plant resources, these resources should be shared between activities. In Table 3.4 resource consumption of each activity was indicated. Total cost of these resources is obtained from the accounting service and then allocated to each order.

Table A.8 shows the total factory overhead costs according to activities. Such as, diamond wheel cutter used in block cutting activity, diamond disk used in calibration, abrasives used in polishing and chamfering, package materials used in packaging and etc. As explained in Section 3.3.3, electricity consumption is calculated according to ampere values of machines. Ampere values of machines are followed by the forms in Table A.4 and Table A.6. By the formula explained in Section 3.3.3 electricity consumption of each order can be found. Labor hours are also obtained from forms and by multiplying the unit cost of labor by the labor hour, labor cost can be obtained. Labor cost also includes the cost of meal, transportation of workers and all taxes related to workers.

After finding cost of activities, the final step is the allocation of activity costs to orders or products. For this purpose, first the cost driver application rate is found. A cost driver is the variable used as denominator in the rates used to apply activity costs to products;

Activity Cost for Period / Cost Driver Volume for Period = Cost Driver Rate

For this study, for two months period, consumption of activities for each order is found and then orders are summed to find total cost driver volume (Table A.7).

After finding the total cost driver volume, Table A.8 resource cost of activities are found and using the above formula cost driver application rates are found. (Table A.9)

If it is applied to polishing activity;

Resource cost for Polishing Activity / Cost Driver Volume for Polishing = Polishing Cost Drive Rate

by applying this formula to all activities, cost driver rate of all activities can be found. After then, by using that rate activity costs are allocated to orders.

Cost Driver Rate x Volume of Cost Driver for Order = Allocated Cost of Order

Table 3.6 shows the activity consumption (or cost driver volume) of different marble types of different dimensions such as tiles of 1.2x.30.6x30.6 cm or strips 2x30xFree Length (FL)cm during two months period. Besides, Table 3.7 shows the total activity costs during that period. By using these tables, cost driver rate which was explained above is found and Table 3.8 shows these rates. As explained before repair-maintenance, marketing-selling and management activities are facility level activities and they will be allocated to products by using labor hour as a cost driver. However, depreciation was not allocated to products in this study since the plant has an investment incentive certificate which has taken from Undersecretariat of Treasury. Depreciation is not applied for certain periods due to plant is exempt from the VAT.

Below table shows the total cost of these activities;

Table 3.9 Cost of Facility Level Activities

Activities	Total Cost
Repair-maintenance	550,000,000 TL
Management	1,650,000,000 TL
Marketing-selling	1,125,000,000 TL

Cost of these activities will also be allocated to products or orders by using cost drivers. To find allocation rate total cost of each activity is divided by the total labor hour worked during two months period. (Table 3.10) By using these rates calculated for each activity, according to the labor hour for each order or product allocation is done.

Table 3.6 Consumption of Activities (hr)

Activity	USAK GREEN		BURDUR BEIGE			B. BEIGE EFE	BURSA BEIGE		OTHERS	TOTAL (hr)
	1.2x30.6x30.6	2x30x60	3x42xFL	3x30xFL	1.4x45.8x45.8	1.4x45.8x45.8	1.2x30.6 x30.6	1.4x45.8x45.8		
Stocking	3	5	6	4	4	5	3	5	5	40
Preparation	18	32	22	13	6	11	7	17	10	136
BC+CC+T1	133	574	574	259	70	280	70	329	329	2618
T2+Calibration	54	82	92	71	30	45	17	50	-	441
Polishing	54	82	92	71	30	45	17	50	-	441
Dimensioning+ Chamfering	54	-	-	-	30	45	17	50	-	196
Waxing+ Selection	108	164	184	142	60	90	34	100	-	882
Packaging	108	164	184	142	60	90	34	100	-	882
Total Hour of Order	532	1,103	1,984	702	290	611	199	701	344	

Table 3.7 Resource Cost of Activities (,000 TL)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	125,000									
Preparation	500,000									
BC+CC+T1	2,000,000	1,872,000				300,000				
T2+Calibration	291,576		100,000							43,750
Polishing	388,876			1,653,000						
Dimensioning + Chamfering	183,400						154,250			
Waxing + Selection	-								45,000	
Packaging	-							1,155,000		

Table 3.8 Cost Driver Rates (TL / Hr)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	3,125,000									
Preparation	3,676,470									
BC+CC+T1	763,941	715,049				114,600				
T2+Calibration	661,170		226,757							
Polishing Dimensioning +	881,804			2,841,270						100,000
Chamfering	935,714						786,900			
Waxing + Selection	-								34,013	
Packaging	-							1,309,500		

Table 3.10 Facility Level Activities Allocation Rate

Activity	Cost of Activity (TL)	Labor Hour (Hr)	Allocation Rate (TL/Hr)
Repair-Maintenance	550,000,000	5,636	97,586
Management	1,650,000,000	5,636	292,760
Marketing-Selling	1,125,000,000	5,636	199,609

3.4.2. Numerical Application

For application to a product, Burdur Beige Efe, Bursa Beige and Usak Green were selected. Burdur Beige Efe is a tile product which has dimension of 1.4x45.8x45.8 cm. Bursa Beige is also a tile product which has dimension of 1.2x30.6x30.6 cm and Usak Green is a both strip and tile product which has dimension of 2x30x60 cm and 1.2x30.6x30.6 cm respectively. Table 3.11 shows the information about the production amount of these products and production efficiency (Prd. Effc.). In Appendix-B and Appendix-C some of the data kept for these products can be seen in detail.

