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Letter to Editor

STATISTICAL AND METALLURGICAL ANALYSIS OF PROCESS INTERRUPTIONS IN CONTINUOUS CASTING OF STEELS

V.P. Mohandas[*] and S.R. Sankaranarayanan[#*]

[*]Department of Metallurgical and Materials Engineering National Institute of Technology Tiruchirappalli, Tiruchirappalli 620015 INDIA

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Abstract

Operational difficulties, as well as quality issues, are encountered in various manufacturing activities, including steel plant operations. In the present study, processes in steel plants, such as continuous casting, have been examined from the statistical and metallurgical perspectives. Then, the breakout related interruptions have been analyzed in terms of Cost of Quality (CoQ), a valuable tool from the field of quality management. The results are technically and philosophically interesting. The approach can also be used for cost benefit analysis.

Keywords*: Continuous casting; Process interruptions; Breakouts; Cost of quality approach.*

1. Introduction

Steel plant operations include iron making, steel making, refining, continuous casting, rolling and downstream operations. All these operations have to be integrated and carried out in a systematic manner. Whenever difficulties / interruptions are encountered in one process, the further downstream process as well as prior upstream process are adversely affected. The loss becomes considerable, once the lost time of production is also taken into consideration.

During continuous casting, liquid steel is converted into “semis” (e.g. blooms) in a bottomless water cooled oscillating copper mould. Interruptions such as breakouts,

[#] *Corresponding author: raman@nitt.edu*

clogging of submerged entry nozzle, delayed opening of ladle are encountered. Problems such as breakouts have been studied technically, though without fully realizing the indirect monetary loss directly due to lost time of production. Often, steel plants have found difficulty in measuring / estimating the opportunity costs, resulting in underestimating the consequences of process interruptions.

2. Process details

Production data from the continuous casting shop of an integrated steel plant, producing more than three million tonnes (carbon steels) of cast steel per year (with six casting machines and four moulds per machine), were considered. Data obtained over a period of more than one year indicated that:

(a) about 92% of the heats / batches in bloom casting went on smoothly without any difficulty,

(b) minor problems, with low nuisance value, were encountered in about 7% of the heats, and

(c) major problems such as breakouts, with high nuisance value, were encountered in about 1% of the heats cast.

Breakouts are serious process interruptions, resulting in safety hazards, loss of liquid steel, need for repairs, casting shutdown in concerned mould for few hours and so on. Number of breakouts need to be reduced, though it is very challenging to fully eliminate caster breakouts. Statistical and metallurgical analyses were performed to go into the types / categories of caster breakouts, adopting the methodology developed by operations personnel. It was then observed that sticker breakouts accounted for nearly 60% of all caster breakouts, as shown in Figure 1.

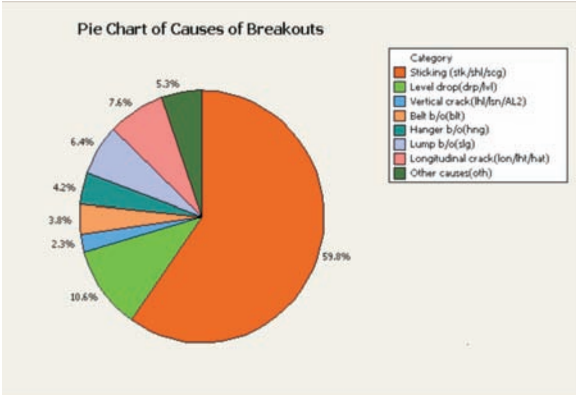

Fig. 1. Different types of caster breakouts encountered in the plan

The analysis was continued further to identify the process variables / parameters associated with sticker breakouts. Based on information available in the literature, as well as from analysis of plant operations, it was decided to focus on the role of steel chemistry (in terms of carbon content). It was then observed that there is a strong effect of carbon content on the frequency of breakouts. As shown in Figure 2, the risk of sticker breakouts is very high, in a range of carbon associated with peritectic transformation. This observation is also in line with typical observations on caster breakouts, in the open literature [1, 2].

Analysis of further metallurgical parameters is in progress. Efforts are also being made to examine changes in mould slag (or casting powder) composition during casting, quality of liquid steel, as well as fluctuations in cooling water circuit.

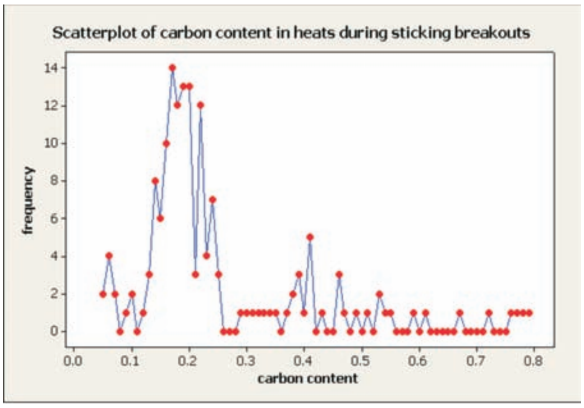

Fig. 2. Relation between Carbon content of steel and the occurrence of sticker breakouts

Simultaneously, an effort was also made towards estimating the consequences of poor quality ie., the economic consequences of process interruptions such as caster breakouts. In the realm of quality management, Cost of Quality (CoQ) includes cost of prevention, cost of failure, opportunity costs and so on. Efforts have been made towards developing a CoQ model, in the context of caster operations. Preliminary results from the CoQ analysis are shown in Figure 3. The "CoQ" used in Figure 3 is to be viewed only on a "relative" basis. The total cost of quality is the sum of controllable costs and opportunity costs; and the total cost is considerable with respect to the value of the cast semis.

Work is being continued to optimize the CoQ; as well as to decide on the cost advantages associated with different strategies for prevention of breakouts. Researchers have already examined various process and control related options - including optimization of mould powders / casting powders, installation of sensors in the mould to monitor mould friction and heat transfer, installation of breakout detection systems [3-6]. Cost estimation is in progress, on the investment associated with a bloom caster breakout detection system and the potential savings associated with reduced number of process interruptions.

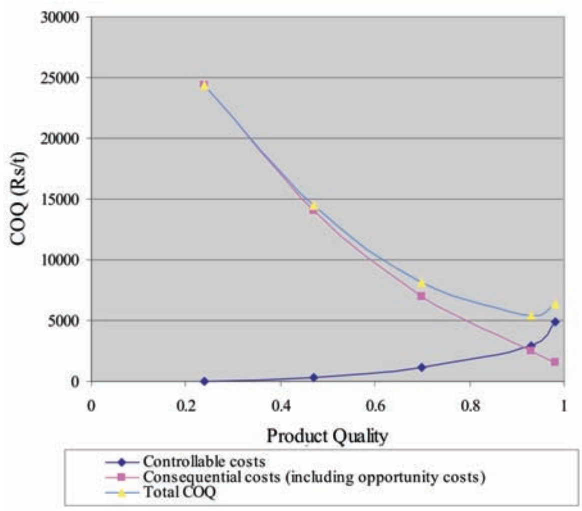

Fig. 3. Trends in Cost of Quality, with respect to breakouts

3. Concluding remarks

Statistical and metallurgical analysis of caster breakouts has been attempted. The initial results have helped in identifying the principal causes for breakouts. The application of CoQ concept has helped in realizing the hidden costs associated with process interruptions in large manufacturing plants.

Process improvements, in extractive metallurgy, based on technological (as in [7]) and economic aspects need to be explored.

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