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THE ECONOMICAL EVALUATION OF COKE PLANT AUTOMATION AT POSCO

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Abstract: Posco has made tremendous efforts to improve poor working environments and to increase productivity in coke plants. By reducing the labour cost and process cycle times, we improve economic efficiency. Also, a new coal preparation technique for the coke process improves energy efficiency and environmental impact. The results show that the automatic operation leads to increase the rate of operation and production cost. In this paper, the economic effect of coke plant automation is analysed on basis of manpower, productivity in coke plants, rate of the operation, energy consumption and environmental protection in Kwangyang works from 1990 to 2000. *Copyright © 2002 IFAC*

Keywords: Coke, Automation, Economical evaluation, Production cost, Productivity

1. INTRODUCTION

The coke plant is an essential part of the steel making process, but it has a very poor working environment characterized by heavy dust emissions, high heat and demanding physical labour. The automation of the coke plant is an essential issue not only to improve the working environment, but also to reduce the fixed cost by enhancing labour productivity. The coke plant comprises the coal preparation process, coke oven process, coke transportation process and gas refining process. Among those processes, the coke oven process involves various kinds of jobs. The raw material piled in the coal bin is carried by charging cars and is loaded in the designated compartment of the oven and the air is cut off and then the coal is carbonised in high temperature, then rigid coke is produced. The final product is moved to transfer car by pusher and carried by the locomotive to the quenching tower and then is cooled by water. Recently, automatic control systems for coke oven operations have been developed and put into practice with progress in instrumentation technology and the widespread use of process computers. Recently, Posco performed research work to automate these processes with Otto in Germany. The goal of the project is to reduce the manpower and cycle times of operation. Before the automation, each carrier required one operator. However, after automation, one operator takes care of the pusher and the other coke oven machines while performing the assigned tasks. A new coal moisture control process is adopted in order to load more raw materials in the oven so that production is increased. The economical effects of automation of coke oven process are analysed on the basis of labour saving, energy consumption, productivity, and environmental protection using the accumulated data such as coke production, the number of operation pusher, charged raw material, energy consumption for ten years from 1990 to 2000.

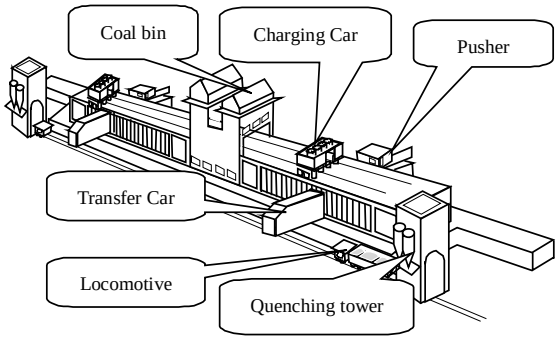

Fig.1. Overview of coke plant

2. AUTOMATED COKE PLANT

In order to automate the overall coke plant, a gross and a precision position control systems for travelling cars (pusher, charging car and transfer car) were installed. For safety, travelling car collision avoidance systems and oven door open/close detection systems were implemented in the pushers and transfer cars. Also a coke oven diagnosis system was developed for longer oven life span.

2.1 Gross and precision position control system

The required positioning accuracies of the travelling cars are shown in Table 1. Since the travelling cars carry heavy loads at high speed, precision position control is very difficult. Therefore the positioning of the car is performed in two steps, gross control and precision control.

Gross position control system

Table.1. Required positioning accuracy

	P/C	C/C	T/C
Weight	400 ton	230 ton	260 ton
Velocity	60 m/min	90 m/min	50 m/min
Accuracy	± 5mm	± 10 mm	± 10 mm

Each car is equipped with an infrared transmitter, a receiver and each oven has masks on it to be recognized by the coke oven number in binary as shown in figure 2. When the car is travelling on the rail, it recognizes each oven number and finds its gross position.