Table 3.11 Production Amount of Selected Products

	Production Amount (m^2)			
	Usak Green (1.2x30.6x30.6cm)	Usak Green (2x30x60cm)	Burdur Beige Efe (1.4x45.8x45.8cm)	Bursa Beige (1.2x30.6x30.6cm)
From BC	228	424	590	250
Export	184	350	320	155
Wax	-	-	174	40
Faulty	42	74	93	45
Σ Export	184	350	494	195
Prd. Effc.	80 %	82 %	84 %	78 %

For numerical application, as mentioned two types of product were selected. While selecting these products two criteria have been considered. First, the product type was determined and two types of product were selected. One is tile and the other is strip product. Second, it was determined the production type of products whether they produced from blocks or rubbles. So Usak Green which strips and tiles were produced from rubbles and Burdur Beige Efe and Bursa Beige which tiles were produced from blocks were selected.

Total cost of the order is found by summing all the costs, both direct and indirect costs. Direct costs are labor and block costs. Block or rubble cost is obtained from accounting records. Calculation of the total cost of order is shown below;

Calculation for Usak Green Strip Product

Labor cost is found by multiplying the unit cost of labor with the labor hour worked for order. From the calculations unit cost of labor was found 245,000 TL/hr. This cost includes the taxes, meal and transportation of workers. Total labor hour worked is found 1,103 hrs from the Table 3.6 and labor cost for this order is ;

245,000 TL/hr x 1,103 hrs = 270,235,000 TL

Block or rubble cost include cost of all blocks or rubbles used in the production. Usak Green order was completed by using rubbles and cost of these rubbles are obtained from accounting records;

Rubble cost = 300,000,000 TL (total cost of rubble used in production)

Facility level activity costs are allocated to order according to allocation rates in Table 3.10. By multiplying the allocation rate of facility level activities by the total labor hour worked for order obtained from Table 3.6 allocated cost can be found.

Cost from Repair-Maintenance;

97,586 TL/hr x 1,103 hrs = 107,637,358 TL

Cost from Management;

292,760 TL/hr x 1,103 hrs = 322,914,280 TL

Cost from Marketing-Selling;

199,609 TL/hr x 1,103 hrs = 220,168,727 TL

As mentioned total cost of order is found by summing the direct and indirect costs. Indirect costs or factory overhead costs are obtained from Table 3.12 for Usak Green order. Summing all the costs in this table total factory overhead cost can be found. On the other hand, indirect costs in this table are found by multiplying the cost driver rates in Table 3.8 with the cost driver volumes in Table 3.6.

In the final stage all costs are summed to reach the total cost of the order;

Total indirect cost of order	1,600,000,000 TL
Labor cost	270,235,000 TL
Rubble cost	300,000,000 TL
Cost from Repair-Maintenance	107,637,358 TL
Cost from Management	322,914,280 TL
Cost from Marketing-Selling	220,168,727 TL
TOTAL COST OF ORDER	**2,820,955,365 TL**

After finding the total cost of order unit cost of product can be found by dividing the total cost to total meter square of order obtained from Table 3.6.

Unit Cost of product ; 2,820,955,365 TL / 350 m^2 = **8,059,872 TL/m^2**

Table 3.12 Cost of Activities for Usak Green Strip Product (,000 TL)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas (*)	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	15,625									
Preparation	117,647									
BC+CC+T1	438,502	410,431				65,780				
T2+Calibration	54,215		18,600							8,200
Polishing	72,307			232,985						
Dimensioning + Chamfering										
Waxing + Selection	-								6,256	
Packaging	-							152,470		

* Not used for this order

Table 3.13 Cost of Activities for Burdur Beige Efe Tile Product (,000 TL)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas (*)	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	15,625									
Preparation	40,441									
BC+CC+T1	213,903	200,213				32,088				
T2+Calibration	29,752		10,204							4,500
Polishing	39,681			127,857						
Dimensioning + Chamfering	42,107									
Waxing + Selection	-								3,061	
Packaging	-							83,673		

* Not used for this order

Calculation for Burdur Beige Efe Tile Product

For Burdur Beige Efe the same procedure is applied by using data in Table 3.13 and calculation is shown below;

Labor cost for Burdur Beige Efe order is ;

245,000 TL/hr x 611 hrs = 149,695,000 TL

Block cost include cost of all blocks used in the production. From the stock card in Table A.2 and from the Table A.4 block amount used in the production can be found;

Block Cost = 40,000,000 TL/m^3 x 16 m^3 = 640,000,000 TL

Facility level activity costs are allocated to order according to allocation rates in Table 3.10.

Cost from Repair-Maintenance;

97,586 TL/hr x 611 hrs = 64,504,346 TL

Cost from Management;

292,760 TL/hr x 611 hrs = 178,876,360 TL

Cost from Marketing-Selling;

199,609 TL/hr x 611 hrs = 121,631,159 TL

Total cost of order is calculated below;

Total indirect cost of order	843,105,000 TL
Labor cost	149,695,000 TL
Block cost	640,000,000 TL
Cost from Repair-Maintenance	64,504,346 TL
Cost from Management	178,876,360 TL
Cost from Marketing-Selling	121,631,159 TL
TOTAL COST OF ORDER	**1,997,811,865 TL**

Unit Cost of product ; 1,997,811,865 TL / 494 m^2 = **4,044,153 TL/m^2**

Table 3.14 Cost of Activities for Usak Green Tile Product (,000 TL)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas (*)	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	9,375									
Preparation	66,177									
BC+CC+T1	101,605	95,102				15,243				
T2+Calibration	35,705		12,245							5,400
Polishing	47,618			153,431						
Dimensioning + Chamfering	50,529									
Waxing + Selection	-								3,685	
Packaging	-							141,426		

