Türkiye 14.Madencilik Kongresi / *14th Mining Congress of Turkey,* 1995 , ISBN 975-395-150-7

ÇAYIRHAN LİNYİT OCAĞINDA OPTİMUM AYAK UZUNLUĞUNUN BELİRLENMESİ

DETERMINATION OF OPTIMUM FACE LENGTH AT ÇAYIRHAN LIGNITE COLLIERY

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ABSTRACT: In this study, firstly, the need regarding optimization of panel dimensions in underground coal mines utilising fully-mechanized longwalls as mining method, is described. Then, a detailed cost analysis is carried out for Çayırhan lignite field, which is Turkey's unique colliery using the fully-meçhanized longwall mining method. After calculations carried out for 6 distinct face lengths (110, 150, 200, 220, 250, and 300 m), optimum face length is found out for Çayırhan, and results obtained are evaluated in detail.

ÖZET: Bu çalışmada önce, üretim yöntemi olarak tam mekanize uzunayak uygulayan yeraltı kömür madenlerinde pano boyutlarının optımizasyonunun gerekçesi anlatılmıştır. Daha sonra, Türkiye'nin tam mekanize uzunayak yöntemi uygulayan tek kömür ocağı olan Çayırhan için ayrıntılı bir maliyet analizi yapılmıştır. 6 farklı ayak uzunluğu (110, 150, 200, 220, 250 ve 300 m) için yapılan hesaplamalardan sonra Çayırhan için optimum ayak uzunluğu hesaplanmış ve elde edilen sonuçlar ayrıntılı şekilde değerlendirilmiştir.

1. INTRODUCTION

Like every underground mining method, also longwall mining has its special conditions, limits and problems. These are, in short, problems relating to rock mechanics, safety of operation, ventilation, transportation, output capacity and mechanization possibilities. All these factors are strongly combined with coal panel dimensions, i.e. panel length and width, and mostly determine the face length. Whereas the panel length is chosen depending upon geological conditions in most cases, face length is, to a large extent, selected considering capabilities of equipment used on face. While this factor was, in earlier times, the most important factor in determining the optimum face length, since the mid-decades of the century, economical viewpoints has gained on significance. Assuming the presence of a certain level of geological conditions, face length is now dominantly determined by economic point of views and equipment available for longwall mechanization.

Optimum face length is bed-specific. This means that an optimum face length determined for a certain colliery is not valid for an other region, colliery or country, and data collected to calculate this length for a certain case cannot be generalised.

This study deals with a case study for determining the optimum face length at Çayırhan lignite colliery, where the unique fully-mechanized longwall operation of Turkey is earned out

2. A SHORT DESCRIPTION OF THE FTELD

The colliery is located 125 km west of Ankara. The two lignite seams of low to middle quality separated from eachother by a slate stone interburden with an average thickness of 0.85 m, are mined out using two longwall faces, where the upper face is operated 30-40 m in front of the lower face for reasons of geomechanical considerations. The retreating longwall faces are 220 m in length, have a pitch of approximately 20°, and operate using the caving system. The coal field is divided into several sectors, subject of this study is sector A with a mineable reserve of about 20 Mt.

Equipment used in faces are EickhofFs double-ended drum shearer loader EDW-200/230-L for coal winning, Westfalia Lünen's double-leg triple-telescopic lemniscatic shields WS 1.7 for face support, and Westfalia Lünen's double mid-chain face conveyor PF 2 30-K/732 for in-face haulage.

Since a panel's headgate is not allowed to cave, it thus forms the tailgate of the next panel. This way, there is no need to leave pillars among the panels. During mining, a roadside pack is stowed pneumatically This maintains the cross-sectional area required m the headgate and prevents mine fires by keeping air from short circuiting through the goaf area. For the transportation of workers and material, electnc locomotives, monorails and coolie cars are used. Coal is conveyed in the panel and mam haulage roads by using belt conveyors All development roads are driven employing roadheader machines.

3. METHOD OF DETERMINATION OF OPTIMUM FACE LENGTH

The question of which answer was looked for in the case of Cayirhan was not only if the chosen face length of 220 m is economic, but also which dependencies and relationships would appear in coal tinning cost when changing the A field's whole layout and rearranging all panels with different face lengths. So, 6 distinct face lengths, including the existent length of 220 m, have been applied to the A field's panels of Cayirhan colliery with the aim to see each time the effect of cost charges on general coal mining cost and the trend of cost curve, and its dependence on face length. In order to realise this object, the A field's layout has been computer-aided-designed 6 times by forming new panels each time, with the unique restriction of keeping A field's mineable coal reserve and annual coal production constant. In this way, at every face length, portional effect of cost charges on general cost and height of coal cost, i.e. economics of face length, could be seen.

