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Influence of Coal Face Mechanization on the Properties of Çayirhan Lignite

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ABSTRACT; The influence of coal face mechanization on the properties of r.o.m. coal - size, ash, sulfur, and moisture contents, volatile matter and calorific values - were investigated at Çayirhan (Ankara). Representative samples were obtained from r.o.m. coal and channel samples from two seams of panel A03 of Çayirhan Underground Coal Mine and chemically and physically analyzed. In addition, samples from roof and floor rock layers, which were unavoidably mixed with r.o.m. coal during mining operations, were taken and analyzed. The results show that the amount of fines and the ash, sulfur, and moisture contents of r.o.m coal in mechanized panels of Çayirhan Underground Coal Mine have increased, while the calorific value has decreased.

I INTRODUCTION

In order to improve working conditions and safety, increase production levels and decrease unit cost of production, it is essential to make use of up-to-date coal mining techniques, machinery and equipment in underground coal mines.

In current conditions, Turkey is not able to meet the demand for energy using only domestic sources. In the current situation, only around 33% of Turkey's energy needs are fulfilled by domestic sources. Turkey, with an annual population growth rate of 1.5% and an average annual growth rate in electricity required of 8.5%, is likely to be more and more dependent upon imported energy sources in the next few years (Özder et al, 1999). In addition, Turkish Coal Enterprises foresee that most of the open pit reserves in the country will have been mined within the next 10 years. In order to attain planned levels of coal production, underground coal reserves gain special attention. According to TKI, in the next 10 years and beyond, more coal is to be mined from underground mines. In addition to all this, due to the growing pressure resulting from environmental concerns, all products must be cleaner and more environmentally friendly than the ones produced in the past.

Therefore, to meet the demand of 2x150 MW power plants, the first fully mechanized panel went into operation İn Çayirhan Underground Coal Mine in 1986.

Despite the fact that the study presented here *was* carried out in 1990, due to the rapid depletion of open-pit reserves and the necessity of designing more underground mines in the next coming years, the subject is still important and valid All of the results of the analyses show that coal samples from mechanized faces are inferior to channel coal samples. Therefore, the results are significant for mines faced with transition from open-pit coal mining to underground coal mining.

2 GENERAL INFORMATION ABOUT THE MINE

2.1 *Location of the mine*

The area under consideration lies within the boundaries of the Ankara and Bolu provinces. Çayirhan is 125 km away from Ankara. The altitude of the region is approximately 1000 m.

2.2 *Coal seam*

Çayirhan Underground Coal Mine consists of two overlying lignite seams separated by an innerburden (interbedded siltstone layer) of 80 cm in average thickness. The upper seam is around 1.70 m thick and the lower seam is 1.80 m thick. A simplified section, showing the seams and the innerburden strata is shown in Figure I.

Figure 1. A simplified section of the seams.

2.3 *Mining method*

At the panel where this study was conducted (A03), the whole face section was mined as two longwall panels (upper face and lower face) working simultaneously. The interbedded siltstone layer was not mined but left at the goaf. The designed average distance between the upper and lower faces is around 30 m. The seams are located at a depth of 150-200 m from the surface with an inclination of 3°-45°.

A gradual transition from a conventional mining system to a semi-mechanized and then fully-mechanized underground coal mining system was first realized at Çayırhan Underground Coal Mine, formerly a subsidiary of the state-owned Turkish Coal Enterprises but recently privatized. Most of the modernization and transition of the mining system took place between 1982 and 1988. The first fully mechanized panel started to mine lignite in 1986.

With the conventional mining system, coal production was carried out manually, using picks, shovels, and blasting. The production rates were relatively low (225 tons/shift).

In Çayırhan Underground Coal Mine, a semi-mechanized panel was in operation between 1983 and 1985. At the face, extraction and the loading of coal onto the conveyor was carried out by hobel. Despite its unsuitable design and die fact that it was taken from Turkish Hard Coal Enterprises (another state-owned company) only on a trial basis, coal production increased to 460 tons/shift.

Finally, with fully mechanized panels, cutting and loading of the coal from the face was carried out by double-drum ranging arm shearer loaders. Face support was achieved with shield-type hydraulic supports. This system has raised the coal production to 1240 tons/shift.

2.4 *Change in r.o.m. production levels by year*

At the time when this study was conducted (1990), mined coal was not subject to any washing processes. It was only screened to +46 mm, -46+32 mm, and -32 mm. If we define fine coal as -32 mm and lump coal as +32 mm, Figure 2 below shows the fine and lump percentages according to year.

Table 1 lists the results of the analysis of saleable coal by year. Figure 3, Figure 4 and Figure 5 show the changes of the properties of saleable coal by year.