* Not used for this order

Table 3.15 Cost of Activities for Bursa Beige Tile Product (,000 TL)

Activity	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas (*)	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	9,375									
Preparation	25,735									
BC+CC+T1	53,475	50,053				8,022				
T2+Calibration	12,240		3,584							1,700
Polishing	15,000			48,301						
Dimensioning + Chamfering	16,000									
Waxing + Selection	-								1,157	
Packaging	-							44,523		

* Not used for this order

Calculation for Usak Green Tile Product

For Usak Green the same procedure is applied by using data in Table 3.14 and calculation is shown below;

Labor cost for Usak Green order is ;

245,000 TL/hr x 532 hrs = 130,340,000 TL

Block or rubble cost include the cost of all blocks or rubbles used in the production. Usak Green order was completed by using rubbles and cost of these rubbles are obtained from accounting records;

Rubble Cost = 180,000,000 TL(total cost of rubble used in production)

Facility level activity costs are allocated to order according to allocation rates in Table-3.10.

Cost from Repair-Maintenance;

97,586 TL/hr x 532 hrs = 51,915,752 TL

Cost from Management;

292,760 TL/hr x 532 hrs = 155,748,320 TL

Cost from Marketing-Selling;

199,609 TL/hr x 532 hrs = 106,191,988 TL

Total cost of order is calculated below;

Total indirect cost of order	737,530,000 TL
Labor cost	130,340,000 TL
Rubble cost	180,000,000 TL
Cost from Repair-Maintenance	51,915,752 TL
Cost from Management	155,748,320 TL
Cost from Marketing-Selling	106,191,988 TL
TOTAL COST OF ORDER	**1,361,726,000 TL**

Unit Cost of product ; 1,361,726,000 TL / 184 m^2 = **7,400,685 TL/m^2**

Calculation For Bursa Beige Tile Product

For Bursa Beige the same procedure is applied by using data in Table 3.15 and calculation is shown below;

Labor cost for Bursa Beige order is ;

245,000 TL/hr x 199 hrs = 48,755,000 TL

Block cost include cost of all blocks used in the production. From the stock card in Table A.2 and from the Table A.6 block amount used in the production can be found;

Block Cost = 40,000,000 TL/m^3 x 8 m^3 = 320,000,000 TL

Facility level activity costs are allocated to order according to allocation rates in Table 3.10.

Cost from Repair-Maintenance;

97,586 TL/hr x 199 hrs = 19,419,614 TL

Cost from Management;

292,760 TL/hr x 199 hrs = 58,259,240 TL

Cost from Marketing-Selling;

199,609 TL/hr x 199 hrs = 39,722,191 TL

Total cost of order is calculated below;

Total indirect cost of order	302,835,000 TL
Labor cost	48,755,000 TL
Block cost	320,000,000 TL
Cost from Repair-Maintenance	19,419,614 TL
Cost from Management	58,259,240 TL
Cost from Marketing-Selling	39,722,191 TL
TOTAL COST OF ORDER	**788,991,045 TL**

Unit Cost of product ; 788,991,045 TL / 205 m^2 = **3,848,737 TL/m^2**

3.5 Discussion of the ABC for the Plant

The main aim of this study was to develop a model that could be used to estimate the production cost of marble products by the help of ABC. Actually, ABC can be defined as a new cost accounting system developed to give more reliable product cost information and provide more accurate information to the manager for decision making.

To be able to compare ABC with the traditional cost accounting system, there should also be the results of the traditional accounting system. However, it should not be forgotten that the present accounting system of the plant is not an ideal one, that is, it is not the best system. In the plant as explained before unit cost of product is found by dividing total expenses to total metersquare produced. So in this situation, it is difficult to compare the result of the ABC system since there are not exact figures about the production cost.

Before constructing the model for the plant, suitability of the ABC for the plant was investigated in terms of, product type, production technology, cost structure and trust to the present system. According to these factors it was seen that ABC was suitable for the plant.

First data collection and keeping of the plant was examined since ABC mainly depends on the extensive data gathering. From the examination of the present system, it was seen that existing data collection was not enough to run the ABC system accurately. For example, data only related to block cutting was being kept and this was also limited to only meter square of products produced. So more detailed data collection system was tried to be formed. For this purpose, for block cutting, and for tile line detailed observation forms including preparation time, stopping time, ampere values etc. were prepared. With the new observation forms prepared for this study, more detailed information could be obtained about production.

In the second step of the model construction, activities were identified. For this purpose, production flowsheet of the plant was prepared. In fact, activity identification step is one of the flexible step of ABC system. One can define many activities considering all the factors. On the other hand, this does not increase the accuracy of the ABC system. On the contrary, it may cause confusion and it increases the cost of measurement for the ABC model. After activities were identified according to flowsheet, they were also classified into a hierarchy which were defined mainly unit level, batch level, and facility level. In Ertas Marble Co. twelve production and four support activities were defined but during the application of the ABC numerically, some activities were combined due to the difficulty of measurement.

After activities have been defined, the next step was the allocation of resource costs to activities. Since the resource allocation begins with the financial information in the general ledger, plant's general ledger was examined and rearranged to provide necessary information for the ABC model. Then it was determined that which activity consumes which resources.

ABC charges all of the indirect costs to activities and then allocates the activities' costs to products. While assigning these costs to products ABC uses cost drivers which are volume related or not. According to activities, suitable cost drivers were selected. While this selection step, it was paid attention to level of activities also. During the selection of batch level activities stocking, preparation and packaging , some confusions were aroused but finally suitable cost drivers were selected for these batch level activities.

