DEVELOPMENT OF A VENTILATION MODEL FOR THE G FIELD OF ÇAYIRHAN COAL MINE

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Approval of the Graduate School of Natural and Applied Sciences.

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ABSTRACT

DEVELOPMENT OF A VENTILATION MODEL
FOR ÇAYIRHAN COAL MINE

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Ventilation problems raised with the beginning of underground mining. In underground mining, to provide safe and healthy working conditions, ventilation should be designed properly. Especially in the planning stage of the project, to design ventilation properly is very important.

The latest upgrade of the popular ventilation simulation program, known as VnetPC 2000, has been applied for the ventilation design.

In this study simulation is conducted to both auxiliary and main ventilation at Çayırhan G Field.

Information describing the geometry of a ventilation network, airway characteristics and locations, characteristics of different fans were prepared as an input.

The output includes predicted airflows, frictional pressure drops, air power, losses in airway and fan operating points for different trials.

After different trials it has been found that for auxiliary ventilation, where minimum required amount of air is 6 m^3/s, ENGART, 30A 40SCV/60HR model fan which is the most economical one was selected.

For main ventilation system, 5 fans which provide airflow more than minimum requirement were chosen. Among them the most economical one, that is ALPHAIR-5400VAX2100 HB, was selected for the mine.

Keywords: Ventilation simulation programming, network analyses, fan selection, auxiliary ventilation, main ventilation, Çayırhan G field.

ÖZ

ÇAYIRHAN KÖMÜR MADENİ G SAHASI İÇİN HAVALANDIRMA MODELİ GELİŞTİRİLMESİ

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Havalandırma problemleri yeraltı madenciliği ile başlamıştır. Yeraltı madenciliğinde sağlıklı ve güvenli çalışma koşullarını sağlamak için havalandırma sisteminin iyi dizayn edilmesi gerekir. Özellikle projenin planlama aşamasında havalandırma sisteminin gerçekleri yansıtacak biçimde dizayn edilmesi çok önemlidir.

Havalandırma Simulasyon Programı olarak en son ve geliştirilmiş VnetPC 2000 programı kullanılmıştır.

Bu çalışmada simulasyon; Çayırhan G sahası için, tali havalandırma ve ocağın ana havalandırması, yukarıda adı verilen program kullanılarak yapılmıştır.

Havalandırma şebekesinin çizgisel diyagramını tanımlayan fiziksel durumu, hava yolu karakteristikleri ve lokasyonları, ve değişik vantilatörlerin karakteristiklerini içeren bilgiler programa veri olarak verilmiştir.

Her hava yolu için yaklaşık hava miktarları, basınç düşmelerive hava güç kayıpları ve fan çalışma noktaları, yapılan her deneme için çıktı olarak alınmıştır.

Değişik fanlarla yapılan denemeler sonunda, tali havalandırma için gereken 6 m^3/s'lik hava miktarını sağlayan fanlar belirlenmiş ve içinden en ekonomik olanı, ENGART, 30A 40SCV/60HR, seçilmiştir.

Ocak havalandırması için gereken hava miktarını sağlayan 5 vantilatör bilgisayar programı sayesinde belirlenmiş olup, bunların içinden işletim masrafı en az yani en ekonomik olanı, ALPHAIR-5400VAX2100 HB, ana pervane olarak seçilmiştir.

Anahtar Kelimeler: Havalandırma simulasyon programı, şebeke analizi, vantilator seçimi, tali havalandırma, ana havalandırma, Çayırhan G sahası

TO MY FAMILY

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CHAPTER 1

INTRODUCTION

1.1. General Remarks

Ventilation problems raised with the beginning of underground mining. The first stage in underground mining is to design a proper ventilation system to achieve safe and comfortable working conditions. In this context, quality, quantity and temperature-humidity controls should be considered.

Quality control includes purifying, removing and diluting the contaminants found in the mine air. The main contaminants are gases and mine dust which should be concerned, especially in mechanized coal mines such as Middle Anatolian Lignite Mine. Quality control has objective to provide required amount of fresh air in the mine. This can be achieved by using suitable main and auxiliary fans. The best selection of fans can only be done by using VnetPC Software as it is done in this study.

1.2. Importance of Mine Ventilation

Effective mine ventilation is required to maintain a healthy underground environment for humans. Without effective ventilation, the environment can become unhealthy or hazardous as a result of the depletion of oxygen, contamination with toxic gases, or the buildup of an excessive amount particulate matter (dust). Each contaminant has an upper limit of concentration that should not be exceeded within an 8-hr period (Karakaş, 2002). This is known as threshold limit value (TLV).

The Threshold Limit Values (TLV) are developed to assist in the control of health hazard. These recommendations are intended to use in the practice of industrial hygiene.

On the basis of extensive studies by the American Conference of Govermental Industrial Hygienist (ACGIH), various categories of threshold limit values have been specified (Anon., 1991). The TLVs are expressed as a time-weighted average (TLV-TWA), or as a Short-Term Exposure Limit (TLV-STEL), or as a Ceiling Limit (TLV-C). These principles are used in all over the world including Turkey.

1.3. Objective of the Thesis

The objective of this thesis is to prepare a model for the design of ventilation network of Çayırhan G Field and to select main and auxiliary fans which provides best working conditions as far as mine ventilation is concerned. In the design development schedules of underground galleries, determining locations of both main and auxiliary fans, are realized emphasizing economical idea for Capital Investment and Operating Costs, etc. As a result, this thesis enables us to make an optimal selection for the ventilation design for Çayırhan G Field.

1.4. Methodology of the Thesis

First, a model for the available ventilation network in C Field was studied by using VnetPC and the information to be about the available fan, pressure distribution and the resistance values of galleries, faces and doors are found. Then a model was prepared for planned G Field Developments using the same computer software. By using this model, different alternatives were tried and the most efficient alternative was determined among the alternatives.

After brief introduction, in Chapter 2 description of Çayırhan Lignite Mine is given. In Chapter 3, the solution of ventilation network and computer sımulatıon model, in Chapter 4, data preparation for the design, in Chapter 5, design sequences of ventilation system, in Chapter 6, modeling and results and finally in Chapter 7, conclusions and recommendations are given.

CHAPTER 2

DESCRIPTION OF ÇAYIRHAN LIGNITE MINE

2.1. General

In this chapter, after the brief explanation of the geology of the region, an operation mine will be described in details. Details of the ventilation and the simulation of a ventilation model will also be discussed in this chapter.

2.2. Geology of Çayırhan

The Beypazarı basin is one of a number of fault bounded basins which was developed as a result of extensional tectonics in western Turkey during the upper Miocene. The basin fill sequence has been summarized by Whateley and Tuncali (1995 a,b). The initial basin fill material consisted of coarse grained clastic and volcanoclastic material. A combination of lowering basin margin relief (through erosion) and basin fill resulted in a base level rise within the basin. The subsequent low energy environment favoured the development of a fresh – water, limnic environment characterized by a high rainfall and seasonally high temperatures. In this setting laterally persistent peat accumulated. A period of epiclastic volcanic activity during this peat formation resulted in a high mineral matter content of the coal and a clastic parting which split the seam into two, referred to colloquially as the first (upper coal seam (Tv)) and second (lower coal seam (Tb)) seams (Whateley and Tuncali, 1995).

Sedimentary rocks of the Çoraklar Formation consists of volcaniclastic conglomerates, sandstones, siltstones, and mudstones, and were deposited as alluvial facies in braided-meandering river and flood-plain environments. A lower lignite bed occurs in the lower part of the Çoraklar Formation and formed in Channel-controlled swamps of a river system. An upper lignite bed occurs in the uppermost part of the Çoraklar Formation, was deposited in a lake-marginmud-flat environment, and is overlain and in sharp contact by the Hırka Formation (Yagmurlu and others, 1988; Helvaci and Inci, 1989).

The formations, age of formation and lithologyin the region is given in Appendix II.

2.3. Description of Mine

Çayırhan Lignite Mine, the first fully mechanized underground coal mine in Turkey, lies in the western part of Ankara Province. A total of 400 million of tons reserve has been, to date, found in the coal basin. Two coal seams with 1.50 and 1.70 m. thickness are separated by a layer of marl having an average thickness of 1 m. The lignite seams are interposed with Miocene formations. The Miocene is composed of conglomerate, sandstone, clay, marl and limestone. The thickness of the Miocene is 150-200 m. Two lignite seams lie in the marl. The seams dip 6º to 26º towards south-east.

Coal contains 30 % moisture, 27.5 % ash and 4.65 % sulphur as mean values. The coal extracted is consumed by the power plant to produce electricity.

Coal is cut by double drum shearers and transported by armoured face conveyors to the lower gateroads. The coal transport both in gateroads and mainroads are all continuously carried out by belt conveyors.

Belt conveyors are used along lower gateroads and mainroads (intake airway) to transport coal directly to the surface. In return airways, monorails are employed to transport man and material. Return airways are supported by hydraulic props.

Cross-sectional areas of return airways were designed for adequate ventilation. However, due to narrow cross-sectional area in return airways, airway resistances have increased, causing a reduction in the amount of air passing through the airways and scrap. In order to decrease resistance of airways, unnecessary accumulation of waste, scrap material, etc. should be removed and suitable mine ventilation network analysis should be applied to get ideal airflow distribution.

To provide coal needed for Çayırhan Thermal Power Plant, having 620 MW power generating an annual electricity production of 4.3 billion kW/h, an agreement of set up-manage model was signed with the company named Park Teknik which is a Turkish-German partnership (Aydın, 2000; Kaygusuz, 2000).

The machinery-equipment brought from Germany having the most developing technology of the world in underground coal mining is projected by Turkish-German technicians. As a production method, Longwall Retreat Mining Method was chosen. This was the method applied by the Middle Anatolian Lignites before the agreement. At the first two stages of the project, a total capital of 200 million DM was invested by the company. Total gallery length opened in one year which is assumed a short term in underground mining is 5000 meters. After completing the mounting of machinery-equipment, production started with a capacity of 2 million tons per year in B Field in 1997 (Aydın, 2000; Kaygusuz, 2000).

Investments in C Field, the second stage of the project, are completed and started producing in November of 1999. So the useful capacity was increased to 4 million tons/year. The modern technology is being used to obtain coal from underground with high safety and with higher efficiency.

Coal in Çayırhan Region is found as approximately 400 million tons of coal. There is an intermediate layer between two seams. Indeed, under the depth of 150m, the third seam is found with a changing thickness of 2-11m. The thickness of intermediate layer in the west and east part of the field between two seams are 1.3-2m and 0.5-0.7m respectively (Aydın, 2000; Kaygusuz, 2000).

Therefore, two seams in the west of the field are projected to work seperately. In the east of the field two seams and a intermediate layer are projected to work as a single seam and mechanized and equipped accordingly.

2.4. Mining Method Applied

Preparation works at the field were started in 1 Juny 1996 and galleries with total length of 16085m were opened till 31 December 1999. At the preparation works roadheaders made in England and Russia are used with an average daily advance of 10m (Aydın, 2000; Kaygusuz, 2000).

In B Field Longwall Retreat Mining Method was chosen as production method. Since the thickness of intermediate layer in B Field is 1,3-2m, two seams are projected to work separately. At each field the thickness of coal seam is homogeneously distributed, faults to effect the occurrence of mechanized panel does not exist. Coal seams are at the depth of 200-250m from the surface with minimum calorific value of 2700-3200 kcal/kg and sulfur content of 3-5%. To decrease the need of maingate, to provide more efficient use of reserves and to reduce the risk of spontaneous combustion of coal, panel maingates were projected to be used as tailgate of the following panel. Face height is 1,60m in upper face; 1,90m in lower face the distance between upper and lower face is kept as 25-30m. To build the production panel, main and tailgates and minimum transportation galleries are opened by using the roadheaders.

Figure 2.1 shows the section taken through the face and illustrates the mining method applied.

Production works in B Field are done by 153 workers, current monthly advance is 129,5m in the upper face and 132,5m in the lower face. Face production capacity is about 59 tons/shift (Aydın, 2000; Kaygusuz, 2000).

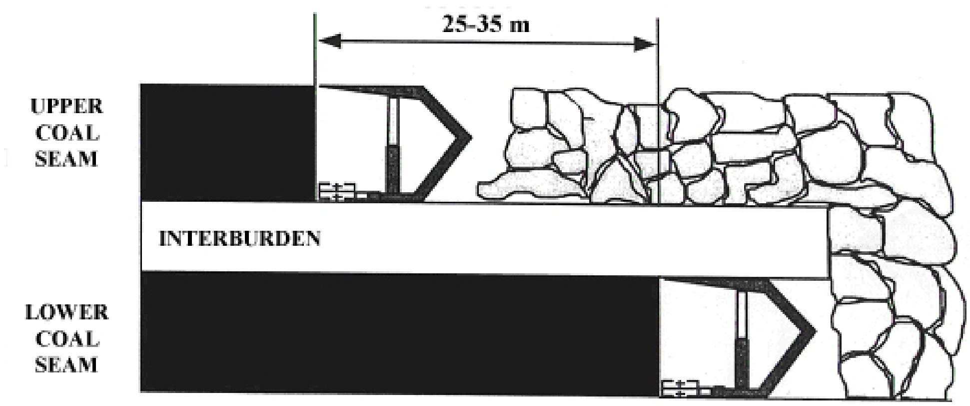

Figure 2.1. Production method in B Field in twin slices.

Retreat Mining Method was chosen as production method in C Field, too. Due to the variations in thickness of intermediate layer between 0.5-0.7m, different than other fields, therefore in C Field it was projected to work two seams and an intermediate layer as a single seam and machinery and equipment were chosen accordingly.

In C Field, the lengths of panels and the faces are 1700m. and 220m. respectively. Face height is about 4.3m when the slope of the face is 30°. To establish production panels, main and tailgates and main transportation galleries are opened by using roadheaders (Aydın, 2000; Kaygusuz, 2000).

Figure 2.2 gives the section taken through the face showing supports and equipment used in the face.

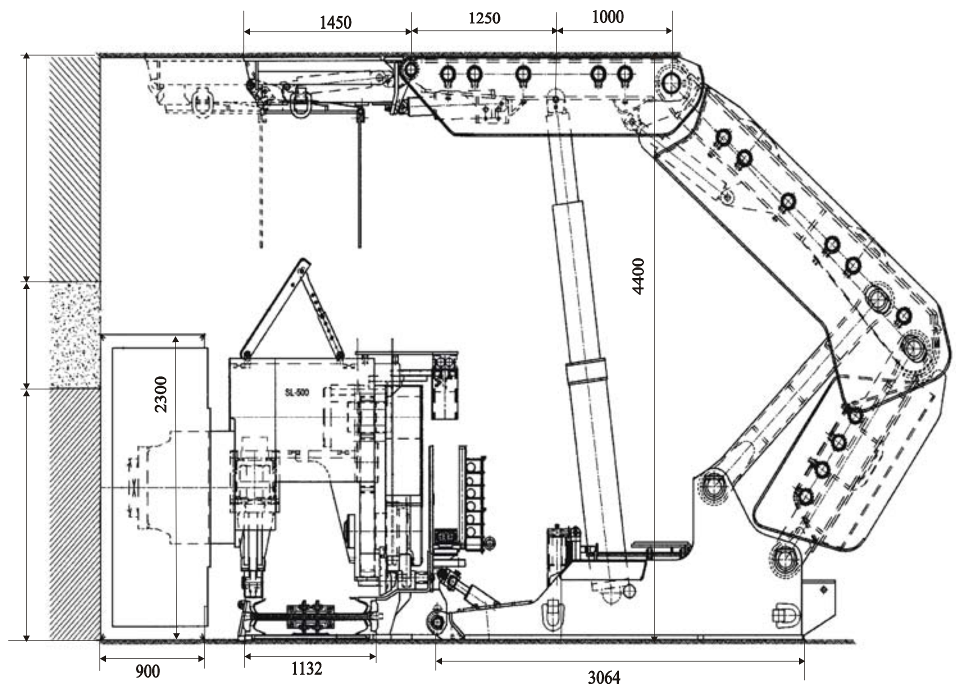

Figure 2.2. Production method in C Field in one slice.

