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Evaluation of Single-Slice and Twin-Face Operations of Çayırhan Lignite Seams

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ABSTRACT: In recent years, Turkey has experienced very high demand for energy. The most reliable way of dealing with this problem is to build thermal power plants utilizing lignite coal as a source of energy. However, at this point, two other problems are encountered. First, those of Turkey's near-surface coal reserves that can be mined economically are being exhausted quite rapidly. Second, production of coal by underground methods is expensive due to the technology applied. Consequently, underground mining is becoming a burden on Turkish society. The two factors that prevent coal from being produced at low cost are the lack of advanced technology and the use of outdated mining methods. In order to overcome these obstacles, it is necessary to invest capital and establish modern mines. In this paper, the B and C fields at Çayırhan underground mine are compared in terms of mining methods and production efficiencies. In the C field, the coal is extracted in a single seam, whereas in the B field, the coal extraction is performed in a double seam. The annual production of Çayırhan mine is 4 million tons.

1 INTRODUCTION

In 1996, Turkish Coal Enterprises (TKI) awarded a contract for the development of part of the Çayırhan deposit to a joint venture between Park Holding and the German longwall firm, SaarTech. Today, Park Teknik, as the joint venture is known, is at the forefront of Turkey's private sector producers, with output for the next 15 years scheduled for 3 Mt/year of power station fuel to be used in Çayırhan thermal power plant.

Eighty-five percent of Park Teknik is owned by Park Holding and 15% is owned by SaarTech, with the two companies taking responsibility for different aspects of the project's development. Park Holding looks after the local administrative aspects, while SaarTech provides technical management input as well as specifying and supplying equipment.

Modern equipment brought from Germany was installed underground by Turkish and German technicians. The mining method applied lias been the retreating longwall method.

Thé machinery and equipment brought from Germany is some of the most developed technology in the world in underground coal mining and is designed by Turkish and German technicians.

In the initial stage of the project, a total of 200 million DM of capital investment was made and a total length of 5000 m of roadways was driven in one year. This is considered a relatively short time in underground mining. After the installation of the face equipment was completed, a total of 2 Mt of coal was produced in the B Field in 1997.

After the investments for the C Field were finalized, during the second stage of the project, coal production was started in November 1999. Production was then increased to 4 Mt/year. As a result of the modern technology used and the high standards of safety established, efficiency and production increased in the mine.

2 PRODUCTION

Çayırhan lies in the Beypazarı lignite basin, about 100 km northwest of Ankara. It contains a number of separate fields, all of which host two principal lignite seams. The overburden thickness of between 150 and 200 m throughout the basin mean that open pit mining could not be used. A third seam some 130 m below the others also contains resources, but it is considered too deep to exploit. Across the basin, seams 1 and 2 vary in thickness from 1.7 to 2.0 m. They are separated by an interburden with a thickness of 1.3-2.0 m in the western part of the area and 0.5-0.7 m on the eastern side. The in-situ resources of these seams total 390 Mt, of which 236 Mt are considered to be mineable. While the thickness of the intermediate layer between the two seams is 1.3-2 m in the western part of die field, it is

0.5-0.7m on the eastern side.

Park Teknik's mining operations have been carried out in the B and C fields, which were developed as completely separate operations. The two fields host a reserve of 35.4 Mt, in which the lignite is of better quality than the average for the basin. The band of interburden is typically over 1.0 m in the B field (in the west) and less than this İn C (in the east), a variation that has had major implications for the mining layout of both fields. Hence, the two seams in the west of the field are worked separately, whereas in the east of the field the two seams together with the interburden are mined as a single seam.

The method of production applied in both fields is the longwall retreat mining method. In order to reduce the need for gateroad drivage, to enable more efficient use of reserves and to reduce the risk of spontaneous combustion of the coal, panel maingates were planned for use as the tailgate of the following panel.

2.1 *B Field*

There exist a total of 13 panels in the layout of this field. The initial development effort was focused here, with the aim of proving the capabilities of the twin-face system İn practice. A typical panel layout in the B field is seam 1, 1.6-m thick, separated from the 1.9-m-thick seam 2 by around 1.6 m of interburden waste (Figure 1). The mining sequence involves the upper face leading the lower one by around 25-35 m, a distance to ensure reasonable pressure distribution on both faces. The face inclination of the currently worked panel B-10 is 6 and the face length is 220 m.