Main aim of this study was to develop a model that can be used in estimation of the production cost. In this study, this aim was achieved by the ABC system. After constructing the model, it was tested on several products. Factory mainly produces strips and tiles. So, for application, tile product and strip products were selected. It was also paid attention to raw material type whether it is rubble or block. In this way, differences in production cost of rubble and block could be seen.

As a strip product, Usak Green was selected which has a dimension of 2x30x60 cm and produced from rubbles. When the ABC was applied, it was seen that the production cost of Usak Green was 8,000,000 Tl/m^2 and the price offered for this product was about 7,000,000 Tl/m^2. Plant management was thinking to gain more profit from cutting rubbles since the rubbles are cheaper than regular blocks. For this order rubble cost was 300,000,000 TL. ABC showed that total factory overhead cost of Usak Green was quite high. Since rubbles are not regular blocks, they were consuming more preparation activity and depending on this more electricity and more labor. For example, total overhead cost was found about 1,600,000,000 TL and labor cost of 270,000,000 TL. Besides, efficiency of production was decreasing, that is, lesser product was being produced due to the shape of the rubble. This proved the correctness of results obtained from the ABC system since ABC accepts that products gain cost depending on the activities they consume. So information obtained from Usak Green product showed this situation.

In addition, as a tile product Usak Green which was produced from rubbles and Bursa Beige which was produced from blocks were selected. They had dimension of 1x30.5x30.5 cm. According to ABC, production costs of these products were found as 7,400,000 TL/m^2 and 3,900,000 Tl/m^2 respectively for Usak Green and Bursa Beige. By the way, price offered for Usak Green was about 6,500,000 Tl/m^2 and price offered for Bursa Beige was about 5,500,000 Tl/m^2. As the Usak Green is consuming more activity than Bursa Beige, it gains more costs. There is clear a difference between the costs of these two products. Usak Green consumed more activities than Bursa Beige since it was produced from rubbles. Because rubbles were consuming more activity than regular blocks and depending on this they were gaining more factory overhead costs. For example, for Usak Green tile product overhead cost was about 740,000,000 TL and for Bursa Beige it was about 300,000,000 TL. Besides, total cost of order for Bursa Beige was about 790,000,000 TL and for Usak Green, it was about two times of Bursa beige which was 1,400,000,000 TL. As it was seen rubble product gains more costs although rubble cost is half of the block cost.

Other product Burdur Beige Efe is also a tile product which has a dimension of 1.4x45.8x45.8 cm and produced from blocks. The cost of this product was found about 4,000,000 Tl/m^2 and the price offered was about 6,000,000 Tl/m^2 which was quite satisfactory. For this order total overhead cost was about 843,000,000 TL and total cost of order was about 2,000,000,000 TL.

Of course, it can not be said that these are the exact figures. To be able to get the exact figures, detailed data collection and inspection of the present system are required. However, this study covers two months of period and all calculations were done by considering two months of period. As mentioned before, ABC requires extensive data collection and this was tried to achieve as possible as. On the other hand, the disadvantages of these forms were the requirements for extra time to keep data. In addition, most of the marble plants observed in Kutahya also have no such a data keeping policy. So firstly, management should be convinced to use these forms.

ABC can also be used as a management tool. It can be used both as a accounting system and management tool. Management can make decisions using the ABC results and data. For example, after the results obtained from this study, management realized that production from rubble was not profitable as they are thinking. By this way, management can see which products are profitable and which are not. So more reliable decisions can be made in selecting the products to produce. In addition, for future orders a cost estimation can be done for all products. As the ABC system runs, more and more data will be gathered for different product and marble types. By arranging these data a detailed database can be formed to obtain information about production. According to this database and present economic situation pricing decisions can be done easily.

ABC showed that main consumption item was the electricity. For example, for Usak Green strip order total electricity cost was about 700,000,000 TL which was 43 % of total factory overhead cost and approximately 25 % of the total cost of order and for Bursa Beige tile product 44 % of total overhead and 17 % of total cost of order. At this point to avoid high cost of electricity factory can build its own power plant. But of course, feasibility study for this should be done.

With the introduction of the new observation forms for ABC, it could be also possible to see the efficiency of the plant and from the records kept for the production it was seen that plant was working with an efficiency of 40-50 % which was quite low. From the detailed examination of forms, it was found that block quality, type of diamond wheel cutter, abrasives used in polishing line are quite important in the production process. Sample forms are given in Appendix-E. From these forms information can be obtained about efficiency of cutters, workers, blocks and etc. For effective production, it should be known what kind of diamond wheel cutter must be used which kind of marble types. In the same way, which numbered abrasives should be used with different kinds of marbles.

To increase the efficiency of the production, more experienced workers and foremen should be employed. Especially in the block cutting machines more experienced workers should be employed to avoid faulty cuttings.

Besides, since the factory is buying blocks and rubbles from outside producers expertise activity on blocks should be carried carefully by employing experienced staffs.

ABC system developed is the first application in marble sector and it depends on the present information at the plant. So it was tried to be unique while constructing the model. ABC is flexible system and a general model was developed which can also be used in similar marble processing plants.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

In this study, an ABC model suitable for marble plants was developed and it was seen that ABC system can be quite successfully applicable to marble plants. However, more detailed data collection work and the explaining of the ABC system to all staff should be done for a longer period without the time limitation.

