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IMPROVEMENTS ON THE SHEARER DRUM PERFORMANCE AT ÇAYIRHAN "A" FIELD

ÇAYIRHAN "A" SAHASINDA KESİCİ YÜKLEYİCİ TAMBUR PERFORMANSLARININ İYİLEŞTİRİLMESİ

E. Mustafa EYYUBOĞLU, *Çankaya Üniversitesi, End. Müh. Böl, Ankara*
Yakup KAYGUSUZ, *Park Termik Elektrik Sanayi ve Ticaret A.Ş., Ankara*
Michael ENSTE, *Kennametal Hertel GmbH & Co. KG, Germany* *
Naci BÖLÜKBAŞI, *ODTÜ, Maden Müh. Bölümü, Ankara*

ABSTRACT

"A" and "F" fields of Çayırhan Coal district have been operated by Park Termik Elektrik Sanayi ve Ticaret A.Ş. since the middle of 2000. A general rehabilitation work has been conducted through the mine including the shearer drums. For this purpose the drums in "A" field were replaced by new drums.

In this study, design specification of the new drums, results obtained and a comparison between old and new drums are presented. Important improvements have been achieved by new drums as compared to old drums.

ÖZET

Çayırhan kömür havzasındaki "A" ve "F" sahalarında kömür üretim çalışmaları 2000 yılı ortasından itibaren Park Termik Elektrik Sanayi ve Ticaret A.Ş. tarafından yürütülmektedir. Ocak genelinde gerçekleştirilen rehabilitasyon çalışmaları ile beraber kesici yükleyicilerin tamburlarında da değişiklikler yapılmıştır. Bu amaçla "A" sahasında kullanılan tamburlar yeni tamburlarla değiştirilmiştir.

Bu çalışmada yeßi tamburların özellikleri, uygulamadan elde edilen sonuçlar ve eski tamburlarla karşılaştırılması- verilmiştir. Yeni kesici tamburlar ile eski tamburlara göre önemli iyileştirmeler sağlanmıştır.

1. INTRODUCTION

Double drum shearers are the principle types of production machines used in longwall mining. The most important parts of shearers are the cutting drums through which machine power is transmitted to the coal being cut. Drums play an important role on the longwall output. On the other hand cutting drums also play an important role on the operation cost.

Çayırhan district, besides being the first mine in Turkey where underground mechanisation was applied, has become the most important coal and electricity production center.

In this paper, the improvements, which have been obtained by replacing existing drums with new drums, are explained. In "A" field, one of the production fields in Çayırhan district, production has been increased considerably, by using modified new shearer drums.

2. GENERAL DESCRIPTION OF ÇAYIRHAN COAL FIELD

Çayırhan Coal Field, situated 125 km North-West of Ankara, has a coal reserve of 410 Mt, of which 236 Mt are considered to be a mining reserve (Montan-Consulting GmbH, 1990; Walker, 1999). Two seams are being mined, which are separated by an intermediate rock layer of 0.5-1.5 m thickness. Where die intermediate rock layer is thicker than 0.8 m ("A"-"F' and "B" fields) two seams are extracted separately by simultaneous faces, on the other hand at "C" field where the intermediate rock layer is less than 0.8 m, the production is carried out as a single longwall face with a thickness of up to 5 m.

"A" and "F' fields where mechanised mining has been applied since 1986 by TKI were taken over by Park Termik in 2000. "B" and "C" fields were developed and mechanised by Park Termik in 1997 and 1999 respectively. The coal production is used to feed the power plant, which has a 620 MW capacity. Table 1 shows the main specification of the shearers used in Çayırhan district.

3. PROBLEMS ENCOUNTERED WITH OLD DRUMS IN "A" FffiLD

After taking over "A" and "F' fields from TKI, rehabilitation works were conducted to increase coal production and efficiency. Rehabilitation of shearer drums was also considered. Since top coal in "A" field includes silex layers which create cutting difficulties, but no silex layers have been encountered in "F' field yet, it was decided to use new shearer drums in "A" field and modify only the shearer drums in "F' field.