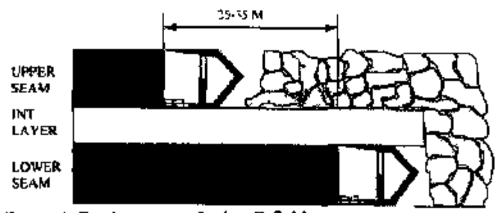

Figure 1 Production method in B field.

Production works in the B field are carried out with 148 workers. There was continuous production activity in Panel B-10 in the year 2000 and 1,651,000 tons of coal was obtained during this period. The monthly production levels are given in Figure 2.

The face equipment, especially the conveyors, nearly finishing the third panel after the contract was signed, required an excessive amount of welding and other kinds of maintenance. Therefore, in the year 2000, there was a remarkable increase in the number of breakdowns in mechanization. Figure 3 shows the proportion of breakdown events and their sources in the B field during working time as a whole in 2000.

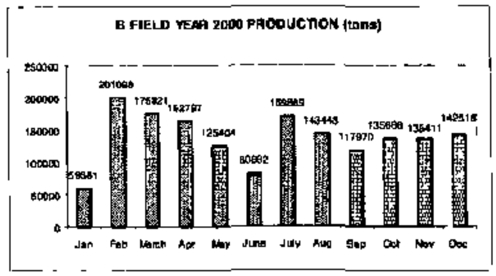

Figure 2 Monthly production in B field in 2000

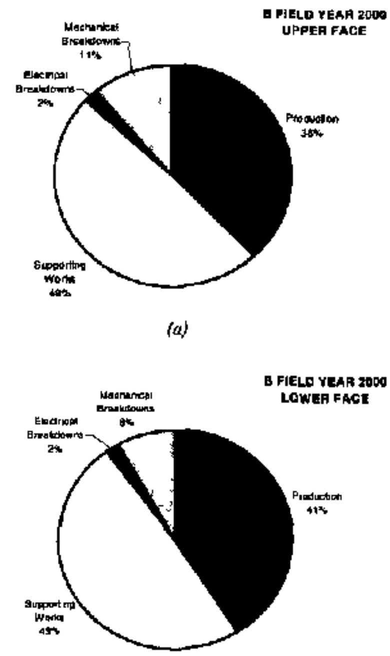

Figure 3 Distribution of breakdowns in B Field

12 *C Field*

Since the interburden layer is around 0.5-0.7m İn the C field, both of the seams and the interburden were combined as if they were a single seam and a single face was projected. The machinery and equipment were chosen accordingly. The face height, up to 5m, is as great as any longwall elsewhere in the world, and the panel inclination is about 30° against the retreating direction.

Panel lengths of 1700 m were chosen and the size of the face was 220 m, the same length as in the B field.

Production works in the C field are carried out with 106 workers, which is considerably smaller than the number of workers in the B field.

An Eİckhoff SL500, a double-drum shearer, is utilized in the faces of the C field. Each of the drums is driven by an electric motor of 500 kW. The total useful power is 1148 kW and the cutting head operating voltage is 3300 volts. The dimensions of the drums are 2300 mm in diameter and 900 mm İn width. The rotation speed is 23 rpm. The drums are globoid-type drums containing 76 cutting ends. The machine İs 14.27 meters long and has a maximum cutting height of 5.09 meters. The maximum hauling speed of the machine equipped with *a* Saartrack hauling system is 10.07 m/min.($F_{m,,,}$ = 445 kN). It weighs 66.5 tons without the drums.

A double-chain-cype AFC, manufactured by DBT, is used in the face. The motor power of this is 2 x 400 kW. The motor power of the transmission conveyors is 250 kW. Both conveyors have a carrying capacity of 2000 t/h. The face conveyor works at a speed of 1.11 m/s and the transmission conveyor works at a speed of 1.32 m/s, with a chain size of 34 x 126 millimeters. The tensioning units of both conveyors are Perinfalk-made PW 800s. Pouring from the face conveyor onto the transmission conveyor is carried out through a MRAR 35 side discharging chute. A SK 11 11 crusher with a power of 250 kW is mounted on the transmission conveyor.

A total of 127 25/50L advancing shields produced by SaarTech are utilized as face support (Figure 4). They are *of the* double-leg type. The height of these shields when opened is 5 m, while the closed height is 2.5 m. Each shield is 1.7 m m width and has a weight of 25.6 t. The setting force is 3400 kN and the sliding force is 4100 kN.