The first step here was the determination of unit costs of road drivage in rock and coal using road heading machines, conventional drivage of face entries, face operation per meter face advance for fully-mechanised and conventional faces, face moves, coal transportation, ventilation, drainage, and maintenance of all roads and gates After the total cost of coal mining was calculated for the face length of 220 m considering operation parameters available in the colliery (this cost contains all expenditures in underground only), the same calculation steps were earned out for 5 different face lengths (110, 150, 200, 250, and 300 m). The parameters which change dependent upon face length (number of faces and face moves, total length of roads to be driven in rock and coal, mainteanance of roads etc.) were determined considering the assumption mat the mineable coal reserve of sector A, and the annual output capacity remain constant at all face length variations. Here, total costs are calculated for mining of the whole reserve of sector A, and, ventilation and drainage costs have been taken as constant at all face lengths

The second step was the design of 5 distinct mine layout plans with different face lengths and the calculation of mineable coal reserve of each panel using a 386-based PC Figure 1 shows two of these layout plans

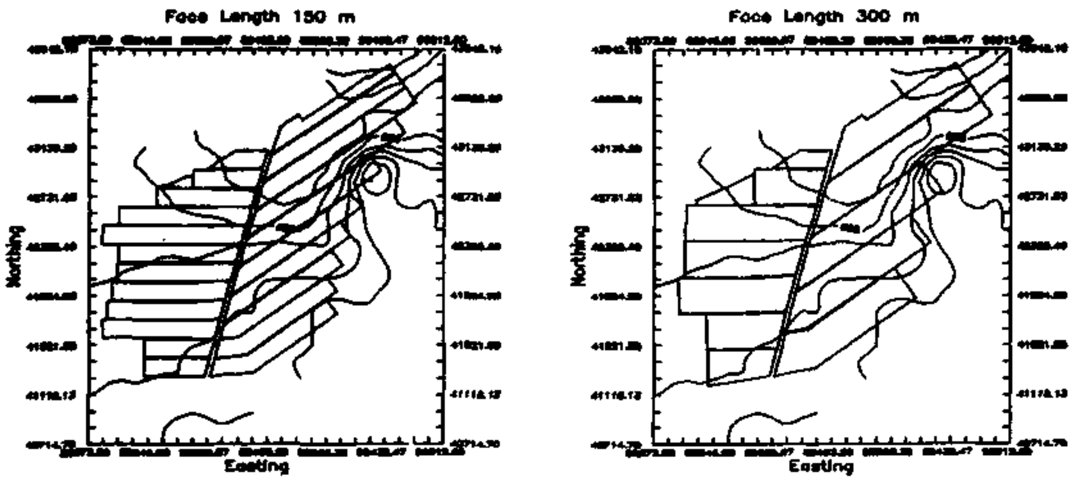


Figure 1. Mine layout plans for face lengths of 150 and 300 m

Based on these designs, length of roads to be driven in rock and coal was measured. Because the annual output capacity had been taken constant, number of faces to be operated, and denvaung herefrom, number of face moves, extent of face equipment etc could easily be found out The extention of the seam do not allow a fully-mechanised mining everywhere Therefore, it is assumpted that such coal seam parts will be won conventionally.

4 EVALUATION OF RESULTS OBTAINED AND CONCLUSION

Main factors that will effect amount of operational and investment costs over production life of a mine with known and unchangeable coal reserve, where for the optimum fece length is searched by changing each time the face length here, are, costs of face operation, length of in-seam roads, number of face moves, maintenance costs of roads of all types (especially of those to be used twice), and costs of conventional faces.

As can be seen in Table 1, to assure a constant annual production capacity, number of faces is 8 at 110 m face length, and 6 at ISO m face length. This causes that absolute investment costs of equipment of all feces operated in each case becomes larger at shorter faces than at mid-long feces, when thought on colliery basis On the other hand, the reason of the portional increase in investment costs of face equipment in longer feces (Figure 2), is, that AFCs used in this case and their auxiliary equipment are much more expensive than shorter ones. Another significant point that can be seen from Figure 2 is that portional cost of labor and personnel shows a decreasing tendency with longer faces, whereas percentages of other cost types remain nearly the same.