The main problems experienced with old drams may be summarised as follows;

a) It was necessary to refurbish the drums in "A" field with new pick boxes due to the wearing and breaking off the pick boxes at the welding points after 70,000-90,000 tons of coal production. This required dismantling and transportation of the drums to the surface for repair and back underground for reinstalling which was time consuming and a costly process and also affecting the coal production adversely. The life of the drums could be increased to 135,000 tons by some modifications (Hekimoğlu and Tiryaki, 1997), but this increase was inadequate as compared to drum lives of 500,000-1,000,000 tons in "B" and "C" fields.

Table 1. Specification of shearers used in Çayırhan district.

	Eickhoff EDW 200/230 L (A-F fields)	Eickhoff SL 300 (B Field)	Eickhoff SL 500 (C Field)
Total installed power (kW)	230	677.5 (300 kW for each drum)	1148 (500 kW for each drum)
Voltage (V)	1100	3300	3300
Drum dimension (mm)	1400x920	1400x950	2300x950
Cutting Dimension (min-max, mm)	1400-2410	1400-2600	2300-5090
Max. Travelling speed (m/min)	4.7	15.4	10.07
Cutting drum speed (rpm)	37	50	23
Weight (t)	26	30	66.5

b) The old drums were originally designed and manufactured nearly 17-18 years ago. New developments in drum design and manufacture recently (such as computer-aided drum design, employing heavy-duty pick boxes, wearing plates) can provide better drum performance and life.

c) Water sprays for dust suppression were home made and providing water in a jet instead of atomising water particles. Additionally, most of the sprays were supplying water to the shank of the picks instead of the tip. Their locations on the drum were also such that they could be easily damaged by the coal being cut.

d) The old drums required extensive welding work during refurbishing of drums with new pick boxes due to high rate of wear on the vanes.

e) Some problems encountered with the old drums were dealt with in previous studies (Hekimoğlu, 1991; Hekimoğlu and Tiryaki, 1997).

Table 2 shows the design specifications of the old drums used in "A" field.

Table 2. Design specification of the old drums.

Drum Dimension	1342x920
Total number of picks on the drum	60
Number of picks on the face ring	21
Maximum tilt angle of corner cutting	60
Number of starts	3
Total angle of wrap	240°

4. CHARACTERISTICS OF THE NEW DRUMS

New drums were designed and manufactured by Kennametal Hertel GmbH & Co. KG considering insufficiency of the old drums. Drum diameter has been increased to 1400 mm to have the same drum size as in "B" field. Some important drum characteristics are given below.

4.1. Modifications to Increase Drum Life

Higher efficiency in coal production can be achieved by increasing drum life. Drum life can be considered as the amount of production in tons during the period between two successive renewals of the pick boxes on the drum, by welding according to *the* design pattern at the surface. On the other hand, life-time of a drum can also be expressed as the amount of coal production in tons, achieved during the period between the first use of the drum and the time at which the drum can no more repaired and should be taken out of service due to very high rate of wearing of vanes and the drum barrel. Experience gained in "B" field shows that drums become out of service after producing about 4 Mt of coal. Drum life in this paper will indicate the coal production between two successive pick box renewals.

4.1.1. Pick Sleeves

Cutting picks can be placed into pick boxes using either fixed or changeable sleeves. Drum life is shorter with fixed sleeves since when they are worn out, they can be renewed only by taking the drum to the surface whereas changeable sleeves can be renewed in underground.

Changeable sleeves can be either loose or tight type. The application of loose sleeves at "B" and "C" fields did not give good results since fine dust was able to enter between pick box and sleeve and causing high rate of wear both on pick box and sleeve contact surfaces. To increase drum life and to decrease pick box and sleeve consumption it has been decided to use tight type sleeves together with heavy duty pick boxes for the new drums at "A" field. Figure 1 shows the type of pick box, tight sleeve and pick used on new drums.

4.1.2. Heavy Duty Pick Boxes

The old drums were equipped with light duty pick boxes, which were wearing and breaking in a short time especially at the face ring and decreasing the drum life. It has been decided to use heavy duty K178-BS type pick boxes for the new drums which have higher strength and greater available welding area providing a stronger weld area (Figures 1 and 8).

Figure 1. Pick box (1), tight sleeve (2), and pick (3).