To implement an ABC system, companies need detailed information on production. The cost of implementing ABC and obtaining the information is higher than the traditional system. For Ertaş Marble Co. to be able to apply ABC, observation forms for different activities were prepared. While preparing these forms, it was tried to avoid complexity. Prepared forms were simple but worked effectively. By the help of these forms, plant management could control the production system more easily. On the other hand, the disadvantages of these forms were the requirements of extra time to keep data.

ABC model constructed for the plant can be extended to other marble processing plants. Activities and cost drivers used in this study can be used as a basis for models for different plants since, ABC is not a rigid system.

It is disputable that the plant managers in the marble sector are willing to use this system completely. Because they believe that they calculate the production cost by considering all factors in production process. They should be convinced that the use of traditional systems in finding unit cost or production cost is less accurate than the ABC system. So before the application of ABC to a plant, first management and all employees of the plant should be informed about the ABC and its efficiency.

Finally, with the application of the model in the plant, cost of some selected products were obtained and it was seen that ABC model constructed for Ertas Marble Co. worked well. This model can be further developed depending on the needs of the organization as the system is implemented.

Further recommendations can be stated as follows;

Constructed ABC model should be run in the computer environment to avoid extra time and work. In this way, more accurate results can be obtained in a shorter time.

During the study it was met with some problems about the data collection and usage of observation forms. If this work is done for a longer period and carefully, more detailed and accurate results can be obtained from the ABC system. Of course at this point, support and the willingness of the management is quite important.

ABC results obtained from the numerical example showed that the production of products from rubbles is not profitable. So, management should reevaluate the policy of production using rubbles since it costs higher than using blocks.

Application of ABC should seriously be considered in Ertas Marble Co. If ABC is adopted exactly plant benefits much more from the ABC system.

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APPENDIX A

OBSERVATION FORMS FOR THE PLANT

Table A.1 Observation Form for Block Cutting

ERTAS MARBLE		
Date:	S / T No:	
Shift:	Block No:	
Type of Marble:		
Dimension	Quantity (m^2)	Total (m^2)
Explanation:		
Shift Foreman		

Table A.2 Stock Card

ERTAS MARBLE						
Block No	Marble Type	Dimensions	Volume (m^3)	Date In	Date Out	Vehicle No

Table A.3 Block Cutters Production Observation Form

SHIFT NO								
DATE	S / T - 1		S / T - 2		S / T - 3		S / T - 4	
	Type	Q(m^2)	Type	Q(m^2)	Type	Q(m^2)	Type	Q(m^2)

Table A.4 New Observation Form for Block Cutting

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations

Table A.5 Observation Form for Calibration, Polishing and Dimensioning-Chamfering

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (number)	Wax (number)	Faulty (number)	Working Hour	Explanations

Table A.6 Observation Form For Electricity Consumption

ERTAS MARBLE				
Amp. / Head	Marble Types			
	Bursa Beige	Usak White	Burdur Beige	Usak Green......
D1 D2 D3 L1 L2				
L1 L2 L3 L4 L5 L6 L7 L8 L9 L10				
L1 L2 L3 L4 L5 L6				

Table A.7 Consumption Of Activities by Each Order

Activity Consumption	Order-1	Order-2	Order-3 .....
Stocking (Stocking Time, hr)			
Preparation (Preparation Time, hr)			
BC + CC + T1 (Machine Hour)			
T2 + Calibration (Machine Hour)			
Dimensioning + Chamfering (Machine Hour)			
Waxing + Selection (Labor Hour)			
Packaging (Packaging Hour)			

Table A.8 Resource Costs of Activities (TL)

Activity	Costs, TL									
	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	xxxxx									
Preparation	xxxxx									
BC+CC+T1	xxxxx	xxxxx				xxxxx				
T2+Calibration	xxxxx		xxxxx		xxxxx					
Polishing	xxxxx			xxxxx						xxxxx
Dimensioning + Chamfering	xxxxx						xxxxx			
Waxing + Selection									xxxxx	
Packaging								xxxxx		

Table A.9 Cost Driver Rates (TL/Hr)

Activity	Cost Driver Rate, TL/Hr									
	Electric	Diamond Wheel Cutter	Diamond Disk	Abrasive (Polishing)	P. Gas	Diamond Disk Cutter	Abrasive (Chamfering)	Package	Wax	Mat
Stocking	xxxxx									
Preparation	xxxxx									
BC+CC+T1	xxxxx	xxxxx				xxxxx				
T2+Calibration	xxxxx		xxxxx		xxxxx					
Polishing	xxxxx			xxxxx						xxxxx
Dimensioning + Chamfering	xxxxx						xxxxx			
Waxing + Selection									xxxxx	
Packaging								xxxxx		

APPENDIX B

DATA RELATED TO BLOCK CUTTING

Table B.1 Data of Block Cutting for Burdur Beige Efe

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time (hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
17/7 -23/07	4	3	1 hr	Burdur Beige Efe	30	1.4x45.8x200	-	83	10	
18/7 -07/15	4	3	-	Burdur Beige Efe	46	1.4x45.8x200	-	90	17.5	
18/7 -15/23	4	3	-	Burdur Beige Efe	45	1.4x45.8x205	-	90	14.5	
19/7 -07/15	4	3	-	Burdur Beige Efe	40	1.4x45.8x200	-	85	15	
19/7 -15/23	4	3	-	Burdur Beige Efe	39	1.4x45.8x200	1 hr	85	14	
20/7 -07/15	4	3	-	Burdur Beige Efe	18	1.4x45.8x200	30min	85	15	
28/7 -15/23	1	4	2.5 hr	Burdur Beige Efe	4	1.4x45.8x200	-	157	7.1	
28/7 -23/07	1	4	-	Burdur Beige Efe	26	1.4x45.8x210	-	160	8.1	
29/7 -07/15	1	4	-	Burdur Beige Efe	27	1.4x45.8x220	-	155	6.5	
				Burdur Beige Efe	9	1.4x45.8x140	-			
				Burdur Beige Efe	6	1.4x45.8x130	-			
29/7 -15/23	1	4	-	Burdur Beige Efe	29	1.4x45.8x190	-	145	6.6	

