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Optimization of Steel Tap to Tap Time at Basic Oxygen Furnace Shop

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Abstract: **All industries mainly concentrate on increasing the quality of its products and increasing its profit. The profit can be increased by using various strategies; one of such strategies is increasing the productivity of the plant. The industry where the project work has been carried out is one of the leading steel producing industries in India. In steel making industries, increasing the productivity can be done by various means; one of such is reducing the steel tap to tap time (cycle time) at basic oxygen furnace shops. Cycle time is the total time from the beginning to the end of any process which includes process time, during which a unit is acted upon to bring it closer to an output, delay time, during which a unit of work is spent waiting to take the next action and sometimes maintenance operations. The main goal of the project is to minimise the Cycle time which in turn increases the productivity. The project has been carried out in three steps. First step is to understand the actual processes and delays present in a cycle and the time taken by these processes. The next step is to collect the data regarding the time taken by the actual processes, maintenance operations and the delays in between the actual processes. In this step data were taken for about 100 heats. In the final step the data taken are analyzed and where the maximum delays occurring are identified. The special attention is given to maintenance operation timings that to carry out some of them simultaneously which will reduce average cycle time.**

***Key words*: Steel, Cycle time, Optimization.**

I. INTRODUCTION

The main challenge to the steel making industries is to produce the steel in less time (cycle time) and with the great quality. The Steel making industries produces the steel of different grades with the good quality depending upon the customer requirements. Steel is an alloy of iron which contains less amount of carbon in it. This making of Steel from the molten iron and maintaining the different steel grades will be done in the steel melting shop units [1].

The conversion of molten iron into the molten steel will be done using furnaces. There are various types of furnaces such as basic oxygen furnaces, electric arc furnaces, and magnetic induction furnaces. This conversion from molten iron to molten steel is done in discrete quantities which are called heats. Each heat will take its own time to complete which is called as Cycle time. The Cycle time includes process time, during which a unit is acted upon to bring it closer to an output, and delay time, during which a unit of work is spent waiting to take the next action. In other words, cycle time is the total elapsed time to move a unit of work from the beginning to the end of a physical process. Calculation of cycle time helps in calculation of output in physical scenario and it can be taken as a small unit of output which is directly proportional to total production. The steps in calculation of cycle time primarily include analysing and recording occurrence time of elemental activities whose combination makes a full cycle time [2].

Here the cycle time means the time of steel tapping end to the next steel tapping end, which can be called as tap to tap time. This cycle time includes the various processes from flux addition to the final slag dumping. In addition to these processes some delays will presents in between the processes and some maintenance operations has to carry out for smooth working conditions. The main goal of the project is to minimise the cycle time by reducing the delays and simultaneous operation of maintenance processes. By reducing the cycle time one can increase the rate of production and hence the productivity. Due to the increase in productivity, the profit obtained will also be increased.

2. Steel Melting Shop-2

The steel industry where the study was carried out is one of the leading steel producers in India. The company produces economical and efficient steel and power through backward integration from its captive coal and iron-ore mines. The industry has 3 Steel Melting Shops (SMS). The project has been carried out in SMS-2. In Steel Melting Shop, the hot metal from the Blast Furnace and the Corex is converted into Steel by blowing 99.5% pure Oxygen through it. Suitable alloying elements are added to produce different grades of steel. At the steel melting shop there are eight de-

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sulphurisation stations, four basic oxygen furnaces, two RH stations, four ladle heating furnaces, three slab casting and one billet casting sections. In the industry our main area of work is at basic oxygen furnaces where the molten metal will be converted into molten steel [1]. The steel conversion process at steel melting shops is represented in the following diagram.

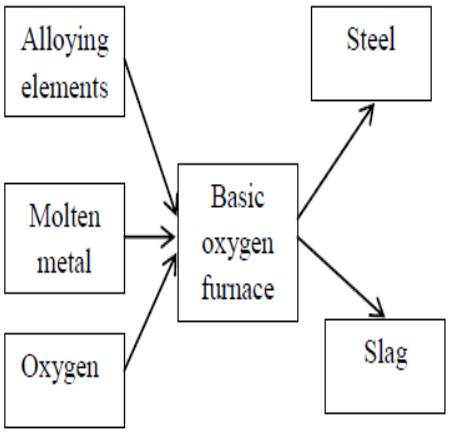

Fig1. Steel Conversion Process at basic oxygen furnace shops

2.1 Problem definition

Almost all the steel making industries are facing the problems such as delays in between the actual processes, allotting the time for the maintenance operations. The industry where the project has been done also has such problems. The industry is now producing the Steel of its installed capacity. The requirement for the steel in the market is increasing day by day therefore, it is necessary to increase its capacity to produce the steel by installing the new units. The installation of new units is of long process and adds extra cost, but the productivity can be increased without installing new units by minimizing the delays and simultaneous maintenance operations. The problem identified in the basic oxygen furnace shop is as follows.

1. Delays in between the actual processes.
2. Maintenance operations consuming the more time.

Elimination of delays is impossible task but these can be minimized. So the suitable suggestions were given to minimize them. The maintenance operations are necessary for the smooth working conditions so one cannot eliminate them but suggestions were given to minimize the maintenance times by carrying out some maintenance operations simultaneously.

3. Objectives of the Study

Based on the problems identified, some of the objectives are defined as follows.

1. To reduce the delays in between the actual processes as much as possible.
2. To reduce the maintenance timing for a converter.
3. To increase the productivity this in turn increases the profit.