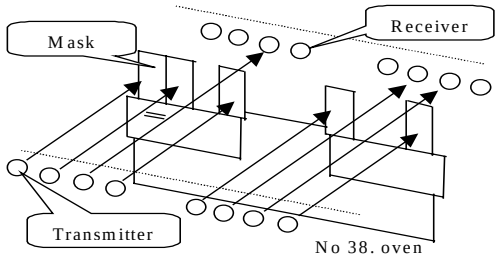

Fig.2. Position control system using infrared

Precision position control system

After the car is positioned in gross motion, precision position control system is activated and reduces the position error within a tolerance. As shown in Figure 3, the system finds the exact position using the door edge detection by comparing the left and right images from two cameras.

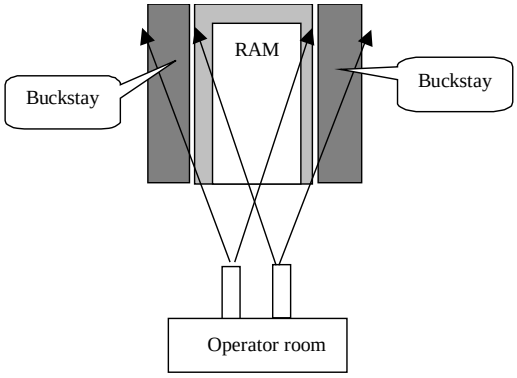

Fig.3. Position control system using camera

2.2 C*ollision avoidance system*

Each transfer car is equipped with a 10.687GHz microwave transmitter and a receiver to detect other cars or obstacles. When the car receives a reflected microwave signal from the obstacle, the alarm system is activated and the car stops travelling. The perception distance is maximum 80m and the system could be operated within temperature range of -15°C ~ 40°C.

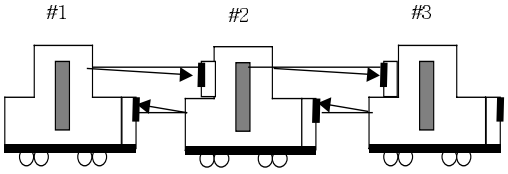

Fig.4. Collision avoidance system

2.3 A door open/close detection system

A door open/close detection system was installed in the transfer car to detect whether the oven door is open or closed. After a pushing work is completed, the image recognition equipment confirms the latching status by checking the angle between the latch and buckstay.

2.4 Coke oven diagnosis using the pusher's reaction force measuring system.

Since it requires large investment to build a new coke oven, it is very important to detect the sign of aging or problem of the oven at an early stage before further development. In order to identify the problem of the oven, a torque sensor is installed on the ram and measures the pushing force of the driving axis. The measured data is transmitted to the computer and is analysed for diagnosis of the oven status and also for checking the carbonising coke status.

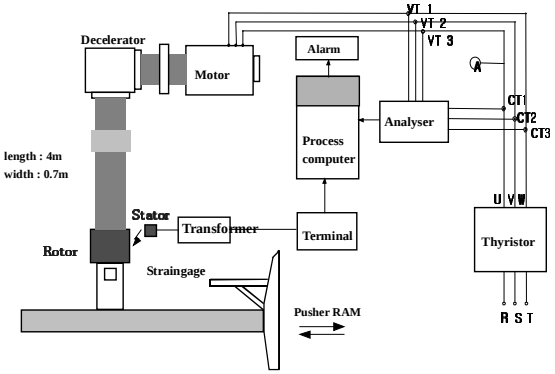

Fig.6. Pusher's reaction force measuring system

2.5 Coal Moisture Control Process

Before the coking process, the coal moisture control process was adopted to increase the coke oven productivity. At Kwangyang works, a demoisturing plant was built and it reduced the moisture of the coal up to 6% by heat exchange in the steam dryer.