Table 1. General data related to costs calculated (over mine life) and colliery operation

Face Length -	110m	150 m	200 m	220 m	250 m	300 m
Rate of Advance (m/d)	3.40	3.40	3.40	3.40	3.00	2.50
Number of Working Faces	8	6	4	4	4	4
Mineable reserve (t)	14 063 780	14 060 442	14 064 659	14 067 918	14 063 991	14 068 642
Coal's Unit Cost (TL/t)	314 985	264 908	231236	222 638	228 266	245 610

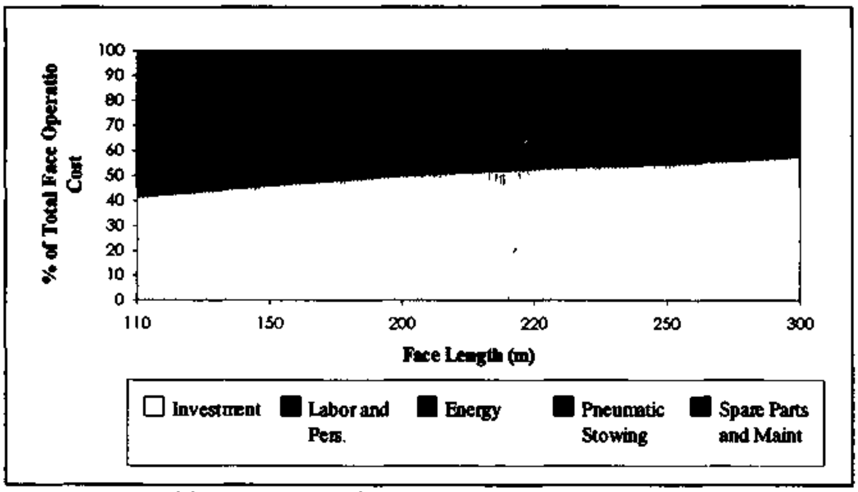


Figure 2. Cost percentages of face operation vs face length

Cost charge that effects the unit cost mostly is face operation costs. As shown in Figure 3, these costs are highest at shorter feces, while tending to decrease with longer faces and reaching their minimum at feces of lengths about 200 to 250 m, and again tend to increase with increasing face lengths The percentage of this cost type in total expenditures is 70.7 % at 110 m, 64 8 % at 200 m, 66 1 % at 220 m, and 68.8 % at 300 m face length, what shows that face operation is the most determining cost type of colliery operation costs

As mentioned before, road drivage costs decrease, from the shortest towards the longest face length, disproportionally in relation with decreasing number of panels, where in-seam drifts are the dominant road type (Figure 4). This is due to the decreasing total length of panel entries to be driven m disproportionate relation with increasing face length, which can be seen in Figure 5 Here, with increasing face length, portion of roads driven in coal decreases, and so, percentage of other types of roads (roads driven in stone, and setup entries) slightly increases