IV. METHODOLOGY

After obtaining approval of the head of the SMS-2 and the HR-Manager of the industry, collection of the relevant information regarding the functioning and process detail of Basic Oxygen Furnace (BOF) at SMS-2 was carried out. The study of existing practices in each section was carried out with the help of the guide and the employees at the shop floor.

The study was carried out in three steps. The first step is to understand all activities in between tap ends to the next tap end at BOF and defining them for calculation of cycle time. Second step is to note down the processing time of each processes, delay time in between the actual processes, maintenance times and the total cycle time. Next step was to identify what are the reasons for the delays and giving suggestions to minimize them. The necessity of different maintenance operations are understood and discussed with the guide to carry out the maintenance operations simultaneously to minimize them.

4.1 Data collection

The primary objective behind the study was to reduce the delay times, for that it is necessary to understand and note down all the process times and in between activities of the Cycle time. Random cycle time data were collected from the shop floor for a period of 6 days (100 heats). In the study the time between one tap ends to another tap end is the Cycle time which is called as a heat. The Cycle time includes the actual processes, delays and sometimes maintenance operations. The Cycle time includes the processes such asFlux addition, Scrap charging, Hot metal charging, Oxygen blowing, Sampling and temperature checking, Steel tapping, Slag splashing and Slag dumping. Each of these processes takes its own time to complete. In addition to these processes, rocking of the converter and maintenance operations also adds the time to the total cycle time. Some of the maintenance operations observed are Mouth jam cleaning (once in a shift), Dozing (once in a shift), Gunning operation (every 100 heats), Sleeve changing (every 100 heats), Hot patch (every 500 heats) and Scanning

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the refractory layers (daily).

V. RESULTS AND DISCUSSIONS

The data taken from the shop floor were studied and analysed. The average cycle time is found out which is represented in the bar chart (Fig.2).

From the bar chart one can observe that the average cycle time varies from 50-58 48 minutes. As observed from the data taken, a heat will be completed in 45-50 minutes if there is no delay occurs in between the processes.

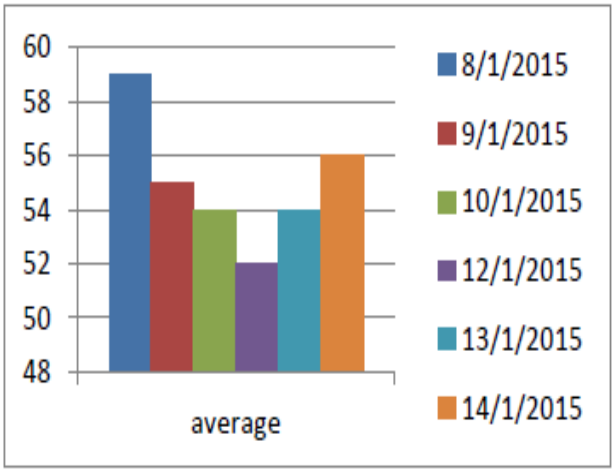

Fig2. Bar chart showing the average cycle time

The possible delays occurring in between the processes are observed and they are delay in rocking, waiting for scrap, waiting for hot metal, delay in starting the blowing, slopping problems, waiting for the chemistry sample results, waiting for the slag pot and waiting for the steel ladle.

The reasons for the above delay are also identified and the suitable suggestions were given to minimize them.

Presently the company is producing 24-25 heats per day per converter. This can be increased by reducing the cycle time per one heat which necessitates the minimization of delays. It is impossible to eliminate the delays completely because some of the delays cannot be controlled. Even the suggestions were given that how to minimize the delays but it is not known how much the delay times will be reduced, so this is not considered for the productivity and profit calculations.

Another way of increasing the number of heats per day is by simultaneously carrying out some of the maintenance operations such as mouth jam cleaning and the dozing operations. Mouth jam cleaning is the converter maintenance operation which is used to remove the mouth jams of the converter which is situated at above 9 meter from the ground level. This will be done once in a shift (3 shifts per day). This operation takes 10 minutes.

Dozing is the maintenance operation which is used to clean the area (0 meter) just below the converter which is the rail road allotted for the steel ladle and slag pot. This cleaning process also will be done once in a shift and it takes 15 minutes.

Here the time can be saved by carrying out the Mouth jam cleaning operation and Dozing operations simultaneously. This will save 10 minutes per shift that means 30 minutes will be saved per day per converter. To adopt this strategy there is a problem; falling of the removed jams from converter over the dozers which may harm the dozer operators. This can be controlled by placing the protection plate (has to be create new one) that to restrict the removed jams to fall on the dozers.

5.1 Productivity calculation

By using this strategy and reducing the delays, two heats can be increased per three days per converter which means 360 tons more can be produced in three days. There are 4 converters, so that 1440 tons of more steel can be produced in three days.

Therefore productivity increased (PI) by the project in one month is calculated as follows.

(PI) month = 10*1440

= 14400 tons.

So the increase in productivity in one year is

(PI) year = 14400*12

= 172800 tons.

5.2 Profit calculation

Now the industry is getting Rs 10000 to 20000 per ton. So the annual profit that can be increased from the project is

Annual profit = 172800*10000

= 1728000000

= 172.8 crores. **5**

VI. CONCLUSIONS

1. By reducing the delays in between the actual processes by maintaining the proper procedures, the cycle time can be minimized.
2. By using the strategy of simultaneous maintenance operations the productivity can be increased and hence the annual profit.

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