4.1.3. Snaking Picks and Wear Plates to Protect Face Ring

Quick wear and breakage of cutting picks, sleeves and pick boxes at the face ring decreased the life of the old drums considerably. To protect the face ring, the face side of the new drums have been provided with six snaking U 47 picks and U 43 duty pick boxes, together with six 75x50x20 mm size TC (Tungsten Carbide) wearing plates. Figures 2 and 3 show the locations of the snaking picks and wear plates.

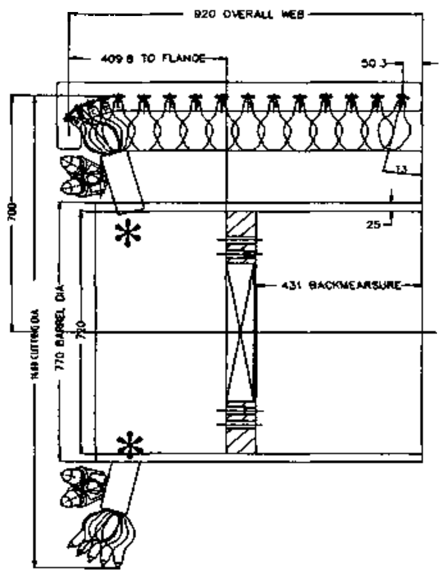

Figure 2. Locations of U47 pick.

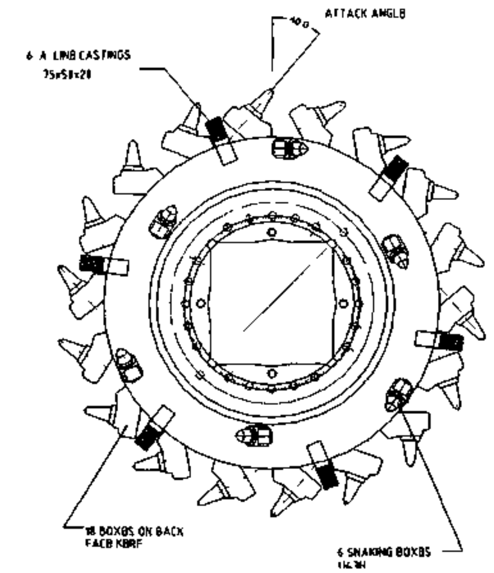

Figure 3. Locations of U47 snaking picks and wearing plates.

4.1.4. Wear Plates to Protect Loading Vanes

Both practical observations and previous work have shown that maximum wear on the loading vanes occur at the loading end of the vanes (Hurt and McStravick, 1988). Three loading vanes on the new drums have been provided with 200x50x20 mm, 150x50x20 mm and 100x50x20 mm size TC wear plates at the ends (Figure 4).

4.2. Lacing Diagram and face ring design

The lacing diagram of the new drum is presented in Figure 4. As it is shown, total of 51 picks are mounted on the drum, while 18 of them are located on the face ring, the rest are on the loading vanes. Only "A" line has 6 picks per line, the rest of the lines on both loading vanes and face ring have 3 picks. The drum is formed with three vanes and each has 200° total wrap angle.

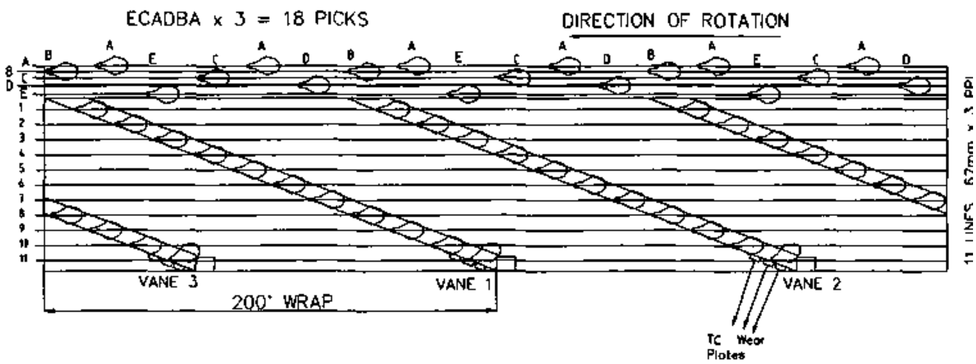

Figure 4. Lacing diagram of drums.