2.5. Ventilation of the Mine

One of the requirements of mine ventilation is the necessity of the constant attention by the mine operator. Just as the physical changes in mine structure with time, the ventilation requirements of a particular mine also changes considerably with time say, from season to season, even day to day. No ventilation system can remain adequate indefinitely; and all systems require monitoring and adjustments to achieve proper ventilation.

The ventilation of mines is a combination of both art and science. The fluid that must be moved is invisible; its properties change drastically with temperature, barometric pressure, and humidity; and methods of measurement are not precise. In part, ventilation engineering must rely upon the art of good industrial ventilation experience and sometimes even the trial – and – error method. Although the direction of flow and the volume can not be predicted correctly by airflow equations in every situations, it is better to try to predict the behaviour of a given ventilation before installation than to proceed blindly with a system design. When used with the discretion that comes from education and experience, the basic laws of ventilation can provide substantial insight into the design of an air-handling system; and they can prevent wasteful or even dangerous designs from being installed.

The emphasis has been placed on the interpretation and use of fan-characteristic curves that are supplied by fan manufacturers. Considerable information can be obtained from these fan curves, particularly when they are used with a graphic model of the mine, drift, or duct in which the fan or fans are to be installed. A few minutes spent comparing the various characteristic curves can help the designer obtain the correct fan for the job.

Every person working underground is entitled to the safest environment that can be provided within the limitations of existing technology and at a reasonable cost. Adequate ventilation is well within both limits, provided that the system is designed intelligently, in conjunction with the mining plan, and not as an afterthought to the mining plan.

Fan characteristic curves show the relationship between the loads imposed upon a fan and the fan's output in terms of the volume of air delivered per unit of time; as the load increases, the output decreases. Primarily, the load on a fan is due to the friction between the air and the walls of the airway. The load is the power necessary to overcome the "back pressure" of the ventilation duct or the mine drift. (Mount, 1998)

As an example of how the fan-characteristic curve can be used, the following case may be given, assume that there is 305 m. (100 ft) ventilation duct in a drift, with 37.3 kW (50 hp) fan at the end of the duct. From the measurements made with a Pitot tube and a manometer, it is found that the total pressure of the fan is 2.48 kPa

(10 in. Wg-water gage). The amount of air produced by the fan can be determined as illustrated in Appendix I. Referring to Appendix I, the 2.49 kPa (10 in wg) value is found on the left side of the graph. A line then is followed horizontally across the graph until it intersects the fan's characteristic curve. That intersection is the "operating point" of the system and is the point at which the capabilities of the fan exactly match the requirements of the particular duct and pressure. In other words, the load caused by friction in the duct is matched exactly by the power of the fan at that point; the output is stable.

Having found the operating point, the volume flow of air can be determined by moving straight down from that point to the bottom of the graph. In this step, it is 10.7 m^3/s (22600 cfm). That is the volume of air that the system will produce with the given fan and duct.

A second curve is shown in Appendix 1; this is the "brake-power" curve and it shows the amount of power consumed at different output rates. Returning to the operating point determined for the fan-characteristic curve, the point at which the vertical line from the operating point intersects the power curve indicates the power needed to pass the volome of air. In this step, the power requirement is found to be about 32.8 kW (44hp) to pass 10.7 m^3/s (22600 cfm) of air.

Not all fans behave like the one shown in Appendix 1; some fans have many different blade settings, and each setting must have its own characteristic and power curves.

CHAPTER 3

SOLUTION OF VENTILATION NETWORK AND COMPUTER SIMULATION MODEL

3.1. Techniques for the Solution of Network

There are four methods that may be used to solve ventilation networks, namely, equivalent resistance, analytical solution, ventilation analogues and successive approximation method.

Equivalent resistance method is applied to networks which are made up of a number of airways connected in series and parallel. Such systems are termed as simple networks. This method is not applicable due to the fact that in practice, mine airways are not in the form of simple networks.

Analytical method makes use of Kirchoff Laws. The number of equation that can be obtained by applying Kirchoff's First Law is (y-1), where "y" is the number of junctions. Remaining (b-y+1) equation is obtained from Kirchoff's Second Law. In this case total number of equation becomes "b" (number of branch) which is equal to number of unknowns. Solution of these simultaneous equation will provide the unknown airflow amounts. In this technique, networks having only two meshes produces quadratic equation that involves Q^2 term. In this case, containing "m" meshes will give the power of 2^{m-1} for Q which is not easy to solve. Therefore this technique is not suitable if the number of meshes is higher than 2.

Ventilation Analogues are designed to simulate a ventilation network. For this purpose pneumatic, hydraulic and electrical analogues have been designed. But due to some practical difficulties, these analogues have not been used extansively.

In Electrical Analogues, although the Kirchoff's Laws are applicable to both electricity and mine ventilation, the basic laws governing the flow are different. In mine ventilation Square Law ($P=RQ^2$), in electricity a linear relationship ($V=IR$) is applicable. In this technique voltages applied across the relevant branches to simulate fan pressure. Therefore the use of this technique is limited.

Iterative Tecniques involve making an initial estimate of the flow distribution, calculating an approximate correction for each branch flow and repeating the iteration until a specified accuracy has been achieved. Shortly this is called as "Hardy Cross Iterative Technique".

Procedure involved in Hardy-Cross Iterative Techniques is given below.

The network analysis software, called VnetPC Computer Programming, is based on this iterative technique.

3.2. Simulation of a Ventilation Model

Simulation is the modeling of a part of the world that we want to understand. A simulation echoes the behaviour of this real world system as it changes from one state to another through time. A computer simulation provides a tool for studying real world systems in order to predict their behaviour under a variety of conditions. Systems to be studied may already exist, or they may be on the drawing board.

Simulation provides a method for checking your understanding of the world around you and helps you to produce better results faster. A simulation is an important tool that you can use to:

a. predict the course and results of certain actions,

b. understand why observed events occur,
c. identify problem areas before implementation,
d. explore the effects of modifications,
e. confirm that all variables are known,
f. evaluate ideas and identify inefficiencies,
g. gain insight and stimulate creative thinking,
h. communicate the integrity and feasibility of your plans. (Güyagüler, 1999)

The power of simulation is the ability to study these issues offline before committing to changes in operations. That means, computer simulation allows you to test strategies and create scenarios without any real-life consequences (Güyagüler, 1999).

The VnetPC is a program designed to assist personnel in the planning of underground ventilation layouts. Given data that describes the geometry of the mine network, airway resistance or dimensions, and the location and characteristic curves of fans, the program will provide detailed listings and graphical representations of:

- branch airflows,
- frictional pressure drops,
- airway resistance,
- air power losses in airways,
- ventilation cost of each airway,
- fan operating points (pressures and airflows),
- duties of required regulators and booster fans,
- gas flows and concentrations in branches. (Güyagüler, 1999)

VnetPC can simulate existing ventilation networks such that fan operating points, airflow quantities, and frictional pressure drops approximate those surveys together with information determined from known airway dimensions and characteristics (Güyagüler, 1999).

Input Data: Before inputting the data to computer, ventilation network of the system is drawn. All airways and junctions must be numbered; fans, doors, regulators etc., should be marked on this digram. After finding resistances of airways, the data is entered to the computer. Depending on the network file, data and the options desired, the junction connections in and out, also branch data is included.

Input data for different types of airways are given below:

1. P – Q, pressure drop and air quantity. These values can be entered as obtained from a pressure-quantity survey.
2. R – fixed airway resistance. This value may be calculated from survey data or determined from resistance equation using airway dimensions and friction factor.
3. K, L, LEQ, ARE, PER – airway physical characteristics (friction factor, lebgth of airway, equivalent length, area and perimeterof airway) used to calculated resistances.
4. Q, R_{min} – fixed airflow rate with minimum airway resistances. May be airflow required through a regulator or booster fan.
5. Q – inject/reject fixed airflow. Used to add or remove air from selected junctions to account for compressibility effects, ducts or compressed air lines or areas of the mine not represented in the network.
6. Information about fan, fan curve.
7. Information about NVP if required.
8. Cost of electricity.

Output Data: Output data is obtained in four parts. Fan operating points, the power requirements and the operating costs, based on power charges supplied by user, are listed. Additionally, the frictional pressure drop, airflow rate, resistance, airpower loss and cost of ventilating is listed for every branch in the network. (Güyagüler,1999)

CHAPTER 4

DATA PREPARATION FOR THE DESIGN

Input parameters for the design can be categorized considering the types, geometry, resistances of airways and ducts, required amount of airflow, fan properties and natural ventilation.

4.1. Airway Types and Geometries

In determining panel boundaries for G Field, several factors are taken into consideration. These factors are; the stratigraphy, coal morphology and tectonical structure of the area. Determining panel boundaries exactly is important due to the fact that it determines the length of galleries which is related with the design of the ventilation system. Panels were designed by the use of Vulcan 3D Mine Design Software and the lengths of galleries which will be used for the design were measured by the use of this program also.

Airway cross – sectional areas and perimeters were determined from the newly drived airways such as main transportation gallery, maingate, tailgate and face by evaluating values from the other fields. Airway friction factors used for friction losses were taken from literature. (Table 4.1)

Airway lengths were given in Figure 4.1

Table 4.1 Approximate Friction Factors for Plastic Tubes, Galleries and Faces.

Airway Types	**Friction Factors (kg/m^3)**
Plastic tube	0.00300
Gallery (sedimentary rock, minimum irregularities, straight, moderately obstructed)	0.01762
Face (sedimentary rock, maksimum irregularities, slightly curved, moderately obstructed, timbered roadway)	0.02411

In this study, shock losses, depending on type of source, panel geometry and the selected machinery – equipment, were categorized and for each an equivalent length value, which will be added to airway length, was determined. Shock losses values, which are shown in Table 4.2, were taken from literature.

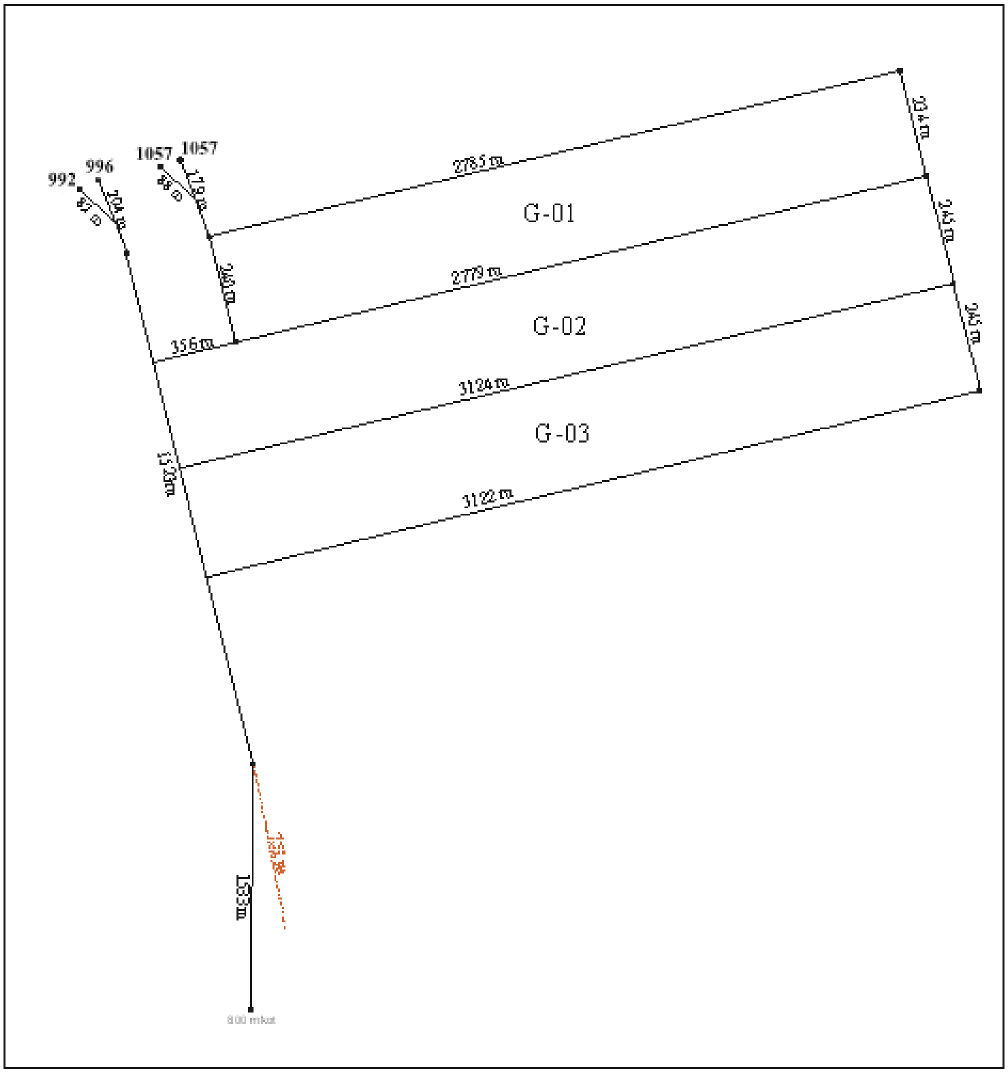

Figure 4.1 Lengths of the airways used in the design.

Table 4.2 Air shock losses types and distributions (Güyagüler, 1999).

Type	Explanation	Equivalent Length m
1	Bend, Obtuse, Sharp	5
2	Bend, Acute, Sharp	50
3	Bend, Right, Sharp	23
4	Contraction, gradual	0.4
5	Contraction, abrupt	3
6	Entrance	1
7	Discharge	22
8	Mine car or skip (10% of sectional area)	4.5
9	Mine car or skip (15% of sectional area)	16
10	Mine car or skip (20% of sectional area)	34
11	Mine car or skip (30% of sectional area)	90
12	Mine car or skip (40% of sectional area)	170

4.2. Air Requirements

In determining the required air amount for underground ventilation systems various factors should be considered. These are;

- Number of workers working at the point and air requirements for each worker according to the type of work they do.

- Required air to dilute flamable, explosive or suffocating gases emissions below their threshold limit values.

- Required air to dilute dust concentration occurred as a result of the activities at the working place below its threshold value.

- Required air to dilute exhaust gas produced by diesel engine vehicle to the acceptable limit values.

- Required air for heat transfer process to decrease the temperature at the working environment.