Table B.1 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
29/7 -23/07	1	4	-	Burdur Beige Efe	63	1.4x45.8x180	-	165	8.2	
30/7 -07/15	1	4	-	Burdur Beige Efe	30	1.4x45.8x180	-	165	6.2	
				Burdur Beige Efe	30	1.4x45.8x190	-			
				Burdur Beige Efe	3	1.4x45.8x120				
30/7 -15/23	1	4	-	Burdur Beige Efe	70	1.4x45.8x190	-	170	7.2	
30/7 -23/07	1	4	-	Burdur Beige Efe	46	1.4x45.8x180	-	170	7.2	
	4	7	2.5 hr	Burdur Beige Efe	8	1.4x45.8x130	-	170	6.9	
	4	7	-	Burdur Beige Efe	26	1.4x45.8x130	-	170	7.2	
	4	7	-	Burdur Beige Efe	37	1.4x45.8x125	-	85	12	
	4	7	-	Burdur Beige Efe	29	1.4x45.8x135	-	85	12	

Table B.2 Data of Block Cutting for Usak Green

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time (hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
25/6 -23/07	2	Rubble	-	Usak Green	12	2x30x62	35min	140	11	
02/7 -15/23	1	Rubble	2.5 hr	Usak Green	10	2x30x150	-	155	9	
				Usak Green	15	2x30x110				
02/7 -07/15	3	Rubble	2 hr	Usak Green	12	2x30x180		115	9.2	
02/7 -15/23	3	Rubble		Usak Green	24	2x30x180		115	9.2	
02/7 -23/07	3	Rubble	1 hr	Usak Green	16	2x30x140		120	15.7	
02/7 -23/07	4	Rubble	40 min	Usak Green	23	2x30x125	1 hr	105	15	
03/7 -15/23	2	6	50 min	Usak Green	48	2x30x120		110	8.2	
03/7 -23/07	2	Rubble		Usak Green	9	2x30x140	2 hr	110	9	
03/7 -07/15	3	Rubble		Usak Green	2	2x30x125		120	11.6	
03/7 -23/07	3	Rubble	-	Usak Green	22	2x30x150		123	13.2	
03/7 -07/15	4	Rubble	1.5 hr	Usak Green	22	2x30x100	1.5 hr	105	18	

Table B.2 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time (hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
03/7 -15/23	4	Rubble	-	Usak Green	33	2x30x145	45min	115	20	
03/7 -23/07	4	Rubble	50 min	Usak Green	22	2x30x130	-	110	15	
04/7 -07/15	2	Rubble	-	Usak Green	23	2x30x170	-	135	10	
04/7 -15/23	2	Rubble		Usak Green	20	2x30x170	1 hr	130	10	
04/7 -07/15	3	Rubble	-	Usak Green	8	2x30x110	1 hr	120	12	
04/7 -15/23	3	Rubble	1 hr	Usak Green	14	2x30x120	-	115	11.3	
04/7 -07/15	4	Rubble	1 hr	Usak Green	32	2x30x140	35min	110	15	
04/7 -23/07	4	Rubble	3 hr	Usak Green	7	2x30x300	50min	115	15	
05/7 -07/15	1	Rubble	-	Usak Green	31	2x30x140	-	135	8.1	
05/7 -15/23	1	Rubble	30 mi	Usak Green	15	2x30x120	30min	120	8.5	
	1	Rubble		Usak Green	12	2x30x140	30min	125	10.8	
05/7 -07/15	2	Rubble	-	Usak Green	6	2x30x130	3 hr	130	10	

Table B.2 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
05/7 -15/23	2	Rubble	1 hr	Usak Green	10	2x30x140	4 hr	128	9	
05/7 -23/07	2	Rubble	-	Usak Green	15	2x30x150	1 hr	143	11.2	
05/7 -15/23	3	Rubble	2 hr	Usak Green	16	2x30x120	-	115	11	
05/7 -23/07	3	Rubble	-	Usak Green	19	2x30x125	4 hr	120	15	
05/7 -07/15	4	Rubble	-	Usak Green	12	2x30x300	2.5 hr	115	15	
05/7 -15/23	4	Rubble	-	Usak Green	23	2x30x300	-	115	15	
05/7 -23/07	4	Rubble	-	Usak Green	7	2x30x160	-	110	15	
06/7 -15/23	1	Rubble	-	Usak Green	33	2x30x115	2 hr	130	9	
06/7 -23/07	1	Rubble	1.5 hr	Usak Green	17	2x30x160	-	120	8.2	
06/7 -07/15	2	Rubble	-	Usak Green	12	2x30x200	1 hr	130	10	
06/7 -15/23	2	Rubble	-	Usak Green	21	2x30x204	1 hr	130	10	
06/7 -23/07	2	Rubble	1 hr	Usak Green	2	2x30x160	1 hr	135	11.6	