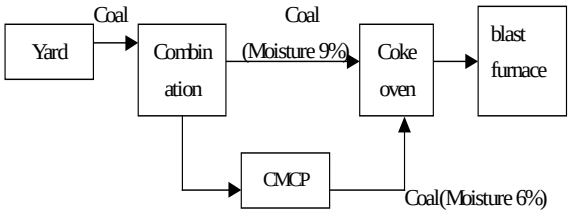

Fig.7. The flow of CMCP

2.6 Configuration of control system

Figure 8 shows the computer control system of coke oven machines. Each of the machines is controlled by a programmable logic controller(PLC) mounted on it. The process computers which are located in the central control room, generate a set of commands for each cycle of operation and monitors the machine

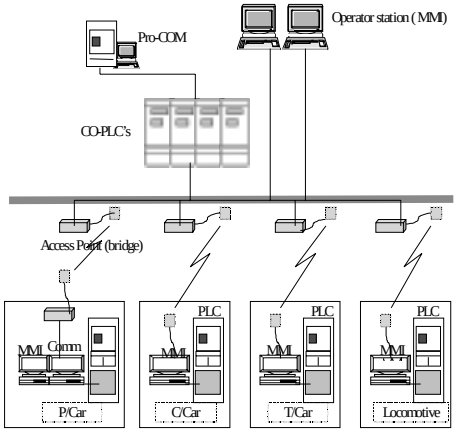

Fig.8. Configuration of control system

operating condition. The PLC performs the single cycle the single cycle of operation in accordance with the command received from the process computer.

3. ECONOMICAL EVALUATION

3.1. Estimation of the economical evaluation by the research report

Posco performed the research work to automate the coke oven processes with the Otto company in Germany with research fund of 140,000 dollars for 9 months from July 1997 to March 1998. According to the final report, estimations of the economical effects after automation are as follows. The rate of operation would be increased by 10%, the cycle time would be reduced under 12 minutes and the manpower would be reduced to 14 persons.

3.2 Economical evaluation results after the automation.

Manpower saving

The newly formed crew consists of one operator (shift worker) in the central control room, two inspectors (shift worker) and two regular daytime workers. Therefore, as the result of automation, manpower is reduced from 40 to 14. In Kwangyang works, only No. 4 coke oven is automated among four ovens and production cost was reduced to 3.12 millions dollars. (0.12 millions dollars/person-year × 26 person/ oven × 1 oven = 3.12 million dollars/year).

Reduction of cycle times

Due to the increased speed of the moving car, the operation cycle time was reduced from 14.36 minutes to 11.38 minutes. So the number of pushing operation is increased to 13 times per a day. This saves 1.47 million dollars per a year.

Energy saving

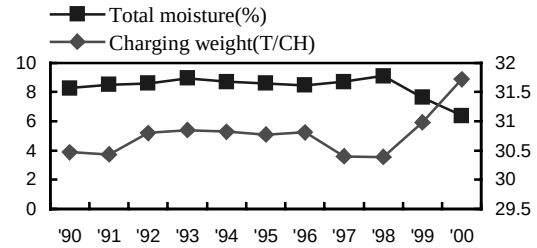

Fig.9 Moisture and charged weight

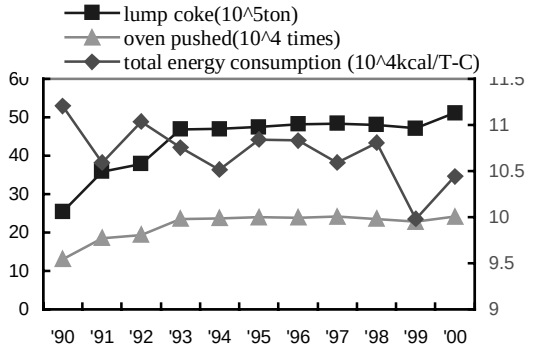

Fig.10. Coke production, the number of pusher operation and energy consumption

Total energy consumption (Mcal/ton-coke) is represented by the sum of fuel, electricity and crude light oil which is consumed in the coke oven process. By adopting a new coal moisture control process, the total moisture of coal was decreased and the charged raw material was increased, as shown in Figure 9.
Figure 10 shows that the coke production was increased but total energy was decreased due to the new coal moisture process in 1999. The total coke production in the year 1998 was increased up to 228109 tons and the saved energy was equivalent to 390000 dollars per year. (0.0216 dollars / Mcal × 79.21Mcal/ton-coke × 0.228 Mton/year = 390000 dollars).