- Required air amount for the mine must be determined considering the highest air requirement for the conditions stated above. If required air for the mine is more than one of this criteria, air flowrate must be adjusted accordingly. Implied criteria has been evaluated according to past experiences, requirements (given below) for faces have been accepted constant and used in the design.

Air requirement for panel face: min 35 m^3/s
Air requirement for development face: min 6 m^3/s

4.3. Air Losses and Beneficial Use Amount

During sending air to development faces through plastic tubes, usually some air leakages occur. These losses prevent sending enough amount of air to the face. Losses can increase because of damages on plastic tubes, increase in total plastic tube length and increase in air pressure at the auxiliary fan exhaust. In this study air pressure at fan exhaust was assumed as main factor and by the use of Figure 4.2 a reduction was applied to the obtained flowrates.

Some amount of the air sent to faces are circulated through the back of the face and can not be breathed. Some of this can rise up to surface through the cracks at the back of the face. Therefore a reduction of 5 % was applied to the beneficial use amount which was obtained theoretically.

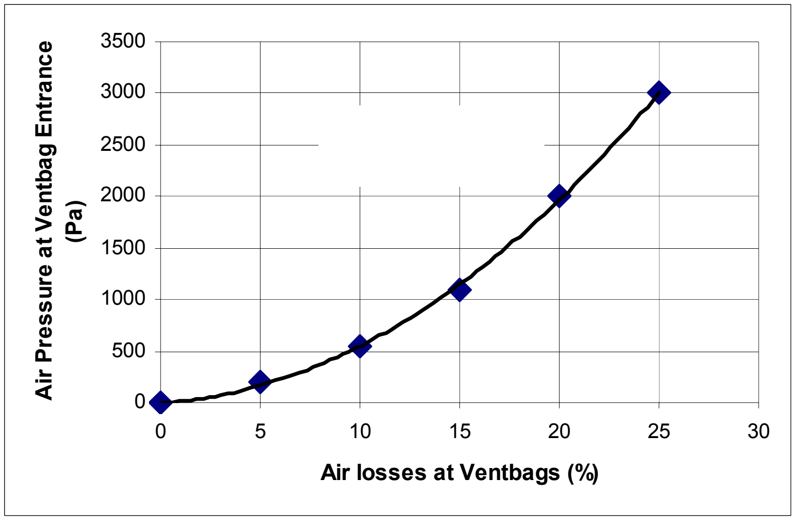

Figure 4.2 Rates of Tube Air Leakage with respect to Entrance Pressure

4.4. Doors and Orienting the Air Flow

Regulators and doors have to be placed to the system to arrange air flows, so that shor cuts can be prevented and sufficient amount of air can be sent to the faces during both development and production stages.

A constant resistant value of 2 gaules was assumed for these doors.

4.5. Main Fan and Auxiliary Fans

In this study the fan curve for the air density of 1.2 kg/m^3, Engart 30A 40SCV/60HR type fan which is currently available in Çayırhan was used as auxiliary fan.

Fan curves of available main fan and auxiliary fans were used as input data for VnetPC 2000 Program. Efficiencies for used fan curves were evaluated manually and used for comments.

Auxiliary fan models used in this study are given in Figure 4.3 with their characteristic curves.

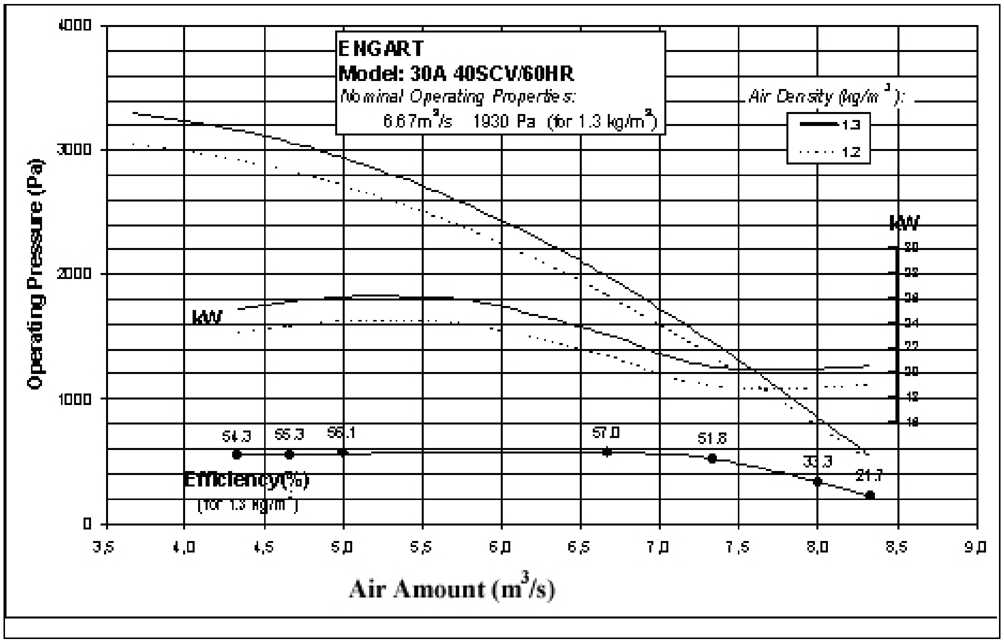

Figure 4.3 (a) Engart, 30A 40SCV/60HR

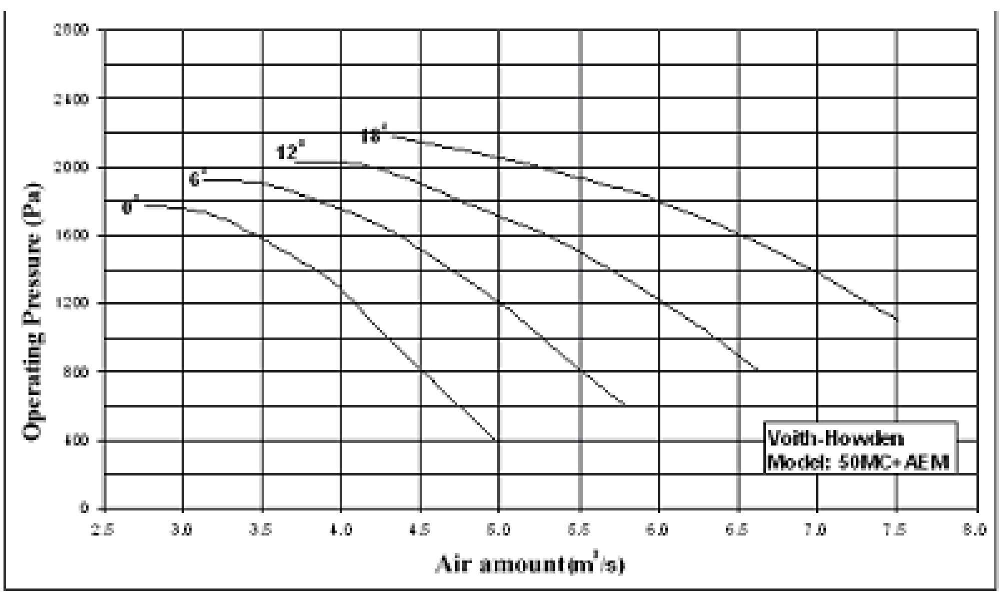

Figure 4.3 (b) Voith-Howden, 50MC+AEM

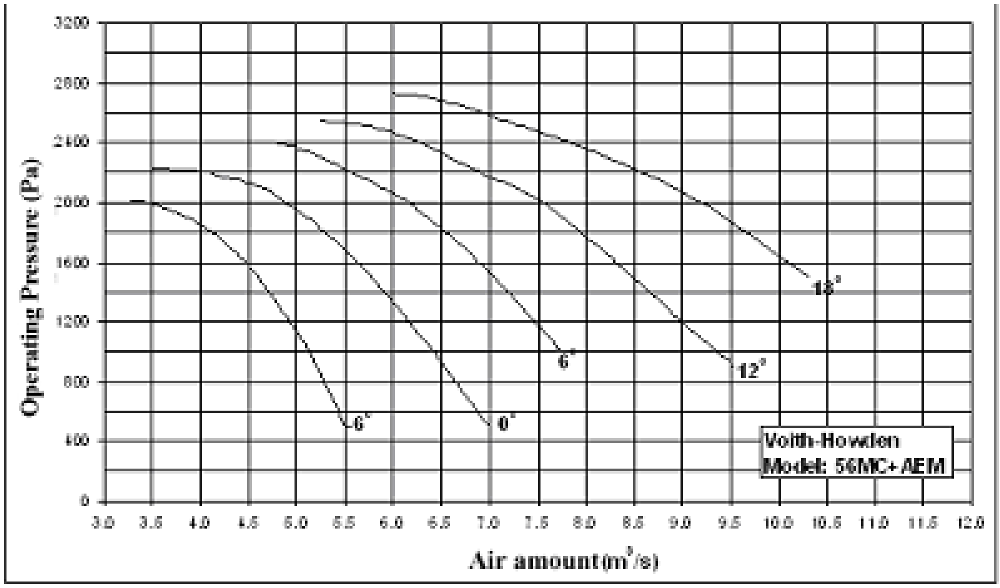

Figure 4.3 (c) Voith-Howden, 56MC+AEM

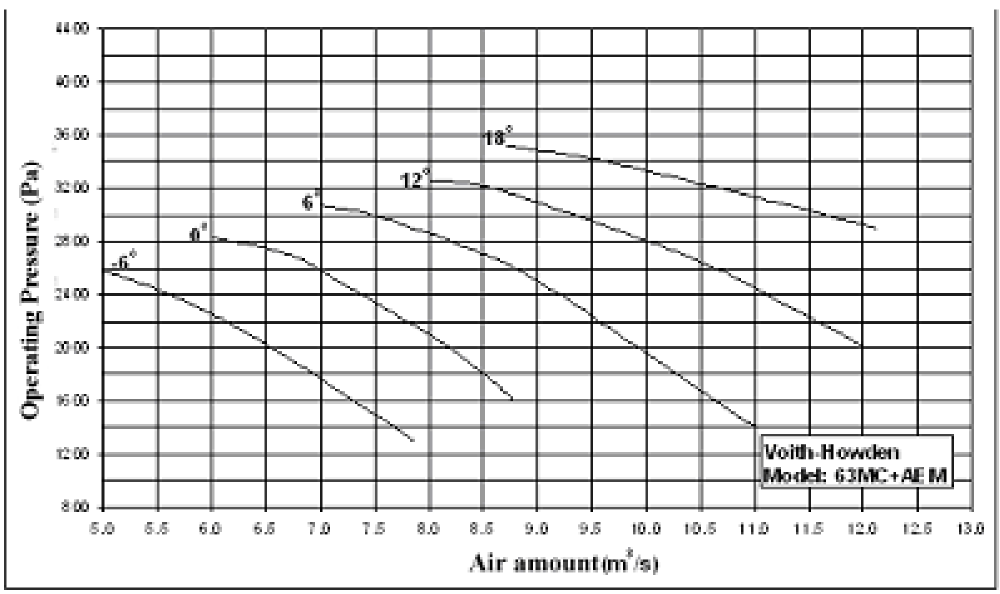

Figure 4.3 (d) Voith-Howden, 63MC+AEM

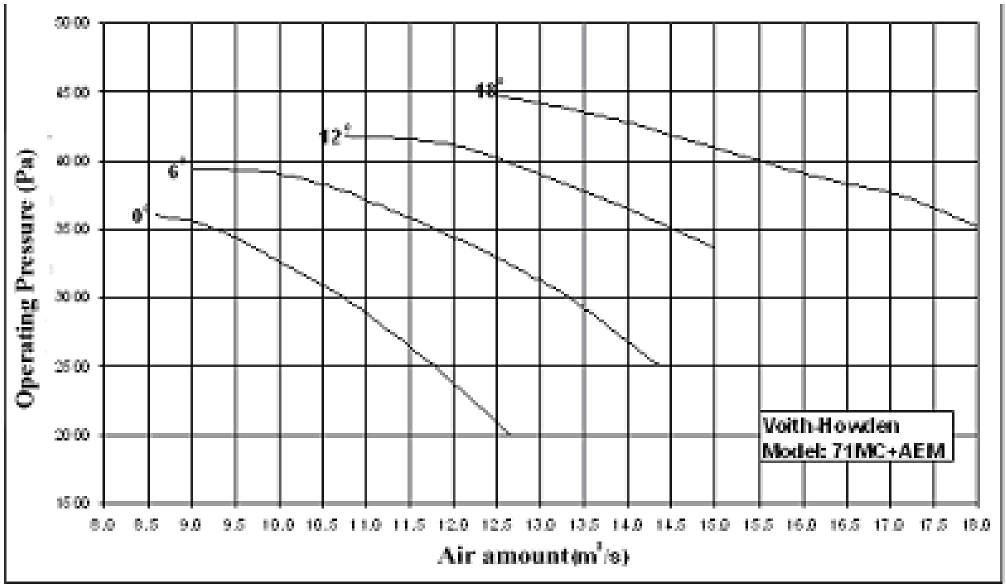

Figure 4.3 (e) Voith-Howden, 71MC+AEM

Figure 4.3 Characteristic curves of Auxiliary fans used in the design.

Main fans and their characteristic curves were given in Figure 4.4.

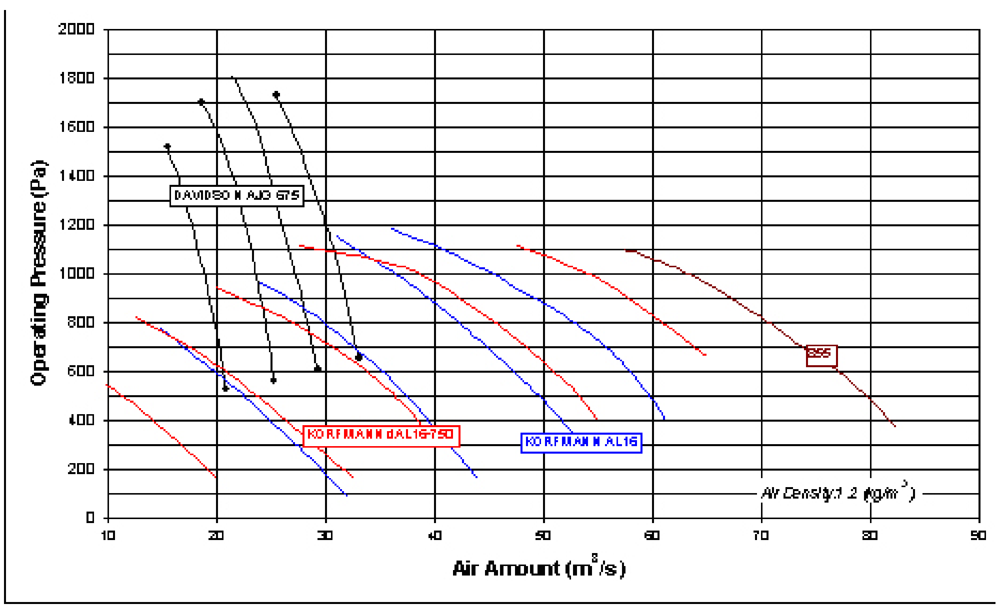

Figure 4.4 (a) Available fans

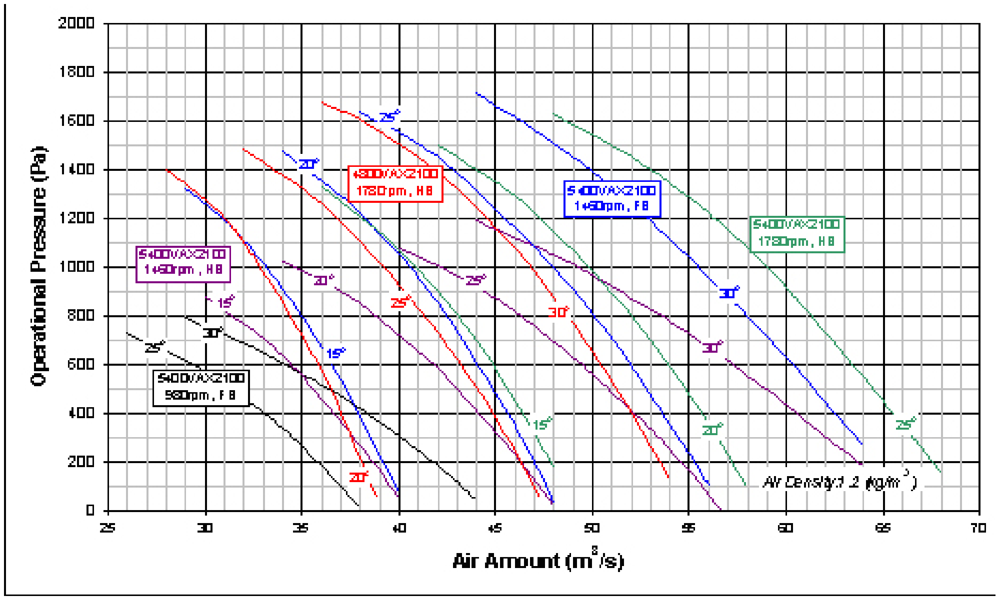

Figure 4.4 (b) Alphair VAX2100 serisi

Figure 4.4 Characteristic curves of fans used in the design.