Table B.2 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time (hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
06/7 -07/15	3	Rubble	50 min	Usak Green	13	2x30x100	3.5 hr	120	11.6	
06/7 -15/23	3	Rubble	-	Usak Green	38	2x30x100	1 hr	115	9.5	
06/7 -23/07	3	Rubble	5 hr	Usak Green	9	2x30x95	-	115	14.5	
06/7 -07/15	4	Rubble	1.5 hr	Usak Green	11	2x30x170	1.5 hr	120	16	
06/7 -15/23	4	Rubble	-	Usak Green	23	2x30x300	-	120	16	
06/7 -23/07	4	Rubble	-	Usak Green	18	2x30x300	-	115	15	
07/7 -15/23	1	Rubble	-	Usak Green	15	2x30x180	1 hr	120	11.3	
07/7 -23/07	1	Rubble	1 hr	Usak Green	20	2x30x160	2 hr	110	11	
07/7 -07/15	2	Rubble	-	Usak Green	4	2x30x120	-	115	10	
07/7 -15/23	2	Rubble	-	Usak Green	22	2x30x110	1.5 hr	115	10	
07/7 -23/07	2	Rubble	-	Usak Green	5	2x30x140	1 hr	120	10.8	
07/7 -07/15	3	Rubble	-	Usak Green	28	2x30x125	-	120	10	

Table B.2 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
07/7 -15/23	3	Rubble	2.5 hr	Usak Green	11	2x30x120	-	115	9.5	
07/7 -23/07	3	Rubble	-	Usak Green	6	2x30x145	-	115	14.5	
	3	Rubble	2.5 hr	Usak Green	2	2x30x180	45 min	115	14	
07/7 -07/15	4	Rubble	-	Usak Green	6	2x30x300	30 min	115	15	
08/7 -07/15	1	Rubble	-	Usak Green	17	2x30x130	-	125	9.4	
08/7 -15/23	1	Rubble	-	Usak Green	13	2x30x130	-	125	10.3	
08/7 -23/07	1	Rubble	1.5 hr	Usak Green	15	2x30x145	-	118	12.4	
08/7 -15/23	2	Rubble	-	Usak Green	24	2x30x160	-	105	10	
08/7 -23/07	3	Rubble	3 hr	Usak Green	8	2x30x180	40 min	110	10	
08/7 -07/15	3	Rubble	-	Usak Green	13	2x30x160	-	105	10	
09/7 -07/15	1	Rubble	-	Usak Green	6	2x30x145	-	100	11	
09/7 -15/23	3	Rubble	-	Usak Green	12	2x30x100	-	120	13.6	

Table B.2 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
22/6 -15/23	1	Rubble	35 min.	Usak Green	145	1.2x30.6x150	1 hr	90	7	
22/6 -23/07	1	Rubble	-	Usak Green	160	1.2x30.6x150	-	120	8	
23/6 -23/07	1	Rubble	45 min.	Usak Green	15	1.2x30.6x150	-	130	9	
24/6 -07/15	2	Rubble	-	Usak Green	3	1.2x30.6x140	7 hrs	120	8	
24/6 -23/07	2	Rubble	-	Usak Green	9	1.2x30.6x140	-	122	9	
26/6 -23/07	2	Rubble	-	Usak Green	15	1.2x30.6x150	1 hr	145	10.6	
26/6 -07/15	2	Rubble	-	Usak Green	19	1.2x30.6x140	1 hr	120	13	
26/6 -15/23	4	Rubble	-	Usak Green	14	1.2x30.6x140	1 hr	80	15	
01/7 -07/15	3	Rubble	1 hr	Usak Green	24	1.2x30.6x95	2 hr	141	11.5	
01/7 -15/23	3	Rubble	-	Usak Green	17	1.2x30.6x130		120	12	
01/7 -23/07	3	Rubble	-	Usak Green	32	1.2x30.6x130	-	118	12	
02/7 -07/15	2	Rubble	-	Usak Green	60	1.2x30.6x135	2 hrs	130	9	

Table B.3 Data of Block Cutting for Bursa Beige

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
23/6 -15/23	4	44	2 hrs	Bursa Beige	40	1.2x30.6x124	1.5 hr	110	12	
23/6 -23/07	4	44	-	Bursa Beige	80	1.2x30.6x124	30 min.	110	12	
24/6 -07/15	4	44	-	Bursa Beige	16	1.2x30.6x130	-	110	12	
31/7 -15/23	1	47	5 hrs	Bursa Beige	38	1.2x30.6x124	-	115	10	
31/7 -23/07	1	47	-	Bursa Beige	30	1.2x30.6x170	-	120	9	
01/8 -07/15	1	47	-	Bursa Beige	59	1.2x30.6x160	30 min.	120	9.1	
01/8 -15/23	2	47	2 hrs	Bursa Beige	60	1.2x30.6x130	-	120	8	
01/8 -23/07	2	47	-	Bursa Beige	93	1.2x30.6x150	-	160	12.1	
02/8 -07/15	2	47	-	Bursa Beige	33	1.2x30.6x180	1 hr	170	11.2	

APPENDIX C

DATA RELATED TO POLISHING LINE

Table C.1 Data of Polishing Line for Burdur Beige Efe

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (#)	Wax (#)	Faulty (#)	Working Hour	Explanation
20/7 - 7/15	3	Burdur Beige Efe	1.4x45.7x45.7	295	115	38	7	
21/7 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	45	66	-	7	
25/7 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	140	4	-	7	
31/7 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	30	105	36	7	
1/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	95	152	16	7	
2/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	105	43	15	7	
3/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	100	296	70	7	
4/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	125	36	12	7	
5/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	115	15	14	7	
6/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	75	-	-	7	
9/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	90	-	95	7	
10/8 - 7/15	*	Burdur Beige Efe	1.3x45.7x45.7	315	-	147	7	