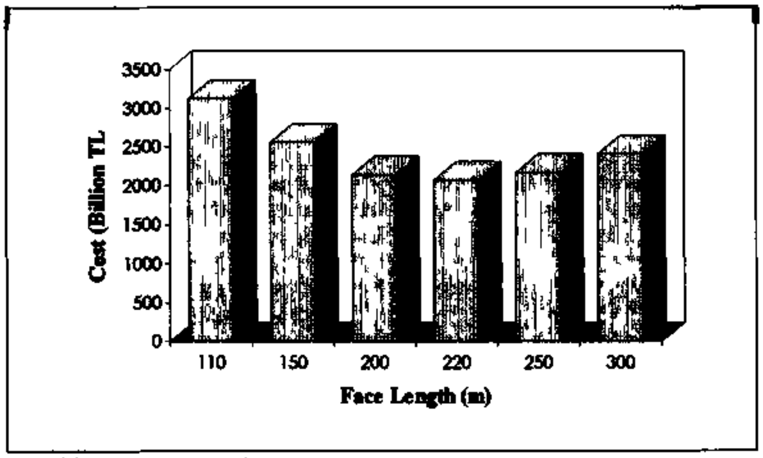


Figure 3 Total cost of face operation vs face length

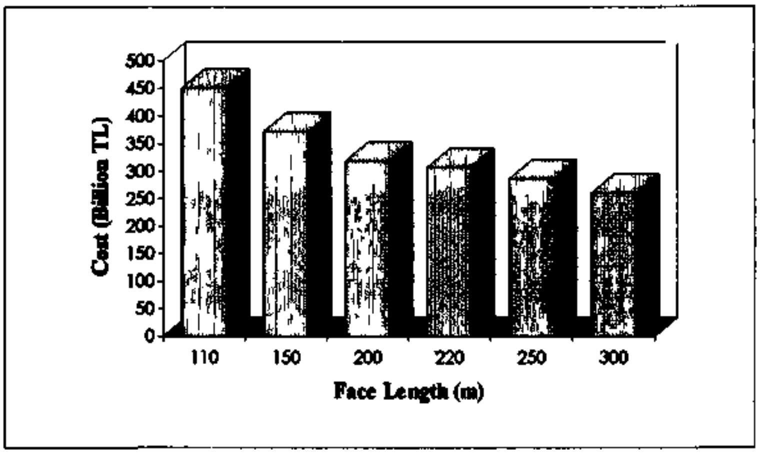


Figure 4 Total cost of road dnvage vs face length

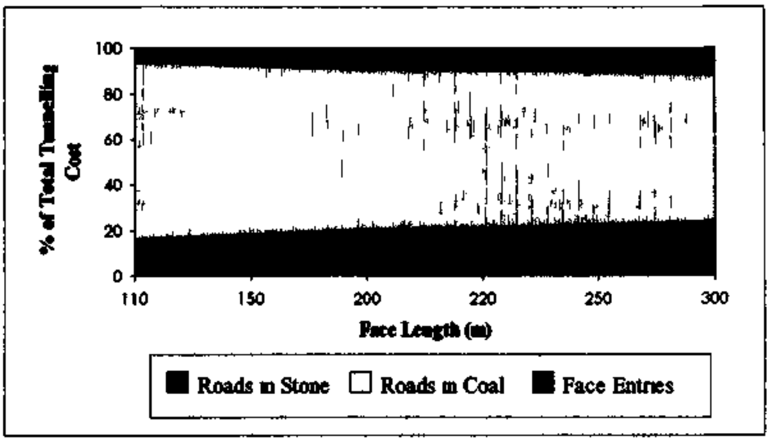


Figure S Portıonal costs of different road types vs face length

In Figure 6, cost distribution of driving roads of three distinct types is given. An important point to be considered here is that, although main roads are driven mechanically in rock and coal using road heading machines, nearly half of the total costs consists of labor and personnel costs, what shows that road drivage is rather a labor-intensive operation. This portion of cost type increases even to approx. 70 % at driving face entries. Moreover, the percentage of road drivage in total costs decreases from 10.2 % at 110 m face length to 7.6 % at 300 m face length. On the other hand, also road maintenance costs, in relation with entire road length to be driven in the colliery, decreases disproportionally with increasing face length (Figure 7), and forms a portional cost of 3.6 % at 110 m face length and 2.2 % at 300 m face length, respectively. Here, with increasing face length, portion of roads driven in coal decreases, and so, percentage of other types of roads (roads driven in stone, and gateroads) slightly increases (Figure 8).