4.6. The Effect of Natural Ventilation

With the connection of air inlet and exit airways, a natural ventilation effect will occur in the mine. This effect changes with mine air temperature, outside air temperature, elevation differences between air inlet and exit points. Changes in air densities due to temperature changes the amount and the distribution of airflow.

During downtimes in C Field which is operating currently, it was observed that there was an air flow of 750 – 850 m^3/min. changing with seasonal weather conditions. Air inlet elevation is +777 and air exhaust elevation is +833 meters in C Field. So there is an elevation difference of 56 meters in elevation between air inlet and air exhaust points. In G Field, planned air inlet elevation is +800 meters, air exhaust elevations are +992 and 1057 meters varyingly. Therefore, differences in elevations are 192 and 257 meters respectively. This shows that the natural ventilation effect in G Field will be more than one in C Field. But true natural ventilation pressure can be obtained after the actual connection of air inlet and air exhaust points.

In this study, natural ventilation was not taken into consideration and just air amounts due to main fans were investigated. After the measurements with the completion of development galleries, main fan characteristics can be modified according to natural ventilation effect.

CHAPTER 5

DESIGN SEQUENCES OF VENTILATION SYSTEM

Design sequence of the ventilation system has been determined considering the order of realization of the workings. In other words design covers from the ventilation of single heading to the ventilation of mine after development works. In this context, it was decided that it would be suitable to design final ventilation system in four steps.

In the first stage where auxiliary ventilation is applied, there will be two steps; namely Step 1 and Step 2.

In the second stage which is composed of Step 3 and Step 4, the main ventilation system will be obtained.

5.1. First Stage Planning

This stage is application of auxiliary ventilation. It has two steps.

In Step 1, two groups of crew will work separately. First group will work in opening of main transportation gallery from North to South and the second group will work in tailgate and maingate developments of G 01 Panel. Ventilation characteristics of both systems (length, cross-sectional area, etc.) are almost the same. Therefore only one application was considered for both systems. Ventilation plan for Step 1 is shown in Figure 5.1. The length of main transportation gallery is

3260 meters and the total length of maingates of G 01 is 3198 meters. To be on safe side, the application was determined for the case of 3260 meters. Ventilation in this system will be carried out with plastic tube plus auxiliary fans system.

Step 2: At this step, maingate of G 01 will be opened through the exhaust gallery of G 01 panel by one group of the crew as seen in Figure 5.2. Total lengths and cross – sectional characteristics of airways for this step are almost the same with ones for Step 1. Total length will be 2198 meters. Therefore there was needed nothing additional for Step 2 and it was decided that results taken from application for Step 1 would be valid for Step 2.

5.2. Second Stage Planning

This stage is application of main ventilation system. This stage also has two steps, namely Step 3 and Step 4.

In Step 3, there will be production in G 01 Panel and at the same time maingate road and face of the G 02 Panel will be opened as shown in Figure 5.3. For this step, summation of the development gallery (maingate) and the length of face will give the maximum distance to be ventilated. Therefore design was done considering for that maximum distance which is 3369 meters in length. In this step one main fan for G 01 Panel and one auxiliary fan for G 02 Panel will be operating as seen in Figure 5.3.

In Step 4, the production in G 02 panel and developments of G 03 panel will be continued simultaneously reaching to the total length of 3367 meters. This will be the worst step for the system as far as ventilation is concerned. In this step one main fan will be operated with one auxiliary fan as shown in Figure 5.4.

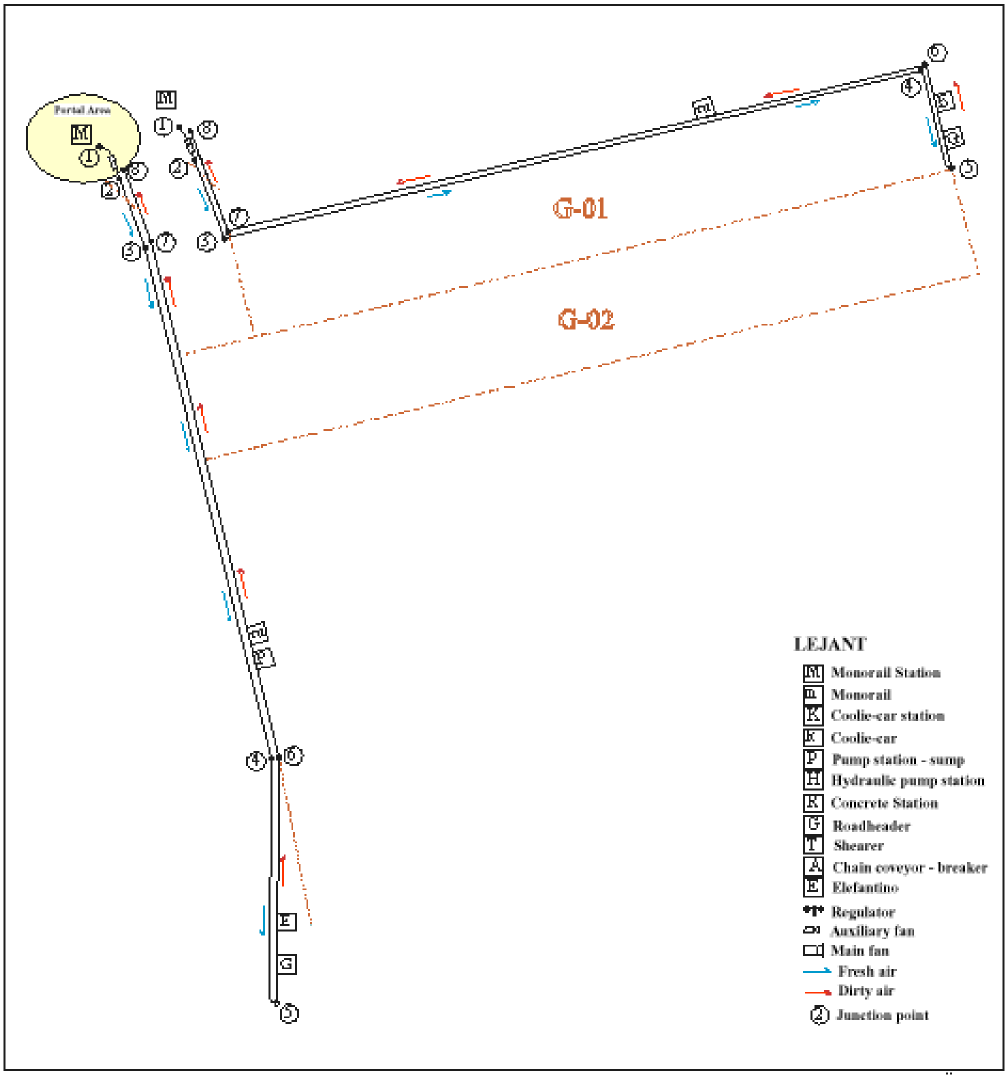

Figure 5.1 Ventilation plan for Step 1.

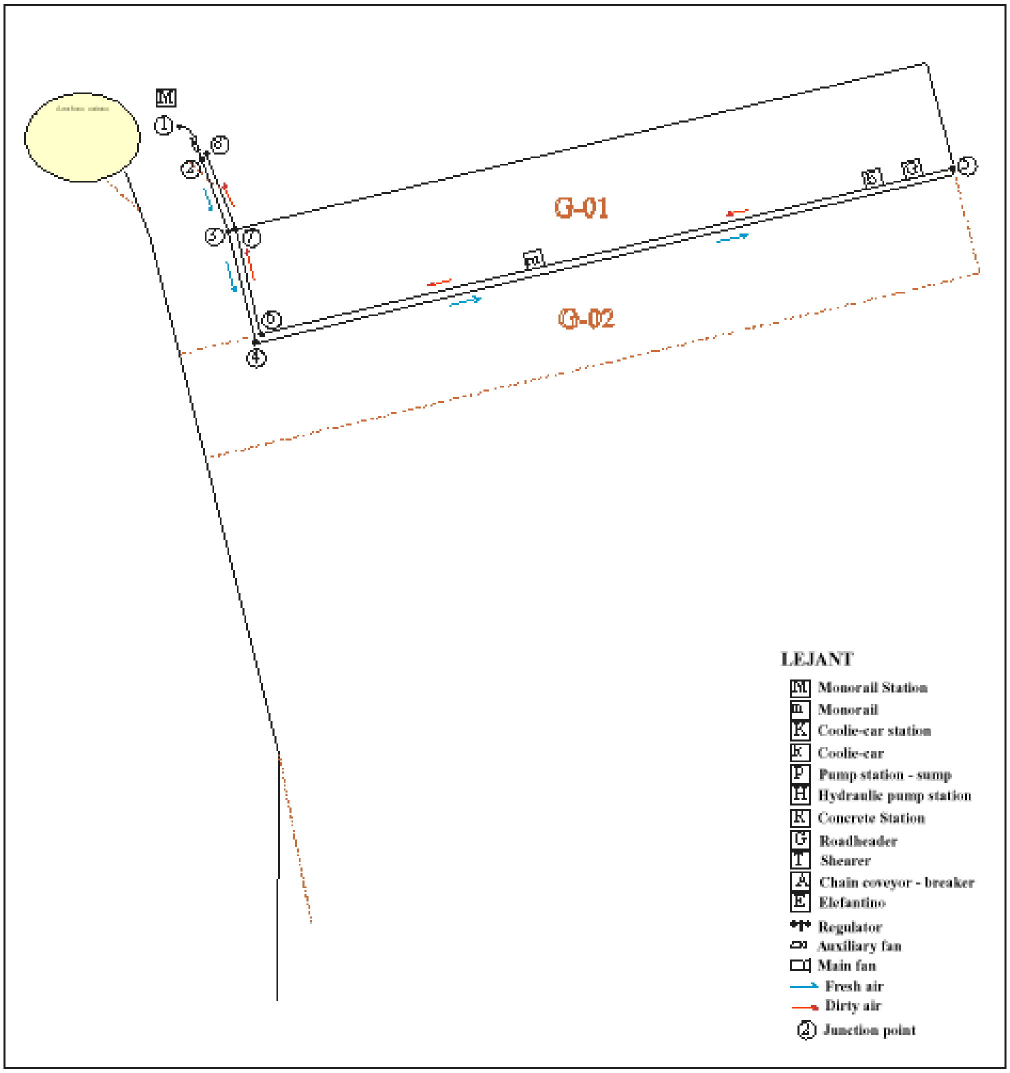

Figure 5.2 Ventilation plan for Step 2.

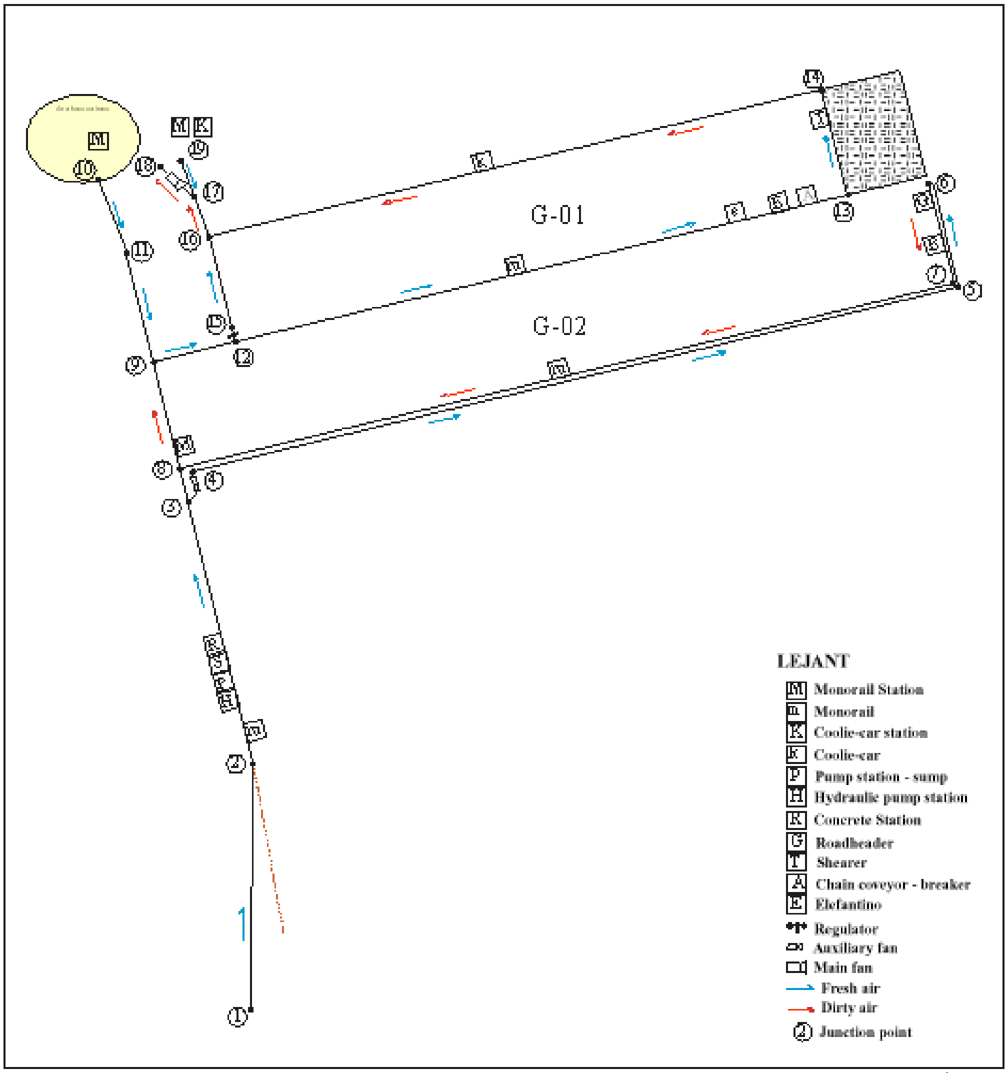

Figure 5.3 Ventilation plan for Step 3.