As it may be seen from the tables and figures presented in this section, there is a gradual decrease in the calorific value and lump percentage of the produced coal and an increase İn the ash, total sulfur and fines contents caused by the shift in mining method from a conventional to mechanized system. To determine why all these changes occurred, the experimental procedure described below was carried out.

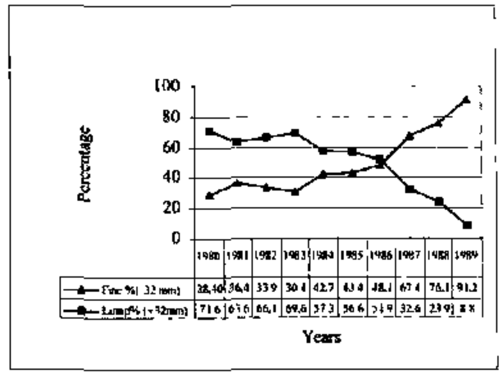

Figure 2. Fine and lump percentage of r.o m. by year.

Table 1. Analysis of saleable coal by year.

Year	Humidity %	Ash %	Total Sulfur %	UCV K.Cal/kg
1985	24.45	24 25	3.8	3590
1986	23.9	26 7	4 25	3430
1987	23 55	30.25	4 35	3180
1988	23 3	28.15	4 35	3175

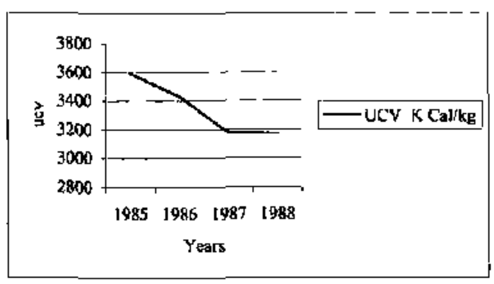

Figure 3. Upper calorific value (UCV) change by year.

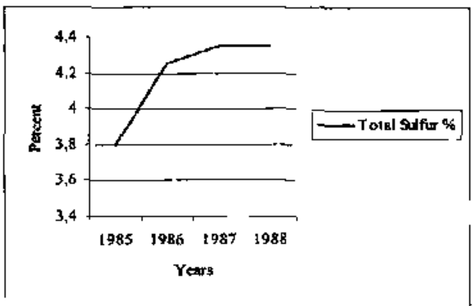

Figure 4. Total sulfur content of saleable coal by year

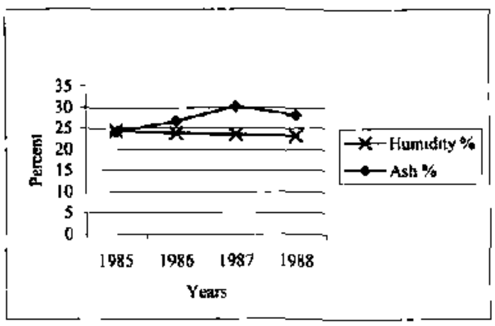

Figure 5 Humidity and ash contents of saleable coal by year

3 EXPERIMENTAL PROCEDURE

Representative samples of ın-situ and r.o.m. coals were collected from the interlaying rocks that were mixed with mined coal during coal-cutting operations. Fig.6 shows the general view of the coal seams, and innerburden layers mixing with mined coal when excavated.

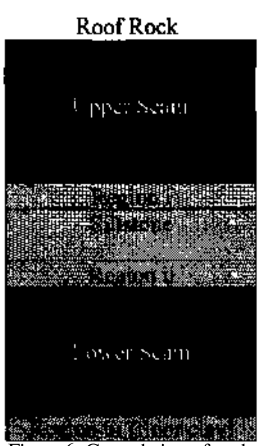

Figure 6. General view of coal seams, and innerburden layers mixing with mined coal when excavated

Region i. Roof of the siltstone layer. The shearer unavoidably cuts this region during coal cutting. The thickness of this layer depends upon the geologic conditions and operator's ability. Since there is no geologic disturbance, nothing is mixed from the main roof. This is because it is very strong and the shearer operator can follow this region visually.

Region iL Floor of the siltstone layer or roof of the lower seam. The siltstone layer between the two seams is so weak that there is continuous siltstone mixing with the mined coal during coal cutting and moving of the shield supports.

Region hi. Floor clay. Due to operating conditions, the operator unavoidably cuts this layer ofrock.

At boundary layers or contact zones (regions i, Ü, iii), there are bands *or zones* approximately 15 cm thick which are rich in fossils and pyntic sulfur content. The importance of these bands stems from their mixing with the produced coal. In this way, the sulfur and ash content of the r.o.m. coal is increased. To find the size distnbution and sulfur content of these zones, the procedure below was used; it is not possible to take pure samples of rock layer cuttings from the faces dunng coal production due to the loading principles of the shearers. For approximation, samples from these regions were collected from a preparatory gallery next to the production panel using a road header. All of the three regions were cut by road header and the samples were subsequently collected.