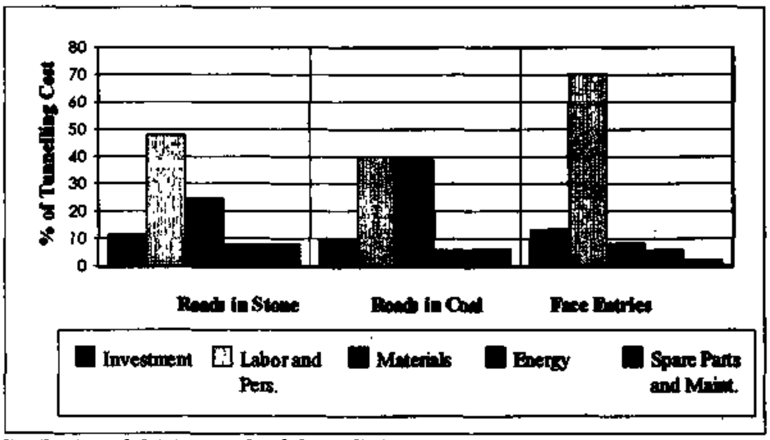


Figure 6. Cost distribution of driving roads of three distinct types

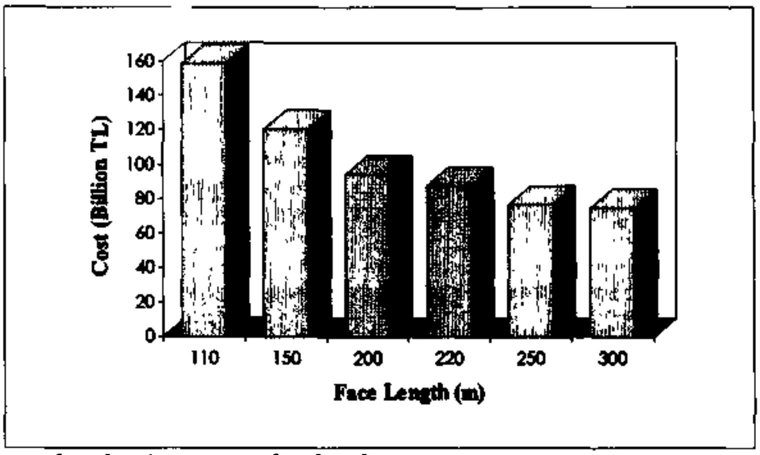


Figure 7. Total cost of road maintenance vs face length

As given in Figure 8, in all cases of different face lengths, panel entries (gateroads) cause almost 85 to 90 % of total cost of road maintenance. Costs of face moves decrease, like road drivage costs, with increasing face length due to the decrease in the number of panels (Figure 9).

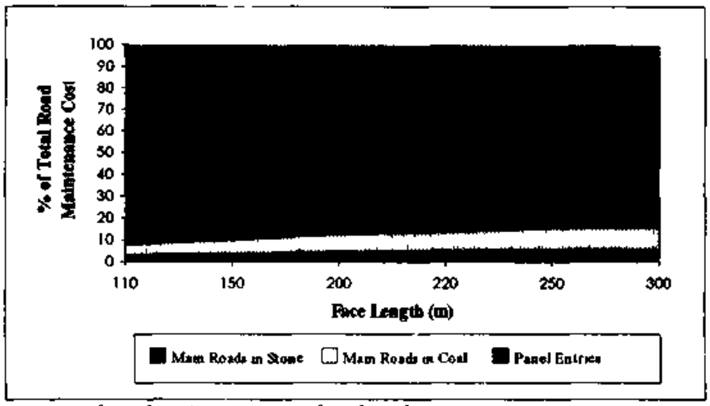


Figure 8 Cost percentages of road maintenance vs face length

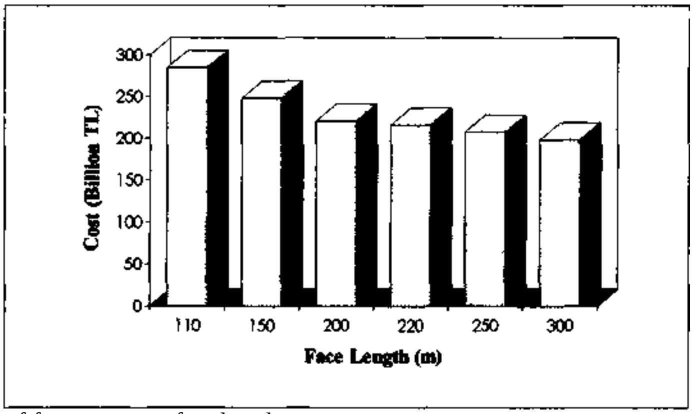


Figure 9 Total cost of face moves vs face length

As shown m Figure 10, about 95 % of cost is formed by labor and personnel, and, spare parts and maintenance costs m all face lengths Percentage of this cost type in colliery's total cost is with 6 9% highest at 220 m face length and with 5 7 % lowest at 300 m face length

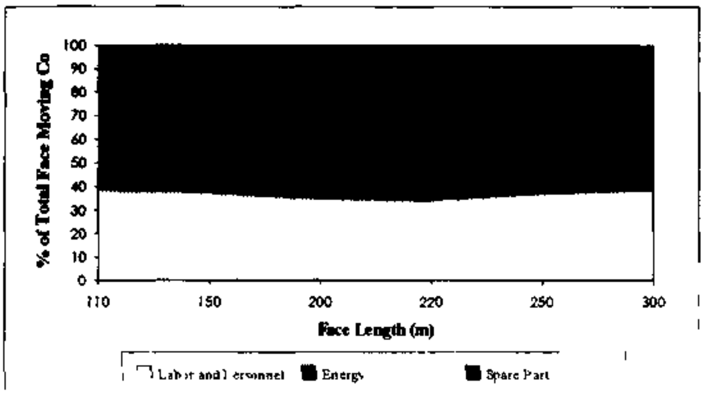


Figure 10 Cost percentages of face moves vs face length

Another important point in the case of Çayirhan is that, with increasing face lengths, panel boundaries are getting limited with coal seam boundaries due to the extension of seam and, therefore, dimensions of panels in the vicinity of seam boundaries get limited. For this reason, coal reserves which cannot be mined fully-mechanised because of their geometry, and must be won conventionally, increase. So, costs of conventional faces increase gradually from the shortest to the longest face (Figure 11). Percentage of this cost charge in total costs increases from 2.3% at 110 m face length to 6.2 % at 300 m face length.

