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.

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.

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
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.

### 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.

### Collision 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.

### 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.

### 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.

### 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.

### 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.
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 E 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

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.

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 CO2 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~'96.9. The
automation of the locomotives is established using
0.47 millions dollar 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).

A : Reduction of
manpower (60%)

B : Increased
productivity(29%)

C : Reduced energy
consumption(8%)

D : Reduced number
of break down(3%)

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.

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