Figure 5 shows the positions of the cutting picks on the face ring. The highest tilt angle of 51.8^0 is provided for the corner-cutting pick situated on "A" line.

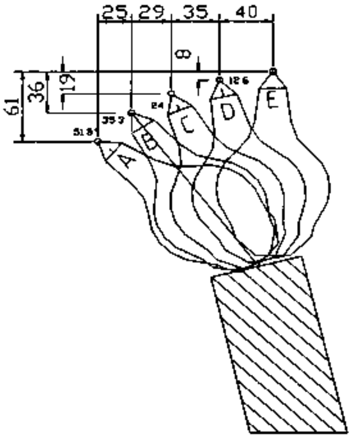

Figure 5. Situation of the face ring picks.

4.3. Dust Suppression Sprays

To solve dust suppression problems encountered with the old drums, new drums have been provided with 0.9 mm diameter sprays which have been located within the drum body, to each pick on the drum except the last pick on each vane. Figure 6 shows the location of the spray.

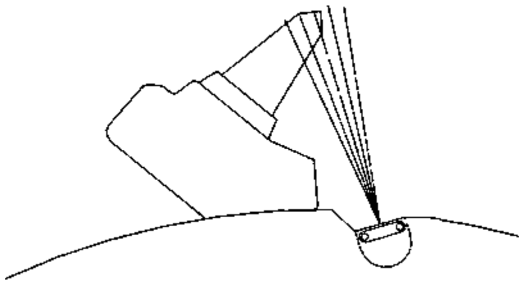

Figure 6. Position of spray on the drum.

4.4 Longer Vane Picks and Heavy Duty Face Ring Picks.

Old drums were fitted with U47 picks on the face ring and Betek B 40 HDS Pecs type light duty picks on the loading vanes. Although the tendency nowadays is to use heavy duty and longer picks with increased machine power, Betek type picks have been selected for the new drums since a huge stock of such picks exists. Figure 7 shows the Betek picks and the pick boxes used on the old drums.

New drums have been fitted with tight sleeves and K178-BS type pick boxes although the Betek type picks remained the same. In this way, the pick height was increased from 124 mm to 154.6 mm to provide greater cutting depth. Face rings have been fitted with Kl-77 heavy-duty picks and K178-BS type pick boxes. Figure 8 shows the type of picks and pick boxes used on vanes and face rings of the new drams.

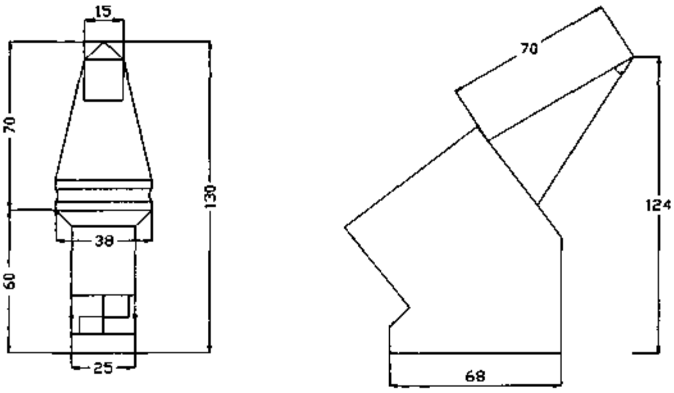

Figure 7. Betek B40 HDS Pecs type pick and pick box.

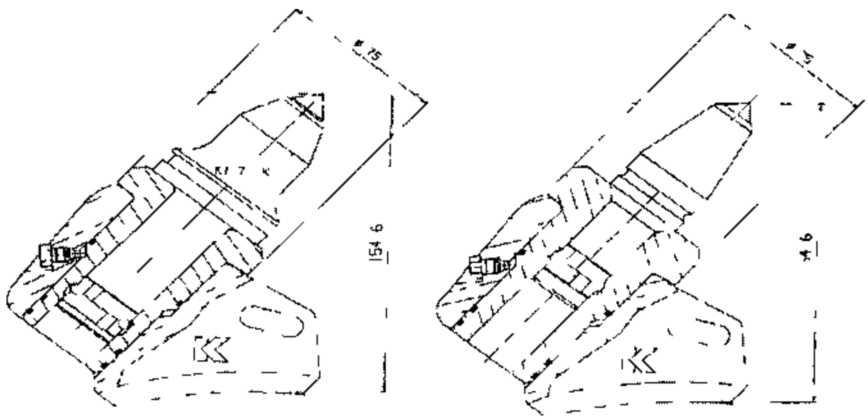

Figure 8. Kl-77 and Betek B 40 Pecs type picks together with K178-BS pick box and tight sleeve.