Three special STBS 27/50L shields are used for supporting each face end. Their open height is 5 m, closed height is 2.7 m, and their width is 1.75 m. The total weight is 38.3 tons. These face-end shields are of the four-leg type.

For both types of advancing shield supports, 16 functional Multimatik P-D, multi-channel hose connections to the roof control blocks are used.

In the year 2000, 2,275,000 tons of coal was produced from the C-12 panel. The production details are shown in Figure 5. The performance of the C field for the year 2000 was very high. The breakdown figures in the C field are given in Figure 6. The sum of the mechanical and electrical breakdowns was 10% of the total time.

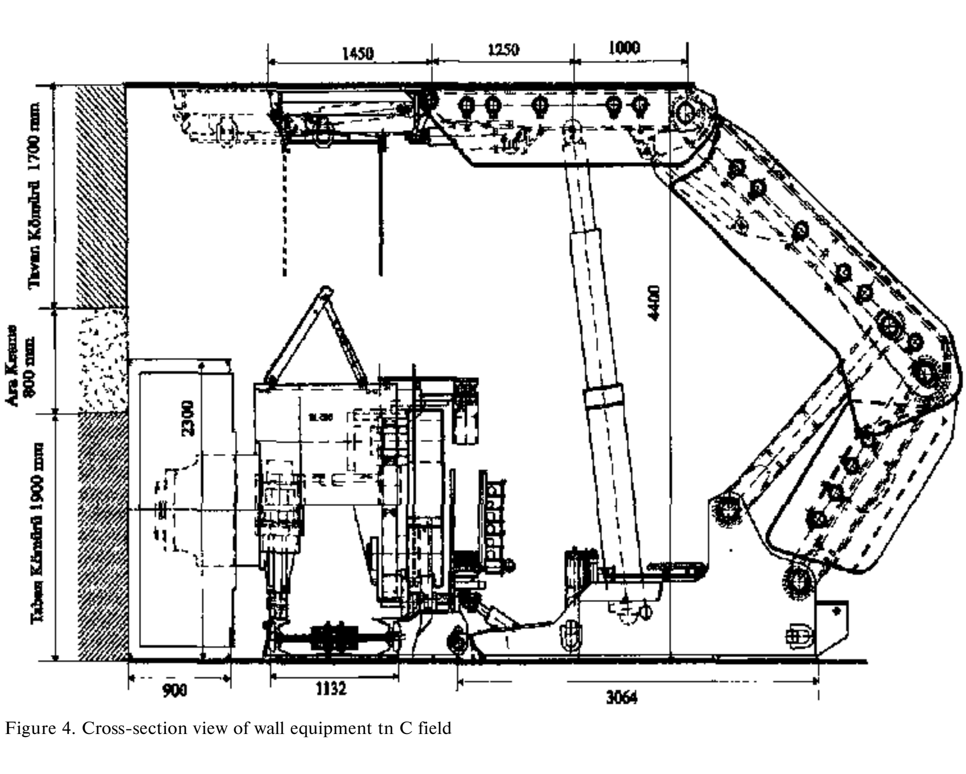

Figure 4. Cross-section view of wall equipment tn C field

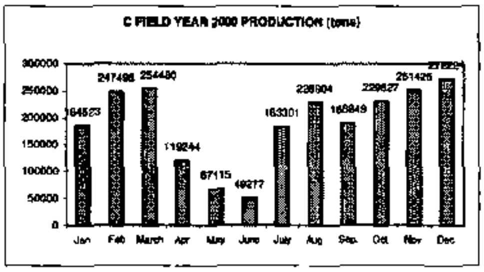

Figure 5. Production in C field in year 2000

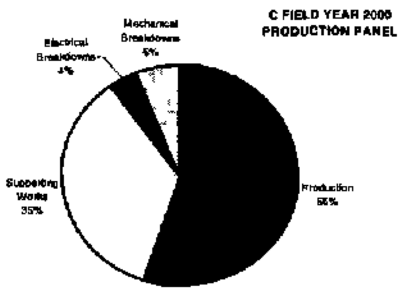

Figure 6 Field C breakdown distribution

3 TRANSPORTATION

3.1 *Coal Transportatiom*

For coal transportation, belt conveyors 1200 mm in width are used. The strap used is a single-layer type covered with nitryl; it has a strength of 1250 N/mm. In all belt facilities, there are stretching and storing units. These facilities are controlled by pneumatic cylinders. All the drums in the belt facilities are covered with rubber. The driving and return end systems were obtained from Germany while the additional parts were produced in Turkey according to DLN standards.