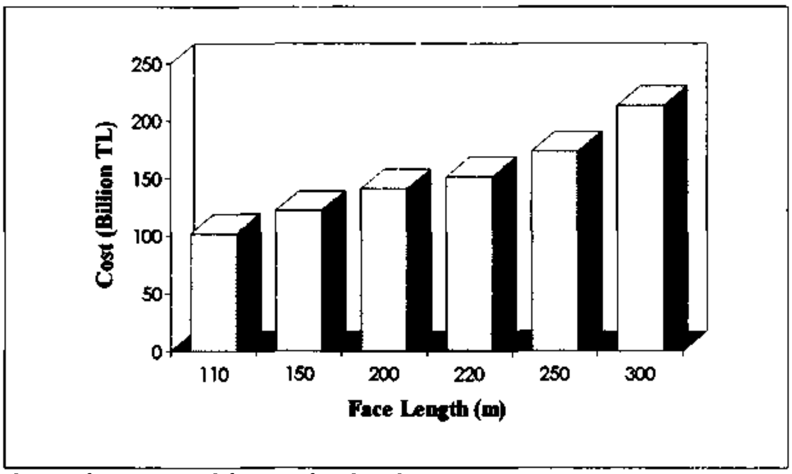
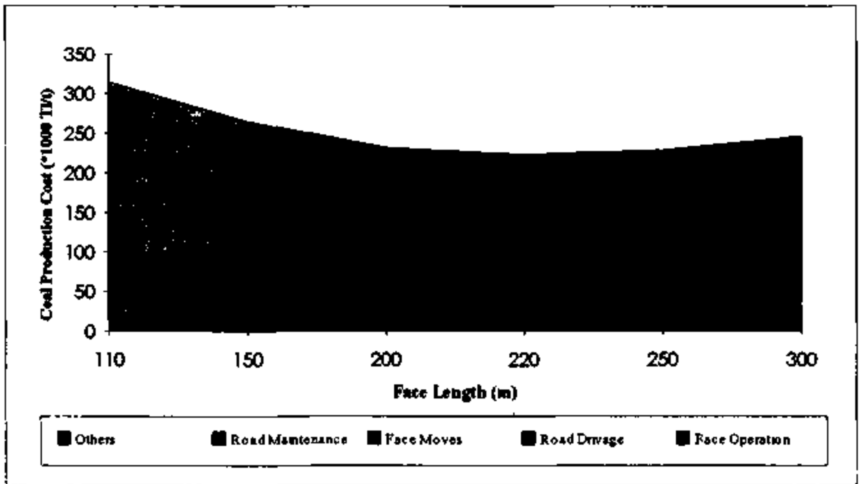


Figure 11. Total cost of conventional faces vs face length

By studying Figure 12, it can be seen that cost types most dependent upon face length are face operation costs, road drivage and maintenance costs, face moving costs, and costs of conventional faces. Therefore, in case of lengthening, and, in particular, shortening of face length, costs to be affected mostly are these ones Considering all these results within the values calculated with, in view of economics, optimum face length for the lignite colliery in Çayirhan results about 230 m. Actually, considering longwalls operating world-wide, it can be seen that face lengths mostly used are between 200 to 300 m.



•Figure 12 Cumulative total cost curve vs face length

The evaluations carried out up to here show that determining optimum coal panel dimensions, and face length in particular, is of decisive importance for the economic mining of an underground coal bed using fully-mechanised longwall mining. Meanwhile, in Turkey, some developments are made regarding the application of fully-mechanised longwall mining at lignite basins like Tunçbilek and Soma in future. Taking into consideration the existent mean conventional face lengths of 125 m in Zonguldak hard coal basin, 65 m in Tunçbilek, and 75 m in Soma, choosing a face length between 200 and 250 m for new developing basins would be a right decision from the view of operation efficiency, safety, and unit coal production cost. Also the 220 m face length presently utilised in Çayırhan can so be considered a suitable selection and it can be said that it reflects the world trend in parameters and technology regarding mining method utilised.

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