3.1 *Results of analysts of coal samples*

For comprehensive understanding of mined coal quality using the mechanized system, channel and r.o.m. coal samples were analysed and compared separately for both seams. The results are as follows:

Table 2. Results of analysis of the channel samples of panel A03 upper seam (as obtained)

Moisture (%)	22.86
Ash (%)	27.14
Volatile matter (%)	29.38
Fixed carbon (%)	20.62
Total S (%)	:3.72
Lower cal. val. (K.Cal/kg)	2700
Upper cal. val (K.Cal/kg)	3033

Table 3. Results of analysis of the rom. samples of panel A03 upper seam (as obtained)

Moisture (%)	24.92
Ash (%)	32.46
Volatile matter (%)	23.95
Fixed carbon (%)	18 67
Total S (%)	•4.24
Lower cal. val. (K.Cal/kg)	2183
Upper cal. val (K.Cal/kg)	2488

Table 4 Results of analysis of the channel samples of panel A03 lower seam (as obtained)

Moisture (%)	: 23.43
Ash (%)	: 26.77
Volatile matter (%)	: 28.31
Fixed carbon (%)	: 21.49
TotalS(%)	:3.33
Lower cal. val (tCCal/kg)	: 2650
Upper cal, val (K.Cal/kg)	: 2925

Table5 Results ofanalysisof ıhero.m samplesof panel A03 lower seam (as obtained)

Moisture (%)	24.12
Ash (%)	34.96
Volatile matter (%)	26.47
Fixed carbon (%)	14.45
Total S (%)	:3.72
Lower cal. val. (K.Cal/kg)	1882
Upper cal. val (K.Cal/kg)	2184

3.2 *Results of analysis of rock cuttings*

The percent sulfur content of the rock cuttings was obtained 5.33 and the percent moisture content of the samples was 11. From the screen analysis results it was observed that the size of the rock cuttings generally varied between -50 mm and +0.5 mm.

3.3 *Comparison of channel and r.o.m. coal samples of pane! A03 using screen analysis results.*

3.3.1 *Lower seam*

Tables 6 and 7 list the results of the analysis of the lower seam channel and r.o.m. samples on an air-dried basis in different size fractions.

Figures 7, 8 and 9 compare the results for the channel and r.o.m. samples of the lower seam

3.3.2 *Upper seam*

Table 8 and 9 list the results of the analysis of the upper seam channel and r.o.m. samples on an air-dried basis in different size fractions.

Tablée Results of analysis of lower seam channel samples.

Size(min)	Wt(%)	Ash(%)	Total S(%)
+100	20 96	18 72	4 28
-100+50	23.24	19 13	4 3b
-50+18	27.95	17 16	4 34
-18+10	M 98	22 45	4 48
-10+0 5	14.9	20 82	444
-0 5	0 88	23 62	4 75
TOTAL	100	19 17	4 36

Table7 Results of analysts of lower seam r o.m samples

Si?efmm^	Wtf%ï	Ashf°/^	Total Sf%ï
+100	12.37	39 27	4 72
-100+50	16 48	42 30	4 80
•50+18	24.92	46 52	5 28
-18+10	16 38	48 91	4 89
-10+05	19 46	44 35	4 73
-0 5	9 94	47 21	4 34
TOTAL	100	44 98	4 87

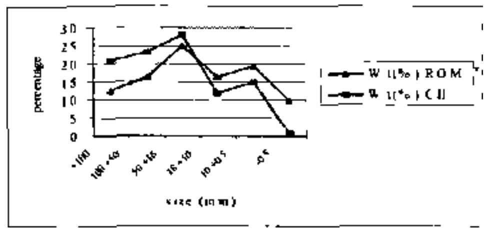

Figure 7 Companson of size distribution percentages of channel and r.o m samples oflower seam

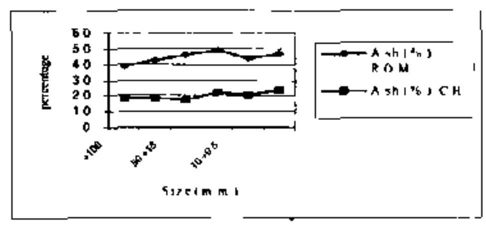

Figure 8. Comparison of ash percentages of channel and r.o m samples of lower seam.