* Unknown (#) Number

Table C.2 Data of Polishing Line for Usak Green

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (#)	Wax (#)	Faulty (#)	Working Hour	Explanation
6/7 - 7/15	*	Usak Green	2x30x60	181	-	24	7	
15/23	*	Usak Green	2x30x60	121	-	18	7	
7/7 - 7/15	*	Usak Green	2x30x60	141	-	74	7	
8/7 - 7/15	*	Usak Green	2x30x60	147	-	60	7	
9/7 - 7/15	*	Usak Green	2x30x60	173	-	126	7	
15/23	*	Usak Green	2x30x60	144	-	6	7	
10/7 - 7/15	*	Usak Green	2x30x60	132	-	-	7	
15/23	*	Usak Green	2x30x60	143	-	3	7	
11/7 - 7/15	*	Usak Green	2x30x60	227	-	-	7	
13/7 - 7/15	*	Usak Green	2x30x60	242	-	14	7	
14/7 - 7/15	*	Usak Green	2x30x60	151	-	-	7	

Table C.2 (cont.)

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (#)	Wax (#)	Faulty (#)	Working Hour	Explanation
15/7 - 7/15	*	Usak Green	2x30x60	95	-	12	7	
16/7 - 7/15	*	Usak Green	2x30x60	115	-	26	7	
17/7 - 7/15	*	Usak Green	2x30x60	82	-	-	7	
18/7 - 7/15	*	Usak Green	2x30x60	173	-	33	7	

Table C.2 (cont.)

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (#)	Wax (#)	Faulty (#)	Working Hour	Explanation
01/7 - 7/15	*	Usak Green	1x30.5x30.5	280	-	100	7	
02/7 - 7/15	*	Usak Green	1x30.5x30.5	140	-	26	7	
03/7 - 7/15	*	Usak Green	1x30.5x30.5	180	-	50	7	
03/7 - 15/23	*	Usak Green	1x30.5x30.5	220	-	90	7	
04/7 - 7/15	*	Usak Green	1x30.5x30.5	312	-	55	7	
05/7 - 7/15	*	Usak Green	1x30.5x30.5	428	-	110	7	

Table C.3 Polishing Line Data for Bursa Beige

Date / Shift	Block No	Marble Type	Dimension (cm)	Export (#)	Wax (#)	Faulty (#)	Working Hour	Explanation
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	208	-	50	7	
10/7 - 15/23	*	Bursa Beige	1x30.5x30.5	328	160	128	7	
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	464	-	229	7	
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	392	-	69	7	
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	40	-	7	7	
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	104	30	12	7	
10/7 - 07/15	*	Bursa Beige	1x30.5x30.5	20	-	50	7	

APPENDIX D

AMPERE VALUES OF POLISHING LINE

Table D.1 Ampere Values of Polishing Line

	Burdur Beige	Usak White	Bursa Beige	Finike White	UsakGreen
D1	14 Amp.	18 Amp.	18 Amp.	18 Amp.	14 Amp.
D2	14	20	20	24	12
D3	14	18	20	22	20
L1	15	13	-	-	-
L2	15	14	15	15	14
L1	12	12.5	12	12.5	12
L2	12	11	12.5	13	9
L3	12.5	10	10	9	11
L4	12	10	9.5	12	10
L5	13	10	10	12	9
L6	13	10	9	13	10
L7	13	10	10	12.5	9
L8	10	10	10	10	9
L9	10	10	10	10	10
L10	8	8	8	8	9
L1	10	11	10	10	-
L2	10	11	10	10	-
L3	5	5	15	10	-
L4	5	11	5	5	-
L5	5	5	5	5	-
L6	5	5	5	5	-

APPENDIX E

SAMPLE OBSERVATION FORM

Table E.1 Sample Observation Forms

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
10/7 -07/15	1	13	-	Burdur Beige	8	2x30x120	1 hr	80	10	
10/7 -15/23	1	13	-	Burdur Beige	-	NOT	WORKED			
10/7 -23/07	1	13	-	Burdur Beige	-	NOT	WORKED			
10/7 -07/15	2					NOT	WORKED			
10/7 -15/23	2					NOT	WORKED			
10/7 -23/07	2					NOT	WORKED			
10/7 -07/15	3					NOT	WORKED			
10/7 -15/23	3					NOT	WORKED			
10/7 -23/07	3					NOT	WORKED			
10/7 -07/15	4	1	-	Burdur Beige	4	1.4X45.8X270	6 hr	85	15	
10/7 -07/15	4	1	-	Burdur Beige	16	1.4X45.8X270	6 hr	85	15	

Table E.1 (cont.)

Date / Shift	S/T No	Block No	Preparation Time (hr)	Marble Type	Quantity (number)	Dimension (cm)	Stopping Time(hr)	V. Wheel Amp.	H. Wheel Amp.	Explanations
11/7 -07/15	1	Rubble	-	Usak Green	6	2x30x145	1 hr	80	10	
11/7 -15/23	1					NOT	WORKED			
11/7 -23/07	1					NOT	WORKED			
11/7 -07/15	2					NOT	WORKED			
11/7 -15/23	2					NOT	WORKED			
11/7 -23/07	2					NOT	WORKED			
11/7 -07/15	3	Rubble	-	Usak Green	20	2x30x120		105	10	
11/7 -15/23	3	Rubble	-	Usak Green	12	2x30x100		105	10	
11/7 -23/07	3	Rubble	-	Usak Green	13	2x30x115		120	13.6	
11/7 -07/15	4	1	-	Burdur Beige		NOT	WORKED			