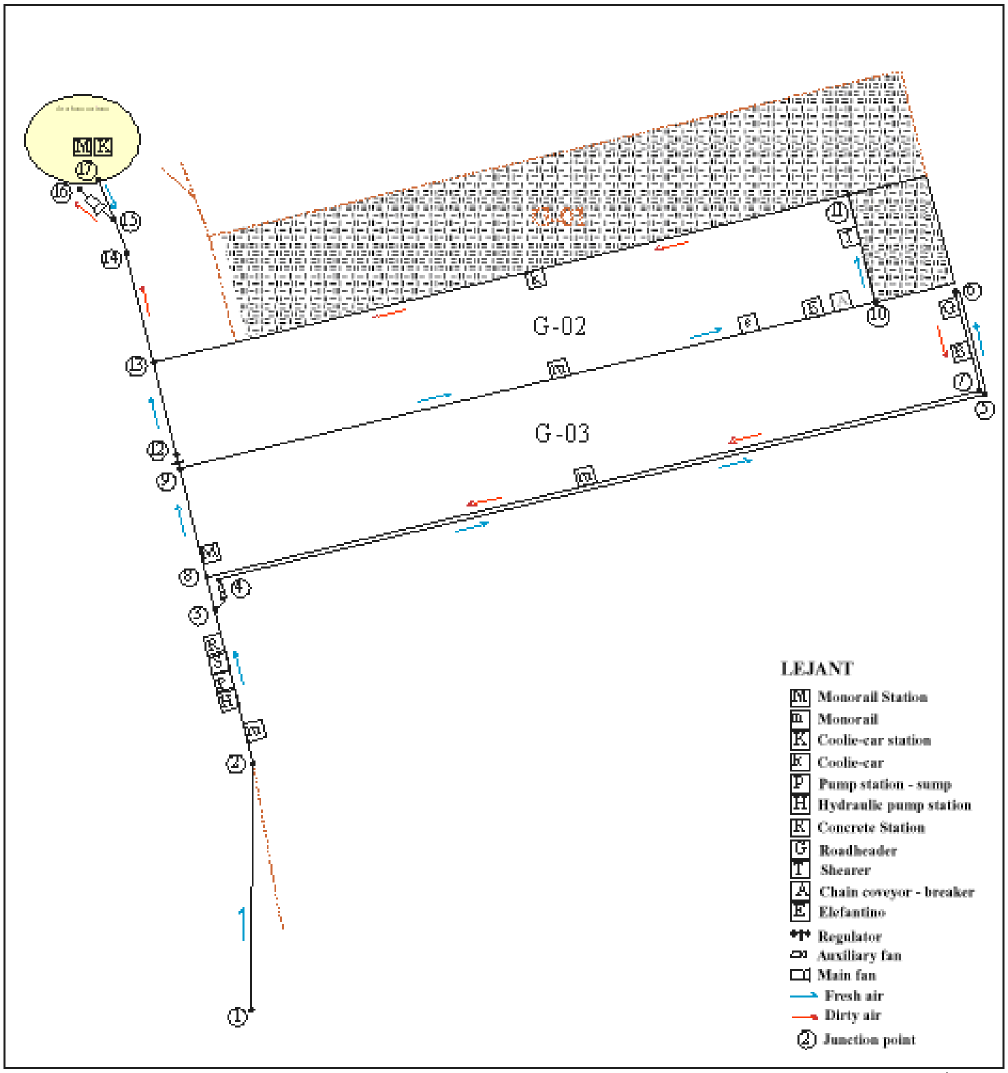

Figure 5.4 Ventilation plan for Step 4.

CHAPTER 6

MODELLING AND RESULTS

6.1. Modelling and Results for Stage 1

Stage 1 has two steps namely Step 1 and Step 2. Airway inputs for Step 1 are given in Table 6.1. These were used as input data for Vnetpc Program. Lengths in the table are valid for main transportation gallery from North to South. Because other development activities of Step 1, development activities of Step2, Step3 and Step 4 are almost the same with this example considering length, cross-section and losses. Modelling were built on this example and it was thought that at the same time this would represent the other steps also. Plastic tube characteristics are also given in Table 6.1 are for a plastic tube of 1200 mm. diameter. Modelling was also applied to plastic tubes of 1000 mm. diameter.

Table 6.1. Airway input data for Step 1

Road No	Length (m)	Shock loss type	Loss code	Equivalent length (m)	Total equivalent length (m)	Cross-section area (m^2)	Cross-section perimeter (m)	k (kg/m^3)
1-2	8	Entrance (with fan)	6	0	0	1.13*	3.77*	0.003
2-3	204	Contraction, gradual	4	0.4	0.4	1.13	3.77	0.003
3-4	1523	Bend, Obtuse, Sharp	1	5	5	1.13	3.77	0.003
4-5	1533	Bend, Obtuse, Sharp	1	5	5	1.13	3.77	0.003
5-6	1533	Bend, Acute, Sharp (from plastic tube-to roadwa Discharge (from plastic tube) Expansion, abrupt (from plastic tube to gallery) Mine car or skip (Roadheader, 30%) Mine car or skip (energy source, %15)	2 7 5 11 9	50 22 3 90 16	181	23.37	24.27	0.01762
6-7	1523	Bend, Obtuse, Sharp Contraction, abrupt (pump+water sump) Mine car or skip (monorail, 10%)	1 5 8	5 3 4.5	12,5	23.37	24.27	0.01762
7-8	204	Bend, Obtuse, Sharp Discharge (from gallery)	1 7	5 22	27	23.37	24.27	0.01762

First variable pressure losses were defined to the model and mine system curves for both plastic tube specifications according to obtained flow rate values. Then available auxiliary fan curves (see Figure 4.3) were defined to the model. An example was made considering Step 1 for the case shown in Figure 6.1. This example is done for main transportation gallery extending from North – South using Engart-30A40SCV/60HR model fan with a plastic tube of 1200 mm. diameter.

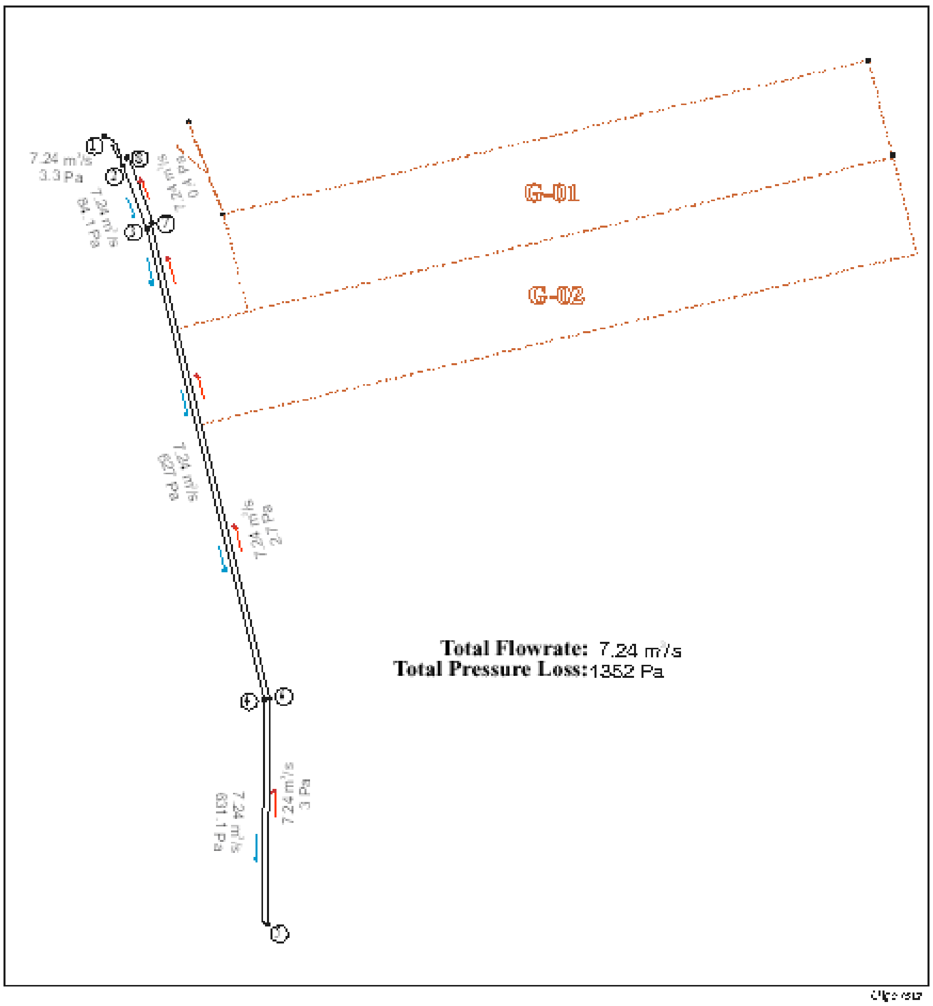

Figure 6.1 An application for main transportation gallery.

The intersection between fan pressure curve and mine characteristic curve (mine system curve) gives the operating point that is operating pressure and quantity.

Curves and intersections for all fan types are given in Figure 6.2. By this way series and parallel fan combinations, if suitable for the system, were intersected with mine system curves as seen in Figure 6.2 (a), (b), (c), (d), (e), (f), (g). Available efficiency percentages were written next to intersection points. At the end of this investigations, the most suitable combination with respect to efficiencies and air requirements were found. These results are given in Table 6.2. Results in this table were evaluated and used for determining the final fan type selection.