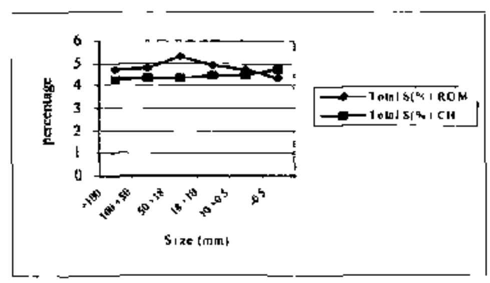

Figure 9. Companson of sulfur contents of channel and r.o.m samples oflower seam.

Table 8. Results of analysis of upper seam channel samples

Size(mm)	Wt(%)	Ash(%)	Total S(%)
+ 100	17.13	28.92	4.12
-100+50	10.68	30.43	4.73
-50+18	28.42	31.28	4.26
-18+10	16.34	28.96	4.02
-10+0.5	26.32	25.72	4.52
-0.5	1.M	29.47	4.46
TOTAL	100	28.92	4.3!

Table 9. Results of analysis of upper seam r.o.m. samples.

Size(mm)	Wt(%)	Ash(%)	Total S(%)
+ 100	10.92	34.27	4.43
-100+50	14.43	38.48	4.2
-50+18	27.35	47.86	6.12
-18+10	17.92	37.43	6.23
-10+0.5	17.83	32.1	5.46
-0.5	11.55	33.96	5.37
TOTAL	100	38.74	5.53

Figures 10, 11 and 12 compare the results of analysis of the channel and r.o.m. samples of the upper seam.

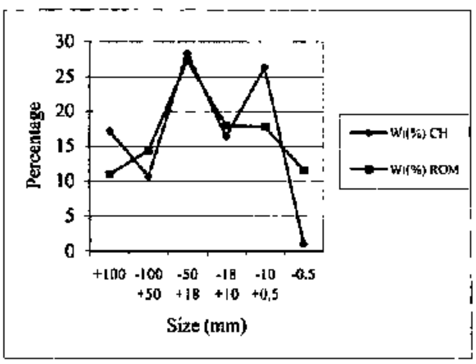

Figure 10. Comparison of size distributions of channel and r.o.m. samples of upper seam.

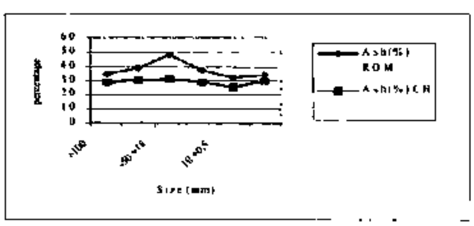

Figure 11. Comparison of ash percentages of channel and r.o.m. sample«.

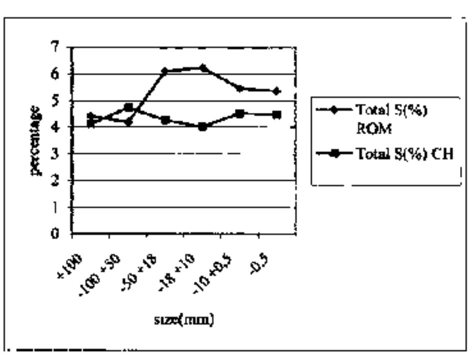

Figure 12. Comparison of sulfur contents of channel and r.o.m. samples.

4 DISCUSSION AND CONCLUSIONS

The analysis of the upper and lower seams in with regard to channel and r.o.m. coal samples shows that due to mechanized coal cutting systems, the moisture, ash, and sulfur contents of the r.o.m. coal samples from Çayırhan Underground Coal Mine were greater than those of the channel samples.

The increase in the moisture content of the mined coal is mainly due to the use of water as a coolant for the cutting tools of the shearers and for the suppression of dust.

The increase in the sulfur content of the mined coal is due to the mixing of the interbedded roof and floor rock cuttings, which have a pyritic sulfur content of 5.33%.

The increase in the ash content of the mined coal is due to the mixing and cutting of neighboring rock layers during coal mining. The increase in the ash content of the r.o.m. samples from the lower seam İs greater than that of the samples from the upper seam. This is due to the weak character of the siltstone layer lying between the two seams. Since this weak layer constitutes me roof of the lower longwall face, a considerable quantity of siltstone particles are mixed during mining operations.

Referring to the statistics produced by the mine management (Table 1, Figures 2, 3, 4 and 5), it can be observed that in the transition from conventional to semi-mechanized and then to mechanized systems, the fines, ash and total sulfur contents of mined coal gradually increase and the calorific value decreases.

The mechanization of Çayırhan Underground Coal Mine has led to remarkable improvements in productivity, from 225 tons/shift to 1240 tons/shift, but the detrimental effects of this transition must be carefully considered in all mines faced with such a transition.

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