In the transportation of coal in the B and C fields, 6 conveyor belts are used. Their technical specifications are given in Table 1. The conveyor in the B field has a speed of 2.5 m/s and capacity of 1500 t/hr. The driving force varies from 270 kW to 750 kW. The conveyor m Field C has a speed of 3 m/s and a capacity of 2000 t/hr. The driving force varies from 220 kW to 750 kW.

Coal poured into silos with capacity of 200 t in the south portal of the B field and 300 t in the south portal of the C field is automatically loaded onto trucks and carried to the delivery point.

3.2 *Material and Man Transportatiom*

There are equipped endless wire systems operating a monorail and coolie-car driven and controlled by the B-C mine entrance to bring workers to their work place in a short time and in safety The monorail equipment is made by Scharf and the coolie-car systems are made by the Walter Becker firm. The monorail can transport weights of 3 t, 5 t, 10 t, 20 t and the rope has a diameter of 18mm. In Field B, transportation of the face equipment is by monorail in the gateroads and by mechanical hoist on the side of the face. In the coolie-car transportation system, conveyence cars of 100 kN and 220 kN can be used. In Field C, the transportation of face equipment is by coolie-car in the gateroads and by hydraulic hoist on the side of the face. The hydraulic unit of the hydraulic hoist is the E III type. The other hoists are of the GT 10000 type. The material transported by hydraulic hoist is moved on the rail system, which is located on the floor in the face. For both the coolie-car system and hydraulic hoists, ropes of 26 mm are used.

Table 1 Technical specifications of belt conveyors

(a) Field B

	Motor Power (kW)	*Length (m)*	*Capacttv (t/hour)*	*Speed (m/s)*
Belt-0	110	150	1300	25
Belt -1	2x110	650	1300	2.5
Belt -2	3x110	1200	1300	25
Belt -3	2x110	850	1300	25
Belt-4	2x110	650	1300	2.5
Belt -5	2x110	in preparation	400	25

(b) Field C

	Motor Power (kW)	*Length (m)*	*Capacity (t/fiour)*	*Speed (m/s)*
Belt -0	2x110	170	2070	3
Belt-1	3x250	570	2070	3
Belt -2	3x110	1200	2070	3
Belt -3	2x110	1100	2070	3
Belt-4	2x110	600	2070	3
Belt-5	2x110	in preparation	400	3

4 MINE-WIDE MONITORING CENTER

All the machines and equipment used In the mine are fully automatic. There is also a push-talk phone system to provide communication between underground and the monitoring center.

This system, which is set up at the surface control center, ensures that all of the operating and non-operating equipment are monitored and their electrical currents are recorded. The monitoring and control system was purchased from the Walter Becker company.

Again, from the monitoring center, CH4 and CO emissions and air quantities in the mine are continuously monitored.

5 CONCRETE PACKING

Since there is tendency for spontaneous combustion to occur in the Çayırhan lignite mine, in order to increase production by avoiding pillars left between panels and to use gateroads twice, as a maingate and later as a tailgate, thus to working adjacent panels with no pillars left in between, a ribside packing system containing concrete and power station fly ash is used as part of the gateroad support. The maingate, which is to be used as the tailgate of the adjacent panel, is held by a concrete block of 3-m width and excavated at coal height taken into the face. The concrete facilities are German patented and there are 4 surface silos in the B field. Each of these silos has a capacity of 100 t and they are utilized separately as cement, ash and 2 mixing silos. Electrofilter ash from the thermal power plant is mixed with cement at 30% in order to form a binding agent. In the C field, there are two mixing silos with a capacity of 100 t. After preparation of the dry mixture in the B field, it is sent to the C field by truck. Dry material in the silo is sent to an underground intermediate silo through pipes by means of compressed air. In this intermediate silo, it is mixed with water and sent to the region where the concrete packing will be built using a concrete pump.

6 COMPRESSED AIR

In the C field, compressed air required for hand tools, concrete units, tensioning stations of belt conveyors, waste water pumps operated by air, cooling of the main drive units, mechanical hoists, pick hammers, etc. is provided by compressors.