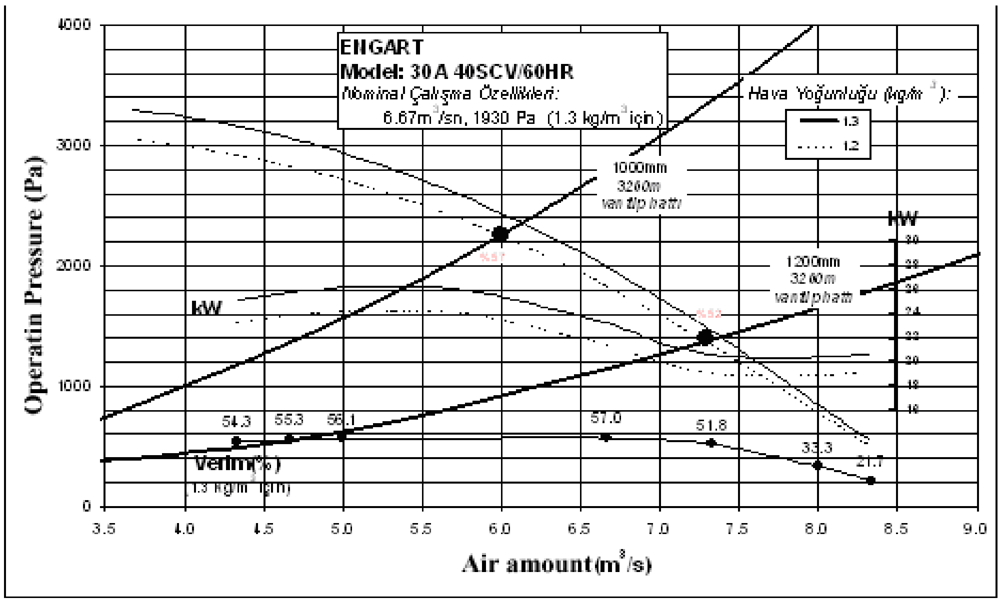

Figure 6.2 (a) Engart, 30A 40SCV/60HR results

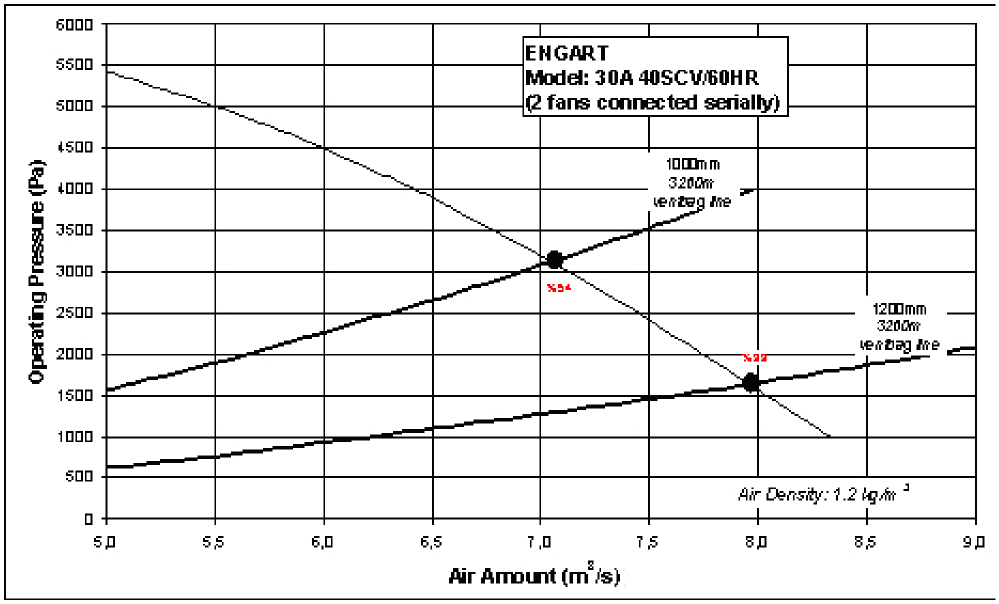

Figure 6.2 (b) Engart, 30A 40scv/60HR (2 connected serially) results

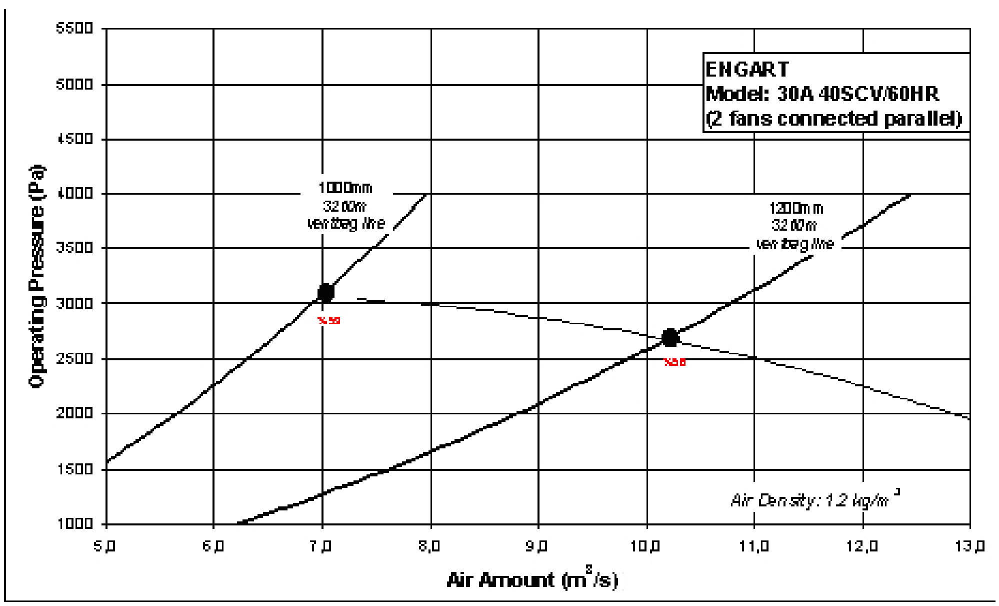

Figure 6.2 (c) Engart, 30A 40SCV/60HR (2 connected parallel) results

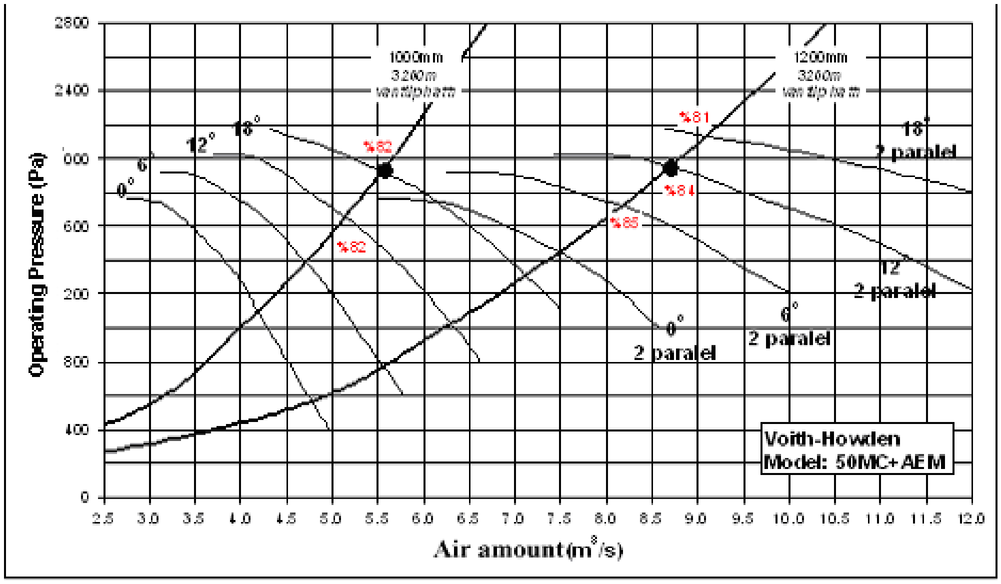

Figure 6.2 (d) Voith-Howden, 50MC+AEM results

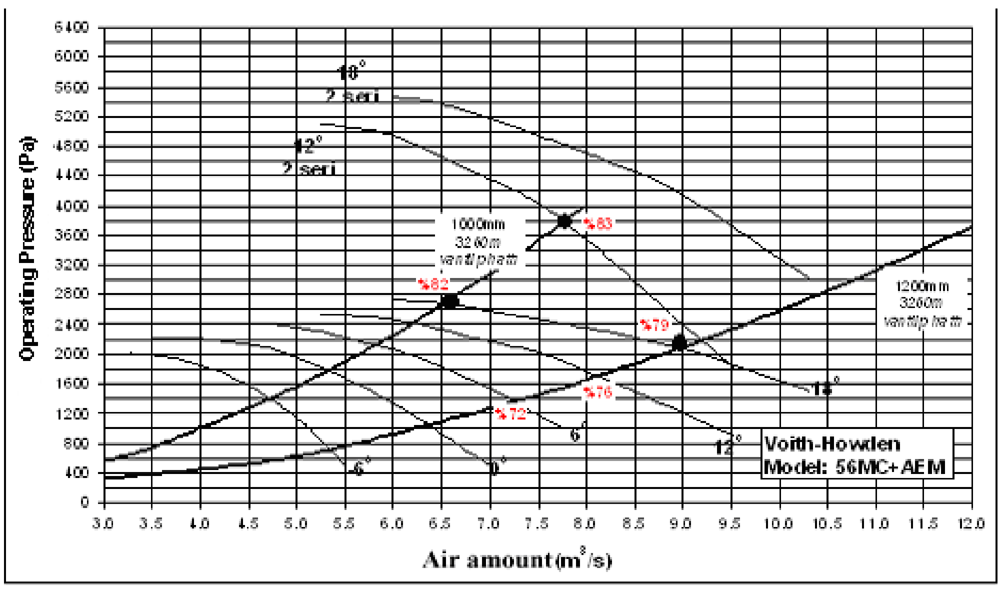

Figure 6.2 (e) Voith-Howden, 56MC+AEM results

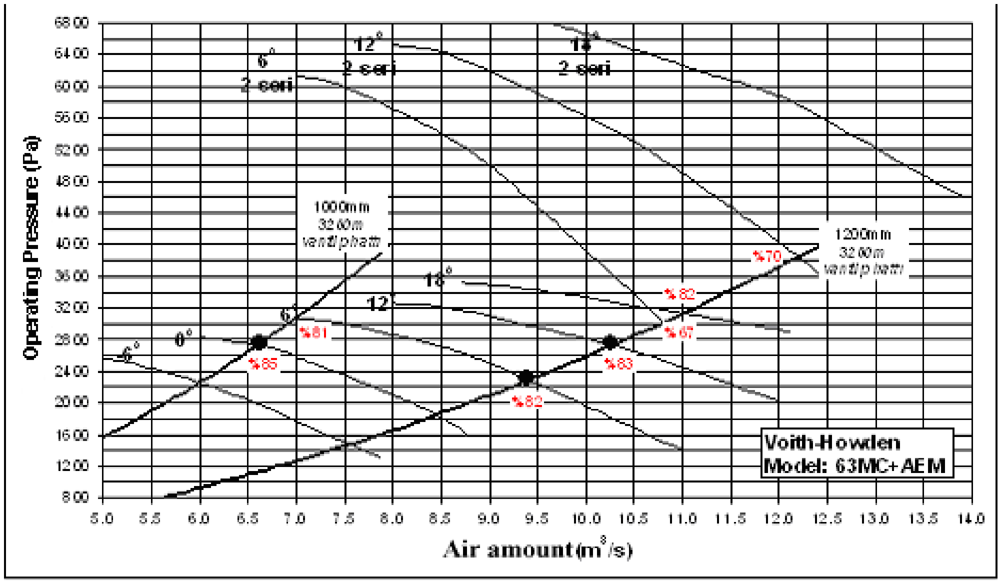

Figure 6.2 (f) Voith-Howden, 63MC+AEM results

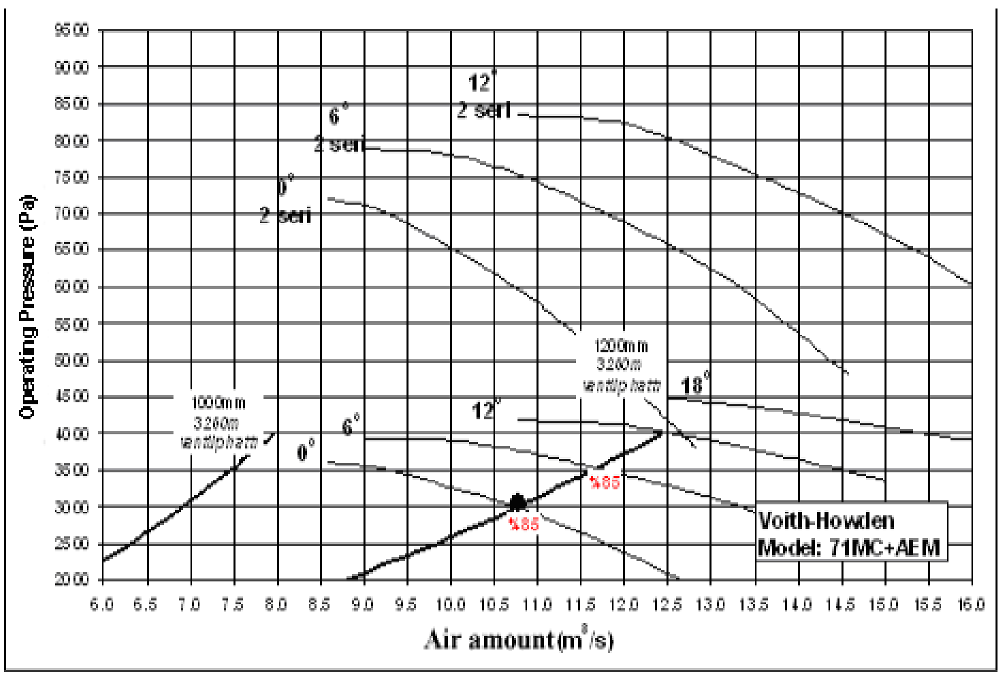

Figure 6.2 (g) Voith-Howden, 71MC+AEM sonuçları

Figure 6.2 Operating conditions of various fan combinations for Step 1.

Table 6.2 Most favourable operating conditions for Step 1.

Fan Model	Fan quantity and connection type	System property	Pressure (Pa)	Theoretical air amount (m^3/s)	Air Leakage (%)	Net air amount at the face (m^3/s)	Air power (kW)	Fan efficiency (%)	Required total motor power (kW)
ENGART, 30A 40SCV/60HR	1	1000mm plastic tube	2225	6	22.5	4.65	13.35	57	23.4
ENGART, 30A 40SCV/60HR	1	1200mm plastic tube	1390	7.3	18	5.99	10.15	52	19.5
ENGART, 30A 40SCV/60HR	2 (seri)	1000mm plastic tube	3100	7.1	27	5.18	22.01	54	40.8
ENGART, 30A 40SCV/60HR	2 (seri)	1200mm plastic tube	1600	7.95	19	6.44	12.72	33	38.5
ENGART, 30A 40SCV/60HR	2 (paralel)	1000mm plastic tube	3100	7	27	5.11	21.7	53	40.9
ENGART, 30A 40SCV/60HR	2 (paralel)	1200mm plastic tube	2700	10.2	25	7.65	27.54	56	49.2
V.HOWDEN, 50MC+AEM, 18º	1	1000mm plastic tube	1900	5.55	23.5	4.25	10.55	82	12.9
V.HOWDEN, 50MC+AEM, 12º	2(paralel)	1200mm plastic tube	1950	8.7	21	6.87	16.97	84	20.2
V.HOWDEN, 56MC+AEM, 18º	1	1000mm plastic tube	2650	6.55	24.5	4.95	17.36	82	21.2
V.HOWDEN, 56MC+AEM, 12º	2 (seri)	1000mm plastic tube	3800	7.75	29.7	5.45	29.45	83	35.5
V.HOWDEN, 56MC+AEM, 18º	1	1200mm plastic tube	2090	8.95	21.6	7.02	18.71	79	23.7
V.HOWDEN, 63MC+AEM, 0º	1	1000mm plastic tube	2700	6.6	25	4.95	17.82	85	21
V.HOWDEN, 63MC+AEM, 6º	1	1200mm plastic tube	2290	9.4	22.8	7.26	21.53	82	26.3
V.HOWDEN, 63MC+AEM, 12º	1	1200mm plastic tube	2700	10.3	25	7.73	27.81	83	33.5
V.HOWDEN, 71MC+AEM, 0º	1	1200mm plastic tube	3000	10.75	26.1	7.94	32.25	85	37.9

By evaluating the results given in Table 6.2, it is seen that air amounts to be sent to gallery face including losses due to plastic tubes can be determined also. In this step, there occur 8 alternatives to satisfy targeted air amount of 6 m^3/s (shadowed in grey). For all of these alternatives, plastic tubes with a diameter of 1200 mm. were used. From the results, it has been observed that ventilation of development galleries of G Field will be done by plastic tubes with a diameter not less than 1200 mm. By this way, it has also been observed that air amount to be sent to available development faces can not be obtained for G Field. Plastic tubes with a diameter more than 1200 mm. can be used at points where cross-sections are suitable. In this step, ventilation can be carried out with fans having relatively less capacities.

In this study, some data needed for final system selection was obtained by analyzing Capital Investment and Operating Costs for 8 alternatives from the information given in Table 6.2. Motor powers for each alternative, their capital investment and operating costs are shown in Table 6.3 and annual operating costs for selected alternatives were plotted as shown in Figure 6.3. Required information and some assumptions which are used in the preparation of input data are given below;

- Auxiliary Fan Requirement : 2 groups of crew for Step 1.
- Plastic tube Requirement : 3500 m. for each group, totally 7000 m.
- Price of 1200 mm. Plastic tube : 17.5 $/m.

- Price of 1000 mm. Plastic tube : 14.5 $/m.
- Price of Engart Auxiliary Fans : Available in Çayırhan, no investment cost.
- Price of Voith-Howden Aux. Fans : 15000 – 20000 $
- Operating Cost : 7 cents/kwh
- Operating Period of Fans : 330 days/year, 24 hours/day
- Amortization Rate : 10 %

Table 6.3 Economical analysis of chosen alternatives.

Alternative No.	Fan Model	Application	Plastic tube type	Net air amount (m^3/s)	Motor power (kW)	Fan investment ($)	Plastic tube investment ($€)	Total investment ($)	Amortization cost ($)	Operating cost ($/yıl)	Total operating cost ($/yıl)
1	ENGART, 30A 40SCV/60HR	1	1200mm	5.99	19.5	-	61250	61250	6125	10018	**16943**
2	ENGART, 30A 40SCV/60HR	2 (serial)	1200mm	6.44	38.5	-	61250	61250	6125	21370	**27495**
3	ENGART, 30A 40SCV/60HR	2 (parallel)	1200mm	7.65	49.2	-	61250	61250	6125	27265	**33390**
4	V.HOWDEN, 50MC+AEM, 12°	2(parallel)	1200mm	6.87	20.2	60000	61250	121250	12125	11197	**23322**
5	V.HOWDEN, 56MC+AEM, 18°	1	1200mm	7.02	23.7	15000	61250	76250	7625	13127	**20752**
6	V.HOWDEN, 63MC+AEM, 6°	1	1200mm	7.26	26.3	18000	61250	79250	7925	14554	**22479**
7	V.HOWDEN, 63MC+AEM, 12°	1	1200mm	7.73	33.5	18000	61250	79250	7925	18576	**26501**
8	V.HOWDEN, 71MC+AEM, 0°	1	1200mm	7.94	37.9	20000	61250	81250	8125	21035	**29160**

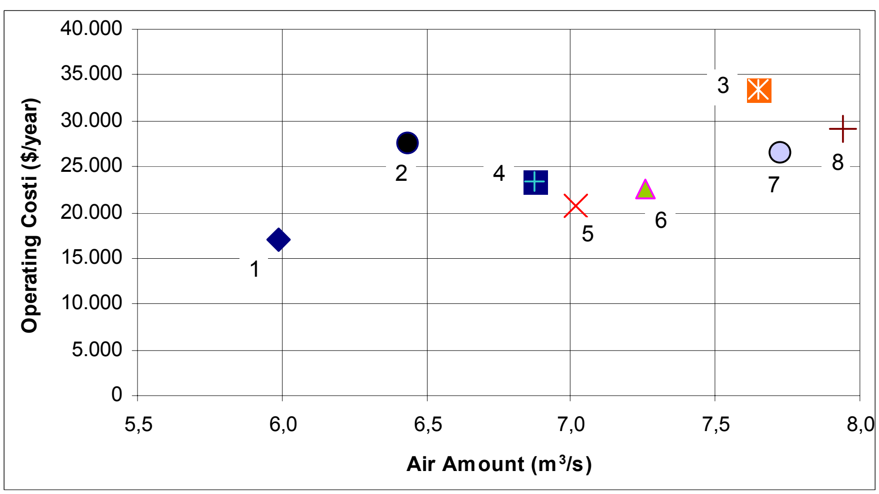

Figure 6.3 Annual operating costs for selected alternatives.