4.5. Theoretical Analysis of the New Drum

The design parameters of the new drums were analysed by the NCB computer program redeveloped by Kennametal Hertel GmbH & Co. KG

4.5.1. Force-Balance Calculation of the Drum

Table 3 shows theoretical results of the force calculation and Figure 9 shows the force-balance diagrams of the new drums obtained through computer analysis.

Table 3. Force-balance results.

Force	Mean	Maximum	Minimum	Mean spread (variance)
Torque (kNm)	23.4	23.7	23.2	0.018
Haulage (kN)	35.9	37.8	33.9	1.744
Vertical (kN)	24.4	26.7	22.1	2.325
Axial (kN)	30	3.1	2.9	0.002

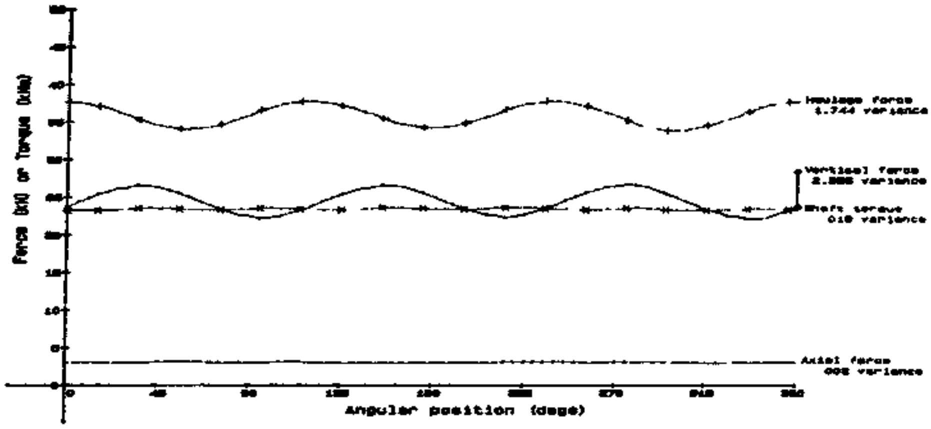

Figure 9. Results of force balance diagrams.

4.5.2. Breakout Pattern of the New Drums

Breakout pattern of the new drums was determined at an advance rate of 108 mm/rev (Figure 10).

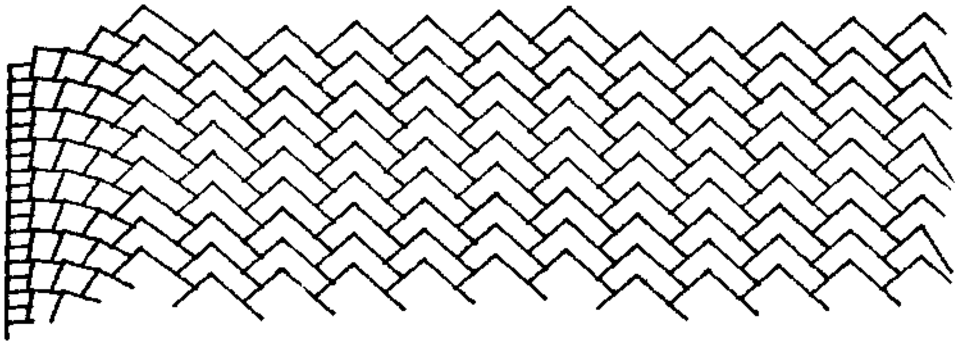

Figure 10. Breakout pattern of the new drums.