Thus, in the C field northern mine entrance, 4 compressors manufactured by Kaeser (see Table 2) and 3 MDH 90 compressors made by Hiross are installed.

Table 2. Technical Specifications of compressors in Field C.

	C FIELD
Manufacturer	Kaeser
Model	FS440
Weight (kg)	6300
Operating Pressure (bar)	7.5
Capacity (nvVsaat)	2000

In Field B, air is provided through OAL compressors.

7 VENTILATION

For the main ventilation gates of the mine, 2 suction-type fans are used in both the C and B fields (Table 3). Both have a flow rate of 40 m /s. The motor power of the one in the B field is 90 kW and that of the one in the C field is 75 kW. The airways in the mine have ventilation doors which are operated by compressed air.

While they are being driven, the sections of new roadways are ventilated by booster fans of 400 m^3/min capacity with dust depressants of 200 mVmm.

Table 3. Technical properties of fans used in ventilation

	B FIELD	*C FIELD*
Manufacturer	Davidson	Korfmann
Flow Rate (m^3/sn)	40	40
Motor Power (kW)	90	75

8 TECHNICAL COMPARISON OF EFFICIENCIES AND PRODUCTION PERFORMANCES

Details of the numbers of workers and their jobs are given in Table 4. The monthly production and worked days for 2000 are shown in Table 5. By using data from these figures, monthly efficiencies for the year 2000 were calculated; these are shown in Figure 7.

As can be seen from Figure 7, the monthly underground efficiencies in 2000 were high except for the months of April, May and June. In the C field, very high efficiency values were reached when they are compared with those for the B field. Generally, the decrease in the number of workers and the higher production due to the use of modern technology and extraction of coal in a single seam makes the C field more productive than the B field. The results proved that the use of modern technology increases efficiency to high levels.

In Figure 8, overall managerial efficiencies with respect to total production and total staff number are shown by month. The overall managerial efficiency for 2000 was 19.3 t/shift If we consider the average European efficiency, which is 6 t/shift, the efficiency of the mine becomes more meaningful. A comparison of the efficiencies of Park Teknik. Endsdorf Colliery and Deutsche Stein Kohle (DSK) is given in Figure 9.

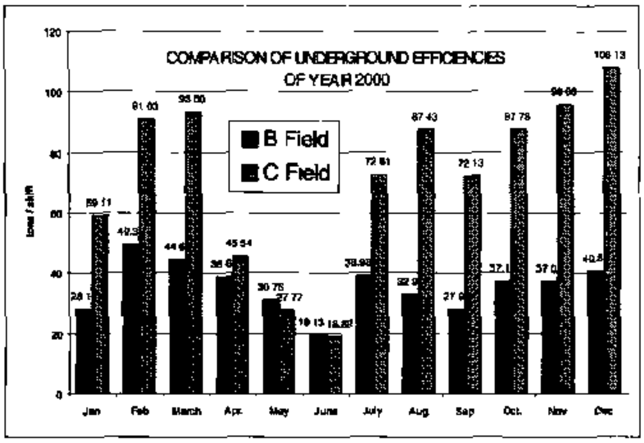

Figure 7 Underground efficiencies in 2000

Table 4 Number of workers and their jobs in B and C Fields

	Shift 1		*Shift 2*		*Shift 3*		*Daily Total*	
	B Field	*C Field*	*B Field*	*C Field*	*B Field*	*C Field*	*B Field*	*C Field*
PRODUCTION								
Shearer Operator* Cable Controller	5	3	6	3	6	3	17	9
Shield operator	4	3	5	2	6	3	15	8
Face End Supports + Concrete	4	4	8	4	8	5	20	13
Return End. Supports + Concrete	4	4	8	4	8	4	20	12
Shield advancing team	4	4	4	4	3	5	11	13
Face cleaning	1	0	2	0	2	0	5	0
Monorail	4	4	4	3	4	3	12	10
A, F, C Dnver	2	1	2	1	2	1	6	3
MECHANICS								
Intermediate Concrete Silo	3	3	3	4	3	3	9	10
Shearer maintenance	4	3	3	3	3	3	1 0	9
Hydraulic shield maintenance	5	3	4	3	4	3	13	9
ELECTRICITY								
Face 1 Shearer ((B field)	1	0	t	0	1	0	3	0
Face 2 Shearer (B field)	0	0	1	0	0	0	1	0
Face SL500 (C field)	0	2	0	2	0	2	0	6
Face End	1	0	1	0	1	0	3	0
Concrete	1	1	1	2	1	I	3	4
TOTAL	43	**35**	53	35	**52**	36	***148***	***106***