According to Figure 6.3, alternative 1 is the most economical and suitable one for the development ventilation system for G Field. Here for each system one Engart Fan will be used, its motor power will be 20 kw. Plastic tube with a diameter of

1200 mm. at a total length of 7000 m. will be purchased. Increasing the operating cost and air amount up to 7 m^3/s will make alternative 5 the most suitable one. For this alternative, in addition to plastic tubes 2 Voith – Howden 56MC+AEM fans will be purchased, so sending an air amount of 7 m^3/s to development faces will be possible with an annual operating cost difference of $3000. The alternative 6 should also be considered.

For other alternatives, either air amount is more than required or operating cost is very high.

6.2. Modelling and Results for Stage 2

Stage 2 has two steps, namely Step 3 and Step 4. For Steps 3 and 4, one active longwall panel and maingate development are available. Differences between them are total lengths of airways and related pressure losses. Possibly purchased fan will have a capacity of supplying the minimum air amount sufficient for each step. Therefore, having approximately the same airway lengths, a fan determined according to conditions of Step 4, will be sufficient for minimum air requirement of Step 3.

Input data and estimations used in modelling Step 3 and Step 4 are given in Tables 6.4 and 6.5.

Table 6.4 Airway input data for Step 3.

Road No	Length (m)	Shock loss type	Loss Code	Equivalent Length (m)	Total equivalent length (m)	Cross-section area (m^2)	Cross-section perimeter (m)	k (kg/m^3)
1-2	1533	Entrance (no fan)	6	1	1	24.5	20.5	0.01762
2-3	1182	Bend, Obtuse, Sharp Expansion, abrupt (pump+water sump) Expansion, abrupt (hyraulic pump station) Expansion, abrupt (power station) Expansion, abrupt (concrete station) Mine car or skip (monorail, 10%)	1 5 5 5 5 8	5 3 3 3 3 4.5	21.5	24.5	20.5	0.01762
3-4	6	Entrance (no fan) Contraction, abrupt (into plastic tube)	6 5	1 3	4	1.13	3.77	0.003
4-5	3124	Expansion, gradual (fan adaptor) Bend, Right, Sharp	4 3	0.4 23	23.4	1.13	3.77	0.003
5-6	245	Bend, Obtuse, Sharp	1	5	5	1.13	3.77	0.003
6-7	245	Bend, Acute, Sharp (plastic tube-gallery turn) Discharge (from plastic tube) Expansion, abrupt (from plastic tube to gallery) Mine car or skip (Roadheader, 30%) Mine car or skip (Energy source, 15%)	2 7 5 11 9	50 22 3 90 16	181	23.37	24.27	0.01762
7-8	3124	Bend, Right, Sharp Mine car or skip (monorail, 10%) Expansion, abrupt (from maingate to mainroad)	3 8 5	23 4.5 3	30.5	23.37	24.27	0.01762
3-8	6	Contraction, abrupt (1 aux.fan and plastic tube in cross-sect	5	3	3	23.37	24.27	0.01762
8-9	243	Mine car or skip (Monorail station, 20%) Bend, Right, Sharp	10 3	34 23	57	24.5	20.5	0.01762
10-11	204	Entrance (no fan)	6	1	1	25	20.5	0.01762
11-9	93	Bend, Obtuse, Sharp Bend, Right, Sharp	1 3	5 23	28	25	20.5	0.01762
9-12	356	Contraction, abrupt (from mainroad to maingate)	5	3	3	24.5	20.5	0.01762
12-13	2779	Mine car or skip (monorail, 10%) Mine car or skip (Energy source, 15%) Mine car or skip (breaker+BSL, 20%)	8 9 10	4.5 16 34	54.5	24.5	20.5	0.01762
13-14	234	Bend, Right, Sharp Contraction, abrupt (from maingate to face) Mine car or skip (Shearer, 40%)	3 5 12	23 3 170	196	21	22	0.02411
14-16	2785	Bend, Right, Sharp Expansion, abrupt (from face to maingate) Mine car or skip (coolie-car, 10%)	3 5 8	23 3 4.5	30.5	25	21	0.01762
12-15	2	Bend, Right, Sharp Expansion, abrupt (from maingate to mainroad) Mine car or skip (air door - regulator, 95%)	3 5 -	23 3 (a very big friction will be put)	-	25	20.5	0.01762
15-16	238	Bend, Obtuse, Sharp	1	5	5	25	20.5	0.01762
16-17	79	Bend, Obtuse, Sharp	1	5	5	25	21	0.01762
19-17	100	Entrance (no fan) Bend, Acute, Sharp Mine car or skip (air door - regulator, 95%)	6 2 -	1 50 (a very big friction will be put)	-	25	21	0.01762
17-18	88	Bend, Obtuse, Sharp Contruction, abrupt Discharge	1 5 7	5 3 22	30	25	20.5	0.01762

Table 6.5 Airway input data for Step 4.

Road No	Length (m)	Shock loss type	Loss Code	Equivalent Length (m)	Total equivalent length (m)	Cross-section area (m^2)	Cross-section perimeter (m)	k (kg/m^3)
1-2	1533	Entrance (no fan)	6	1	1	24.5	20.5	0.01762
2-3	934	Bend, Obtuse, Sharp Expansion, abrupt (pump+water sump) Expansion, abrupt (hyraulic pump station) Expansion, abrupt (power station) Expansion, abrupt (concrete station) Mine car or skip (monorail, 10%)	1 5 5 5 5 8	5 3 3 3 3 4.5	21.5	24.5	20.5	0.01762
3-4	6	Entrance (no fan) Contraction, abrupt (into plastic tube)	6 5	1 3	4	1.13	3.77	0.003
4-5	3122	Expansion, gradual (fan adaptor) Bend, Right, Sharp	4 3	0.4 23	23.4	1.13	3.77	0.003
5-6	245	Bend, Obtuse, Sharp	1	5	5	1.13	3.77	0.003
6-7	245	Bend, Acute, Sharp (from plastic tube-to gallery) Discharge (from plastic tube) Expansion, abrupt (from plastic tube to gallery) Mine car or skip (Roadheader, 30%) Mine car or skip (Energy source, 15%)	2 7 5 11 9	50 22 3 90 16	181	23.37	24.27	0.01762
7-8	3122	Bend, Right, Sharp Mine car or skip (monorail, 10%) Expansion, abrupt (from maingate to mainroad)	3 8 5	23 4.5 3	30.5	23.37	24.27	0.01762
3-8	6	Contraction, abrupt (1 aux.fan and ventbag in cross-sectio	5	3	3	23.37	24.27	0.01762
8-9	248	Mine car or skip (Monorail station, 20%) Bend, Right, Sharp	10 3	34 23	57	24.5	20.5	0.01762
9-10	3124	Bend, Right, Sharp Contraction, abrupt (from maingate to face) Mine car or skip (monorail, 10%) Mine car or skip (Energy source, 15%) Mine car or skip (breaker+BSL, 20%)	3 5 8 9 10	23 3 4.5 16 34	80.5	24.5	20.5	0.01762
10-11	245	Bend, Right, Sharp Contraction, abrupt (from maingate to face) Mine car or skip (Shearer, 40%)	3 5 12	23 3 170	196	21	22	0.02411
11-13	3124	Bend, Right, Sharp Expansion, abrupt (from face to maingate) Mine car or skip (coolie-car, 10%)	3 5 8	23 3 4.5	30.5	25	21	0.01762
9-12	2	Mine car or skip (air door - regulator, 95%)	-	(a very big friction will be put)	-	25	20.5	0.01762
12-13	241	-	-	0	0	25	20.5	0.01762
13-14	93	Bend, Right, Sharp	3	23	23	25	21	0.01762
14-15	104	Bend, Obtuse, Sharp	1	5	5	25	21	0.01762
17-15	100	Entrance (no fan) Bend, Acute, Sharp Mine car or skip (air door - regulator, 95%)	6 2 -	1 50 (a very big friction will be put)	-	25	21	0.01762
15-16	82	Bend, Obtuse, Sharp Contruction, abrupt Discharge	1 5 7	5 3 22	30	25	20.5	0.01762

For both steps, by changing pressure inputs for models prepared by Vnetpc 2000, air inlet amounts were determined and mine system curves were drawn. These curves were intersected with main fan pressure curves in section 4.5 and flow rates and power consumption for these fans were determined.

The most suitable fans selected from available database are shown in dark in Table 6.6. In section 4.2, minimum air requirement was defined as 35 m^3/s, but due to short-cuts at air doors in air returns and high dust concentration in South entrance and possible seasonal changes in natural ventilation, the fan to be determined should provide a flow rate of at least 50 m^3/s.

After these calculations, the investigation has been continuedto find out whether available fans in Çayırhan are suitable or not. Results are given in Figure 6.4.

Studying in Figure 6.4 unveils that Korfmann dAL model fan and the fan at the elevation of 855 meters can provide required air amounts to the system given in step 3. It can also be seen from the figure that DAVIDSON AJ6675 Model fan is not suitable for the operating conditions of G-Field. Configuration alternatives of Korfmann and fan at 855m. elevation are given in Figure 6.6 with their related values.

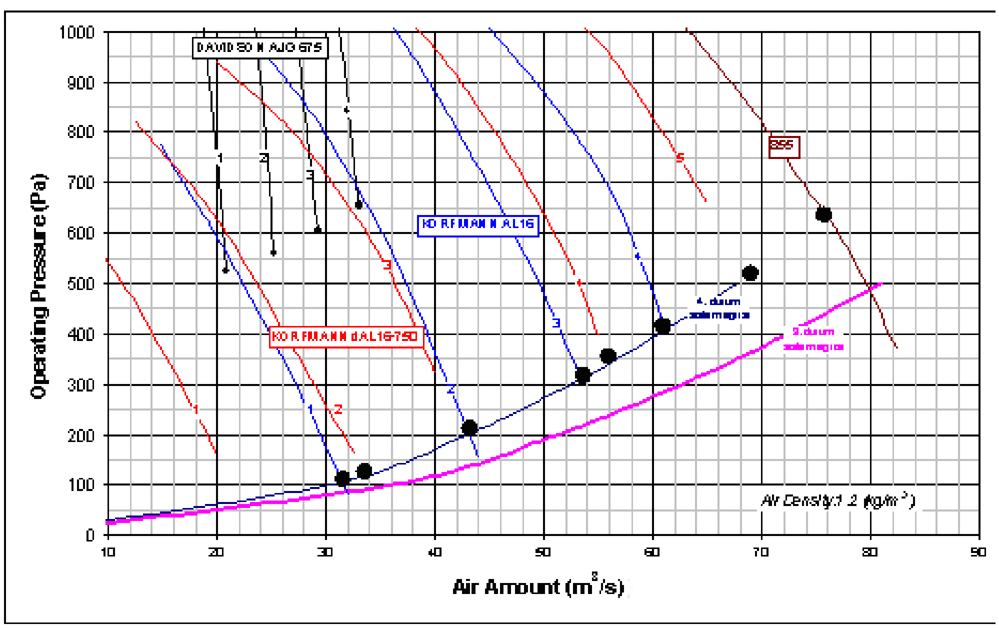

Figure 6.4 Results of available fans

Similarly, results of VAX2100 series fans from USA origin ALPHAIR firm catalog, which is the most suitable fans for G-Field conditions, were used to draw a graph (Figure 6.5) and their system results were given in Table 6.6 for the comparison.

In Table 6.6, due to the lack of efficiency performance curves or motor power curves related to any configuration of fans except ALPHAIR fans, an efficiency value of 25% was assumed in prediction of total motor power. The reason for this decision is that the intersection point of mine characteristics curves with performance curves (pressure curves) of these fans is at low efficiency zone. In fact, intersection points of ALPHAIR fans were also at low efficiency areas.

In this study, the most suitable fan was chosen from available database. As activities starts and related measurements are made, detailed information can be obtained from fan manufacturer firms and then fans with high efficiencies (less energy consuption) can be chosen by the use of their database.

When mine characteristics curves and performance curves of fans are shown on a common graph to make a comparison with respect to air amounts and motor power consumptions, it is seen that Alphair 5400 VAX2100-1460 rpm-HB model fan has the lowest motor power (having more advantage) at an interval of 50-65 m^3/s. Especially choosing the upper limit of this interval makes Alphair 5400 VAX2100-1780 rpm-HB model fan more efficient.

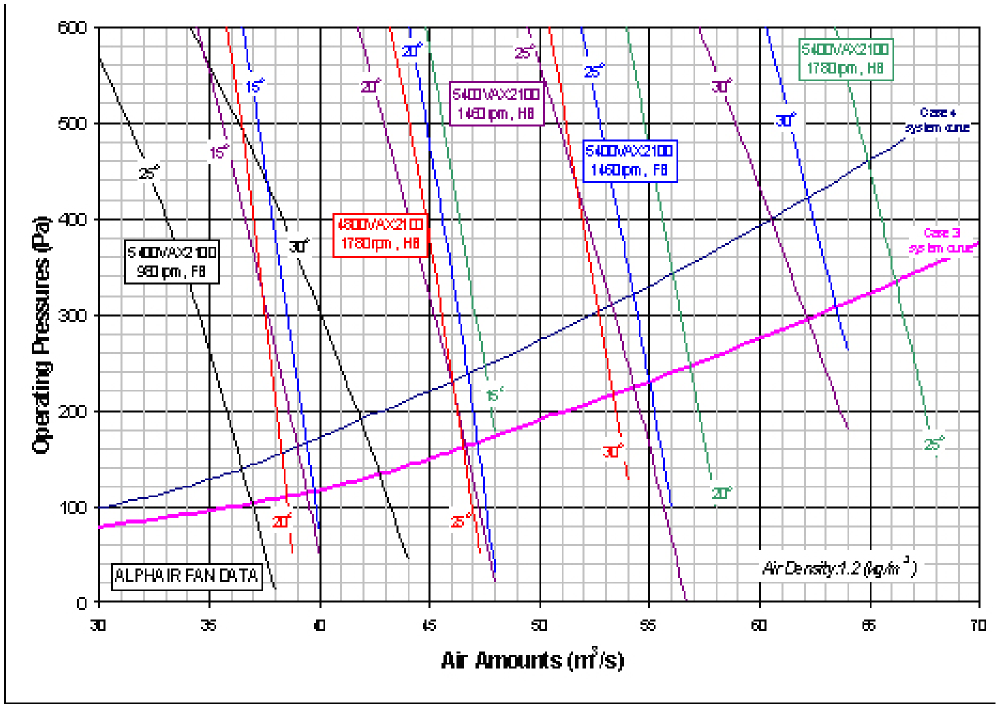

Figure 6.5 Results for Alphair Fans

Table 6.6 Results of available fans for Step 4.