Small shaft torque variation and equal pick load distribution represent theoretically good and efficient cutting characteristic of the new drums

5. PERFORMANCE COMPARISON OF THE DRUMS

Production in A 10 panel started in Apnl 2001 with old drums, which were replaced with new drums at the end of May 2001. For comparison, performance results in May 2001 with old drums and after 1st June 2001 for new drums were taken into consideration.

5.1. Machine Speed and Cutting Rate

Short-term (instantaneous) measurement results and long term results were used in drum comparison. Short-term results were established by measuring the machine speed while the machine was cutting at its maximum capacity. Long-term results were established from the production reports, which include also very short stoppages. Table 4 shows the short term and Table 5 shows the long-term performance results.

Table 4. Short term (instantaneous) measurement results.

	Old Drums		New Drums	
	Top Face	Bottom Face	Top Face	Bottom Face
Speed (m/min)	Up-gradient: 2.85	Up-gradient: 1.85	Up-gradient: 3.58	Up-gradient: 3.66
	Down-gradient: 1.9	Down-gradient: 1.95	Down-gradient: 3.48	Down-gradient: 3.68
Cutting rate (m^3/min)	Up-gradient: 2.84	Up-gradient : 2.93	Up-gradient : 4.88	Up-gradient: 5.19
	Down-gradient: 2.63	Down-gradient: 2.99	Down-gradient: 4.77	Down-gradient: 5.16

It can be seen from Table 4 that with new drums the maximum cutting rate was increased by 41.64% in upward direction and 44.73% in downward direction in the top face, and 43.54% and 42.05% respectively in the bottom face.

Table 5. Long term results based on production reports.

		Top Face	Bottom Face	Duration
Speed (m/min)	Old Drums	Down-gradient: 2.21	Down-gradient: 2.07	01.05.2001-18.05.2001
		Up-gradient: 1.66	Up-gradient: 1.94	
	New Drums	Down-gradient: 2.59	Down-gradient: 2.37	02.07.2001-14.07.2001
		Up-gradient: 2.32	Up-gradient: 2.05	
Cutting rate (m /min)	Old Drums	Down-gradient: 3.03	Down-gradient: 2.89	01.05.2001-18.05.2001
		Up-gradient: 2.25	Up-gradient: 2.715	
	New Drums	Down-gradient: 3.55	Down-gradient: 3.32	02.07.2001-14.07.2001
		Up-gradient: 3.16	Up-gradient: 2.87	

Long term performance results giving mean cutting rate, on the other hand, showed less increase in cutting rate with new drums; 28.79% in upward direction and 14.08% in downward direction in the top face, and 5.4% and 12.77% respectively in the bottom face.

5.2. Production and Drum Life

Amount of production, pick consumption and drum life are the other parameters considered in the comparison. Table 6 shows the results obtained with old and new drums.

Comparison was based on the observations in May 2001 for old drums and between June-November 2001 for new drums. Table 6 shows that mean shift production was increased by 16.5% in the top face and 9.92% in the bottom face with new drums. Since production was concentrated at "A" field during April, May and June 2001 due to panel movements in "B" and "C" fields; it will be more realistic to compare the production rates in May for the old drums and June for the new drums (Table 7).

Table 6. Performance results.

	Old Drums		New Drums	
	Top Face	Bottom Face	Top Face	Bottom Face
Duration	01.05.2001-23.05.01	01.05.2001-31.05.01	01.06.2001-31.11.2001	01.06.2001-31.11.2001
Total Production (t)	41,083 (for 23 days)	60,894	395,886	411,069
Mean monthly production (t)	41,083 (for 23 days)	60,894	67.199	68.813
Mean Shift Production (t)	838.43	869.91	1,004.2	965.77
Pick Consumption (picks/1000 tons)	6.43	9.51	5.33	8.11

Table 7. Comparison of production rates.

	Old Drums		New Drums	
	Top Face	Bottom Face	Top Face	Bottom Face
Duration	01.05.2001-23.05.2001	01.05.2001-31.05.2001	01.06.2001-31.06.2001	01.06.2001-31.06.2001
Mean Shift Production (t)	838.43	869.91	1120.83	1104.28

Table 7 shows that mean shift production was increased by 25.19% in the top face and 21.22% in the bottom face.