Reduction of break down rate of transfer car

The causes of the electrical breakdown were the malfunction of PLC boards, vibration sensors and communication network. The mechanical failures caused by worn-out cylinders, damaged pressure suppliers and limit switches. The number of manual operations of the transfer cars is shown in Table 2. After the automation, the breakdown rate was reduced and POSCO saved 3.3 millions dollars per year. The repairing cost itself is approximately 0.17 millions dollars and the loss during the repairing period is 77.5 dollars/door × 250 door/day × 2 days = 0.16 millions dollars.

Table 2. Manual operation in T/C

	'96.3	4	5	6	7	8	9	10	11	'97.6
times	146	160	31	45	25	19	8	21	26	25

Environmental effect

Kwangyang was designated as a restricted area for environmental protection by the Korean government in 1999. The government specified the maximum

allowable emission of SOx and Nox, and strongly recommended the low energy consumption for the aspects of CO_2 restriction. After the automation, energy consumption was reduced and a dust collector was installed. So coke oven gas(COG) quality was improved. However it was difficult to calculate the economical effect in terms of dollars.

Investment for automation

It cost 0.409 millions dollars to construct of position control systems and for the development of a visual centre confirmation system in the coke chamber, 53000 dollars were invested in '95.10~'96.9. The automation of the locomotives is established using 0.47 millions dollars in 1992. For the automation of the transfer cars, 0.403 millions dollars were invested in'97.12. ~'99.3. Therefore the total investment of the automation is 11.9 millions dollars (5.76 millions dollars in Pohang, 6.13 millions dollars in Kwangyang).

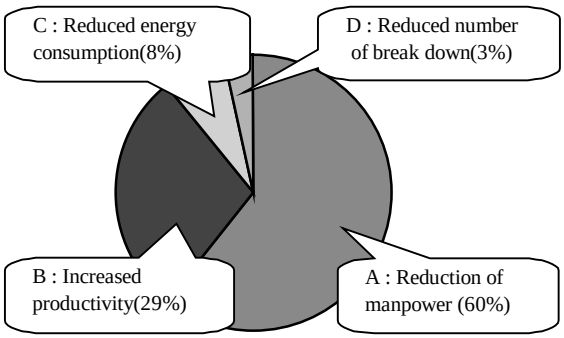

Fig.11. Overall economical evaluation

Overall economical evaluation

As a result of the coke plant automation, Posco has saved 5.15 million U.S. dollars annually. Therefore it takes only two years to recover the total investment for the coke plant automation. Figure 11 shows the distribution of the saved money according to contribution factors. 'A' represents the saving due to the reduction of manpower, 'B' represents the saving due to the increased productivity, 'C' represents saving due to the reduced energy consumption, and 'D' represents the saving due to the reduced number of break down.

4. CONCLUSION

In this paper, the economical effects of the coke plant automation was analysed on basis of labour saving, energy consumption, productivity, and environmental protection using the data accumulated in Posco, such as the amount of coke production, the number of pushing operations, the weight of charged raw material, and energy consumption, each year. Before the automation, Posco generated a research project to investigate the possibility of the automation. The research report specified the target systems, automation methods, and estimation of the economical effects. There is a little discrepancy between the estimation and real evaluation. Some effects are very difficult to calculate in terms of dollars. However, as a result of automation, Posco saved a substantial amount of money and will make an effort to continue the automation of remaining parts of the processes.

REFERENCES

Ironmaking Dept. Operation results for KY all cokes in 2000. POSCO

Maintenance technical Dept. Automation of coke oven machine. POSCO. 1996.

H. S. Kim, R. Worberg and K.P. Leuchtmann.(1992). Process Automation of coke Plant Kwangyang stell works/south Korea. 2nd International Cokemaking Congress. 330~337.

S. Ito, S. Mochizuki, F.Murakami, K. Oki, Y. Takanohashi and Y. Konno (1992). Automation of Operations of coke oven machines. 2nd International Cokemaking Congress. 206~213.