Table 5 Monthly work days and production m 2000

Months	*Number of work days*		*Production (tons)*	
(Year 2000)	B *Field*	C *Field*	*B Field*	C *Field*
January	15	31	59381 00	184523 00
February	29	27	201098 00	247498 00
March	28	27	175821 00	254480 00
April	30	26	162797 00	119244 00
May	29	24	125404 00	67115 00
June	30	26	80682 00	49277 00
July	31	25	169889 00	183301 00
August	31	26	143443 00	228904 00
September	30	26	117970 00	18884900
October	26	26	135666 00	229827 00
November	26	26	13541100	251425 00
December	25	25	142518 00	272224 00

9 CONCLUSIONS

From a general point of view, it should be noted that single slicing is superior to twin-face production in three aspects.

I) When compared to twin faces, some operations underground have automatically been discarded İn single slicing, for example, the removal of supports and stowing material between upper and lower faces becomes unnecessary. In addition, the drawbacks of excessive closure both in main- and tailgates, observed especially between the upper and lower faces, are almost eliminated. In other words, less labor and lower production cost figures are achieved.

2) The immediate roof overlying the Çayırhan lignites mainly consists of strong claystone, whereas the interburden composition is a relatively weak claystone-marl layer. This may cause problems in roof support in the gateroads of the lower face. Consequently, the advance rate and coal production are higher with single slicing than with twin faces.
3) It is clear that the quantity of equipment used in single slicing is low and all the mining operations are concentrated at a single face. Therefore, there is significantly better supervision in such panels.

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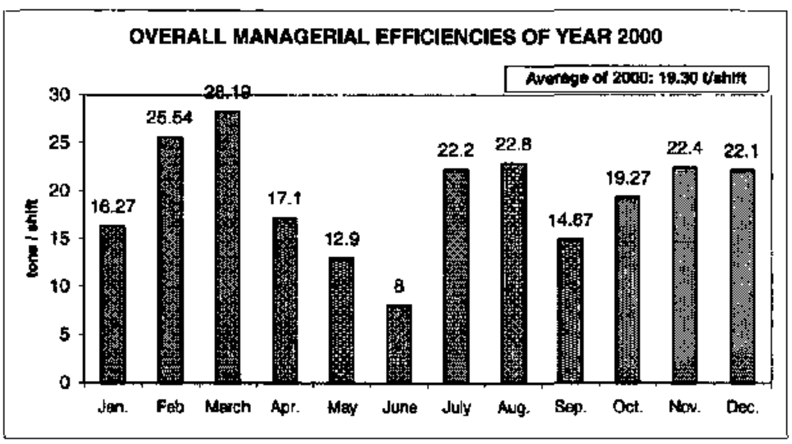

Figure 8. Overall managerial efficiencies of year 2000.

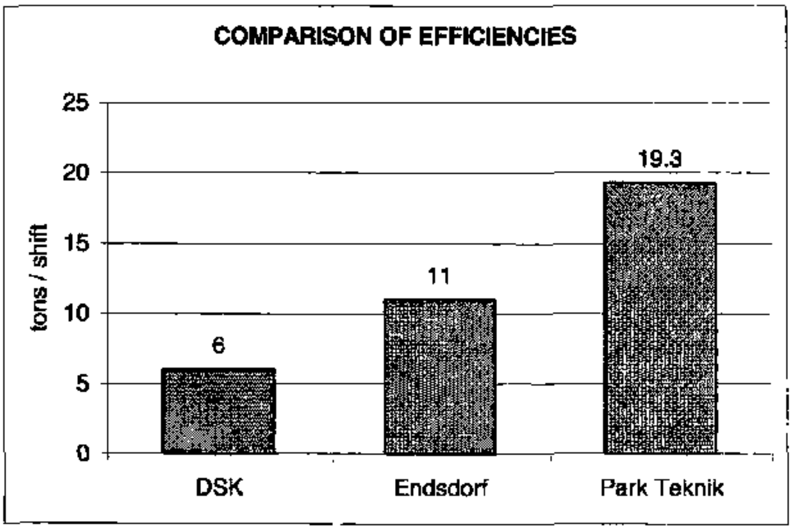

Figure 9.Comparison of average efficiencies in 2000.