Fan Model	Operating Parameters: Operating Pressure (Pa)	Air amount into the mine (m^3/s)	Air Power (kW)	Fan Efficiency (%)	Total Motor Power (kW)
855	630	76.00	47.9	25.0*	191.5
DAVIDSON, AJG 675, 1	-	-	-	-	-
DAVIDSON, AJG 675, 2	-	-	-	-	-
DAVIDSON, AJG 675, 3	-	-	-	-	-
DAVIDSON, AJG 675, 4	-	-	-	-	-
KORFMANN, AL 16, 1	105	31.50	3.3	25.0*	13.2
KORFMANN, AL 16, 2	205	43.00	8.8	25.0*	35.3
KORFMANN, AL 16, 3	310	53.50	16.6	25.0*	66.3
KORFMANN, AL 16, 4	410	61.00	25.0	25.0*	100.0
KORFMANN, dAL 16-750, 1	-	-	-	-	-
KORFMANN, dAL 16-750, 2	120	33.50	4.0	25.0*	16.1
KORFMANN, dAL 16-750, 3	205	43.00	8.8	25.0*	35.3
KORFMANN, dAL 16-750, 4	340	56.00	19.0	25.0*	76.2
KORFMANN, dAL 16-750, 5	515	69.00	35.5	25.0*	142.1
ALPHAIR FANLARI					
5400VAX2100 25d 980rpm, FB	120	36.50	4.4	23.7	18.5
5400VAX2100 30d 980rpm, FB	189	41.80	7.9	28.2	28.0
5400VAX2100 15d 1460rpm, HB	160	39.00	6.2	27.7	22.5
5400VAX2100 20d 1460rpm, HB	230	46.00	10.6	32.1	33.0
5400VAX2100 25d 1460rpm, HB	310	53.30	16.5	33.7	49.0
5400VAX2100 30d 1460rpm, HB	400	60.50	24.2	34.8	69.5
5400VAX2100 15d 1460rpm, FB	165	39.40	6.5	21.7	30.0
5400VAX2100 20d 1460rpm, FB	239	46.70	11.2	25.4	44.0
5400VAX2100 25d 1460rpm, FB	320	54.20	17.3	26.7	65.0
5400VAX2100 30d 1460rpm, FB	423	62.25	26.3	28.8	91.5
4800VAX2100 20d 1780rpm, HB	158	38.25	6.0	17.8	34.0
4800VAX2100 25d 1780rpm, HB	230	46.00	10.6	20.2	52.5
4800VAX2100 30d 1780rpm, HB	304	52.70	16.0	23.9	67.0
5400VAX2100 15d 1780rpm, HB	245	47.40	11.6	28.3	41.0
5400VAX2100 20d 1780rpm, HB	342	56.10	19.2	30.9	62.0
5400VAX2100 25d 1780rpm, HB	460	64.80	29.8	33.9	88.0

Korfmann dAL16-750 model, operated in Çayırhan C-field, can provide almost the same amounts of air by high motor powers causing more energy consumption. On the other hand air amount produced and motor power requirement of the fan at 855m. elevation is more than needed for G- field.

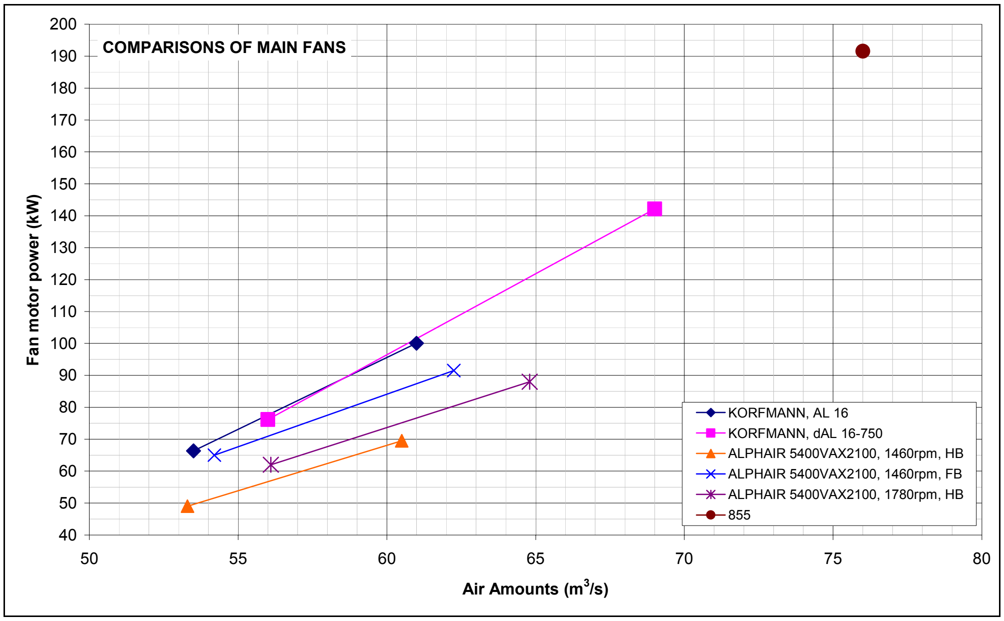

Figure 6.6 Comparisons of main fans with respect to efficiencies.

After the evaluations made above, net air amount to be sent to face by identified fan can be determined. Table 6.7 is prepared through data from the model. In this table, air flow rates used at the face for Step 4 are given. At the first stage, air amounts provided by fans, which are used in the modelling, can be seen in Appendix 1.

Table 6.7 Beneficial air amounts at the face by selected fans for Step 4.

Fan Model	Operating pressure (Pa)	Air amount into the mine (m^3/s)	Beneficial use rate (%)	Beneficial air amount at the face (m^3/s)	Total motor power (kW)
855	630	76	95	42.79	191.52
KORFMANN, AL 16, 3	310	53.5	95	34.39	66.34
KORFMANN, AL 16, 4	410	61	95	30.04	100.04
KORFMANN, dAL 16-750, 4	340	56	95	31.5	76.16
KORFMANN, dAL 16-750, 5	515	69	95	38.92	142.14
ALPHAIR FANLARI					
5400VAX2100 25d 1460rpm, HB	310	53.3	95	29.96	49
5400VAX2100 30d 1460rpm, HB	400	60.5	95	35.84	69.5
5400VAX2100 25d 1460rpm, FB	320	54.2	95	32.13	65
5400VAX2100 30d 1460rpm, FB	423	62.25	95	35.02	91.5
4800VAX2100 30d 1780rpm, HB	304	52.7	95	29.64	67
5400VAX2100 20d 1780rpm, HB	342	56.1	95	31.53	62
5400VAX2100 25d 1780rpm, HB	460	64.8	95	36.52	88

In Table 6.7, 5 configurations to provide minimum air flow rate of $35m^3/s$ necessary for the face are seen in gray. These are;

	Flowrates and motor powers
Fan at 855m. elevation	42.8 m^3/s, 191.5 kW
KORFMANN, dAL 16-750, 5	38.9 m^3/s, 142.0 kW
ALPHAIR, 5400VAX2100 30d 1460rpm, HB	38.5 m^3/s, 69.5 kW
ALPHAIR, 5400VAX2100 30d 1460rpm, FB	35.0 m^3/s, 91.5 kW
ALPHAIR, 5400VAX2100 25d 1780rpm, HB	36.5 m^3/s, 36.5 kW

The most economical alternative to provide necessary air amount for the face is ALPHAIR-5400VAX2100 HB model fan and its motor revolution will be 1400 rpm and its blade angle is 30^0. Fan available in C field will be adjusted according to configuration 5 (such a name is given because of the lack of blade angle information in performance curves), an air flow rate of 39 m^3/s will be produced with the motor power of 142 kW. But the energy consumption will be two times higher than the most economical one. That indicates that it is not a good selection.

It is known that, for underground ventilation systems fan operational costs are more important than fan capital investments. Fan capital investments show big differences depending on fan type, selected according to mine conditions and fan manufacturer firm. At the end it has a little effect in total investment. A fan, selected incorrectly, will cause serious negative effect in production costs, due to high energy consuption, as a result of low efficiency rate, to provide necessary air amount.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The conclusions drived from this study can be listed as follows.

This study showed that in the design of mine ventilation system and/or selecting suitable fans, it is a must to utilize the ventilation network software. In this study the recently developed program known as “VnetPC 2000” has been used.

In the first stage, which has two steps (1 and 2), the auxiliary ventilation designs are made. The first step (main transportation gallery (3260m from North to South) and second step (tailgate and maingate development (3198m) of G 01) have very similar ventilation characteristics. Therefore design for the longer one can be applied to both. Ventilation design for the first step showed that there are 8 favourable fans each satisfying the conditions (Table 6.2). Due to the economical analyses (Figure 6.3) the most economical one is found (ENGART, 30A 40SCV/60HR). It has also been observed that by increasing cost $4000, air amount can be increased 20%.

In the second stage, which has Step 3&4, the main ventilation designs are made. In Step 4, there will be production in G 02 Panel and at the same time maingate road and face of the G 03 Panel will exist. The total length to be ventilated is about the same with Step 3, but there exists an extracted panel, which can cause spontaneous combustion, therefore design has been conducted for this case. Ventilation design showed that 5 fans satisfy the requirements of generating 35 m^3/s. The fans providing 35 m^3/s of air are:

	Flowrates and motor powers
Fan at 855m. elevation	42.8 m^3/s, 191.5 kW
KORFMANN, dAL 16-750, 5	38.9 m^3/s, 142.0 kW
ALPHAIR, 5400VAX2100 30d 1460rpm, HB	38.5 m^3/s, 69.5 kW
ALPHAIR, 5400VAX2100 30d 1460rpm, FB	35.0 m^3/s, 91.5 kW
ALPHAIR, 5400VAX2100 25d 1780rpm, HB	36.5 m^3/s, 36.5 kW

Among these, the most economical one was selected considering operation costs. As a result ALPHAIR-5400VAX2100 HB was chosen. To reach more precise results the following recommendations should be considered.

- Values given or estimated in this study must be investigated later due to possible harder conditions to be encountered during operation of G Field.

- Natural ventilation pressure should be considered in the design of ventilation system.

- After completing main system galleries and first panel preparations, an investigation for losses (at faces and different airways) and natural ventilation affect should be made, necessary measurements have to be taken. So before purchasing a main fan, a more sensitive selection can be made and preventing an useless investment will be possible.

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APPENDIX I

To Find Operating System for the System

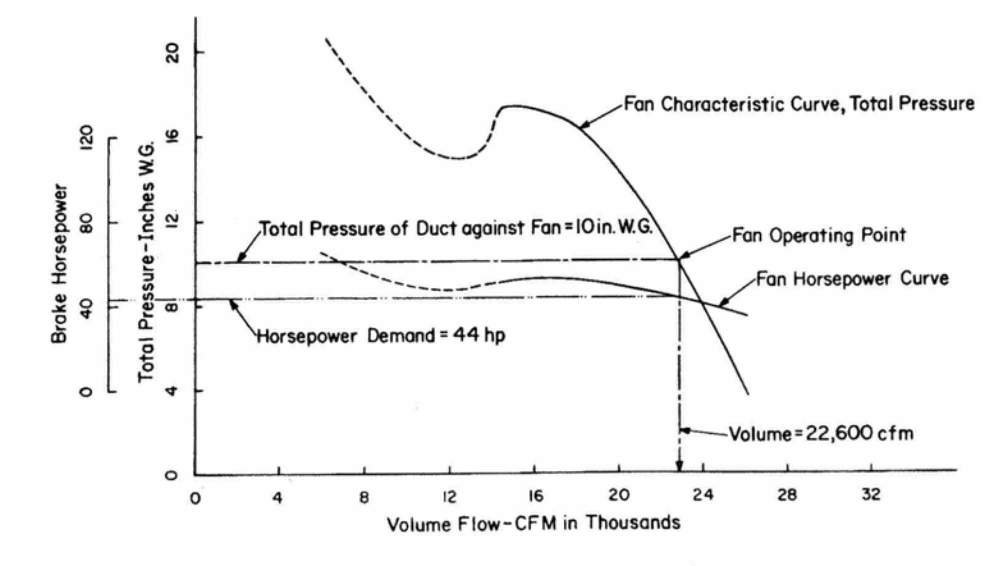

Figure I.1 An example for fan curve

APPENDIX II

Stratigraphy of Çayırhan

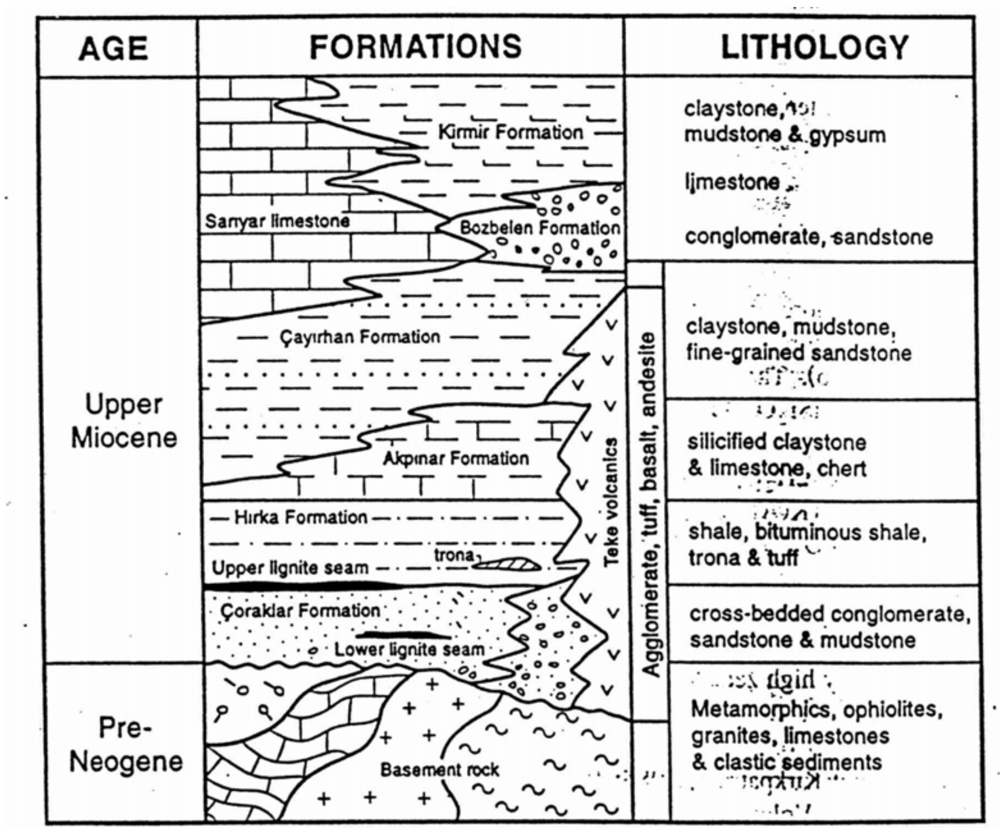

Figure II.1 Stratigraphy of Çayırhan