Another important criterion in drum comparison is the drum life. Experience with old drums showed that drum life varies between 70,000 to 90,000 tons of coal production. On the other hand, the production achieved with new drums between 1st of June and 31st of November 2001 is shown in Table 6. The rate of production increase is already up by 456% though the life of new drums have not finished yet. New drums are expected to produce 1,000,000 tons before they require pick box renewals.

Table 6 also shows that pick consumption rates have decreased with the new drums. The decrease in pick consumption nearly corresponds to 160 picks per month.

5.3. Depth of Cut

Higher production rates achieved with new drums can be explained by the increase in depth of cut. Depth of cut taken by the drum picks can be determined from the formula given below (Hurt and McAndrew; 1981 and Hurt et.al.; 1982);

$$d = \left(\frac{D}{n}\right) \sin\theta$$

where;
d = depth of cut (mm)
D = advance per revolution (mm/rev)
n = number of cutting sequence

8 = angular position of the pick (degree)

Table 8 shows the depths of cut (9= 90 degrees) obtained with old and new drums during short term (instantaneous) measurements.

Table 8. Comparison of depth of cut.

	Old Drums		New Drums	
	Top Face	Bottom Face	Top Face	Bottom Face
Depth of cut (mm)	Up-gradient: 25.6	Up-gradient: 16.66	Up-gradient: 32.58	Up-gradient: 32.97
	Down-gradient: 17.11	Down-gradient: 17.56	Down-gradient: 31.35	Down-gradient: 33.15

An increase on the depth of cut is the best explanation of the increase of the production level with the new drums.

5.4. Dust Concentration

The use of effective sprays and proper locations on the new drums reduced the dust concentration within the upper gateroad by about 27%, although production rate has increased considerably.

6. PROBLEMS EXPERIENCED WITH THE NEW DRUMS

One of the main problems encountered with the new drums was the wearing of the sleeves and the pick boxes located at the end of each vane. This problem was overcome by positioning the last pick on each vane at 13° skew angle. The same modification was carried out also on drums at "B" and "C" fields.

Another problem was the wear on the sleeve surfaces. To overcome this problem sleeve surface were welded with 5-mm thick hard facing electrode.

7. CONCLUSIONS

The main conclusions that can be derived by using the new drums, which were designed and manufactured by Kennametal Hertel GmbH & Co. KG, can be summarised as follows;

a) Both maximum and mean cutting rates have been increased approximately by 42.9% and 15.26% respectively with employing new drums.

b) By the end of November 2001, the drum life was increased by 456% (from 90,000 tons to 411,069 tons). The new drums are still operating and expected drum life is 1,000,000 tons.

c) Pick consumption rates were decreased in the top and bottom faces by 17.1% and 14.72% respectively.

d) Considering peak coal demand periods, mean shift production was increased by 25.19% in the top face and 21.22% in the bottom face.

e) Dust concentration in upper gateroad was reduced by 27%.

REFERENCES

Hekimoğlu, O.Z. (1991) OAL Müessesesındeki tamburlu kesiciler ve karşılaşılan sorunlar. *Türkiye Madencilik Bilimsel ve Teknik 12 Kongresi Bildiriler Kitabı,* s.133-147.

Hekimoğlu, O.Z., and Tiryaki, B. (1997) Effects of drum vibration on performance of coal shearers. *Transactions of Institution of Mining and Metallurgy (IMM), Section A, Mining Industry, 106,* pp. A91-A94.

Hurt, K.G., MacAndrew, K.M. (1981) Designing roadheader cutting heads. *The Mining Engineer,* September, pp. 167-170.

Hurt, K.G., Morris, C.J., MacAndrew, K.M. (1982) The design and operation of boom tunnelling machines cutting heads. In; Baumgartner (Editor), *Proc. 14th Can. Rock Mechanics Conf, (Vancovver, May) Can. Inst. Min. Metall.,* pp. 54-58.

Hurt, K.G., and McStravick, F.G. (1988) High performance shearer drum design. *Colliery Guardian,* December, pp.428-429.

Montan Consulting GMBH (1990) Final Report on Beypazarı Lignite Project.

Walker, S. (1999) Çayırhan challenge, *World Mining Equipment,* December, 12 p.