

Quality Management in the Manufacturing Process of Iron Casts on Foundry Lines

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Abstract

The paper presents issues of quality management related to iron casts manufactured on automated foundry lines for automobile industry. The influence of the choice of electric furnace and automated foundry line with vertical or horizontal mould division on the quality of casts made of nodular or grey cast iron was presented. Analysis of different scenarios of the course of action manufacturing processes was performed basing on a simulation experiment, record data related to the quality of the manufactured casts and manufacturing prime costs analysis. The research used universal tools applied in simulation analysis of production systems (Rockwell Automation: Arena Simulation Software) and a spreadsheet used for cast manufacture cost estimation. The proposed variants have been assessed using the Pareto analysis on the basis of results of reports generated for a simulation experiment. The paper also presents suggestions of activities aimed at further improvement of the quality of foundry processes.

Key terms: Quality Management, Application of Information Technology to the Foundry Industry, Cast Production Organization, Modelling and Simulation of Production Systems, Manufacturing Costs Estimation.

1. Introduction

Foundry production management is a continuous process of taking decisions conditioned by changing situation of an enterprise aimed at ensuring proper functioning of a foundry from economic and financial point of view. The issue of management of foundry industry includes a number of questions, both practical and methodological, which influence time, quality and cost of the manufactured casts [1-3].

There are two basic ways of improving manufacturing process management. The first of them consists in experimenting on a living organism and learning from mistakes. Some concepts of new solutions are transferred into real objects, and are tested and implemented during realization. New solutions, after being tested and verified, can be transferred to other areas. This is easy to do, although quite dangerous, as all changes in organizations may seriously disturb their functioning. The second method

involves conducting modelling studies before the realization of new solutions in real time. Such approach is related to difficulties which result from the need of building exact models of complex manufacturing processes, above all production management processes realized in most cases by human [4-7].

Using modelling and simulation of production systems for foundry industry allows to eliminate experiments on a living organism. Proposals of new solutions in production organization may be tested on a digital model. In case of series and large-scale production, a simulation experiment can be applied, among others, for manufacturing process scheduling, management of reserves and material flow logistics. A simulation model makes it possible to quickly check different scenarios of production order realization (fig. 1) and choose the most advantageous solution in view of the adopted criteria [8-12].

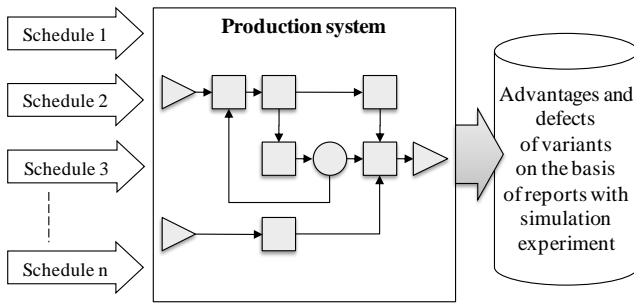


Fig. 1. Using modelling and simulation in managing casts manufacturing processes

2. Research object, aim and methodology

The research object of the present paper is a system of iron casts manufacturing in expendable moulds on automated foundry lines. The research was limited to analysing activities in the area of melting shop and smeltery functioning (fig. 2)

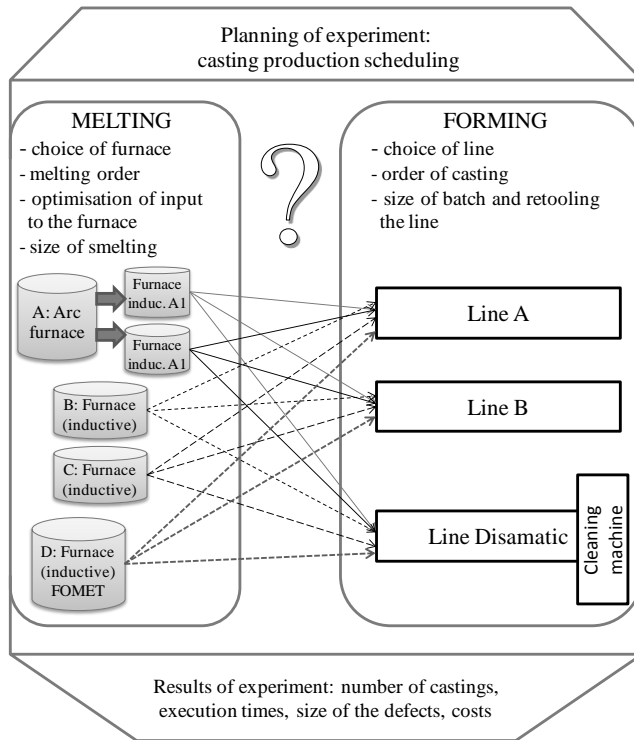


Fig. 2. Research object: system of iron casts manufacture

The aim of the research is to optimise scheduling of production orders. The influence of the choice of furnace and automated production line on the quality of casts and shaping manufacture prime costs was analysed.

For visualisation and process analysis, a simulation model has been built in the Arena packet (fig. 3)

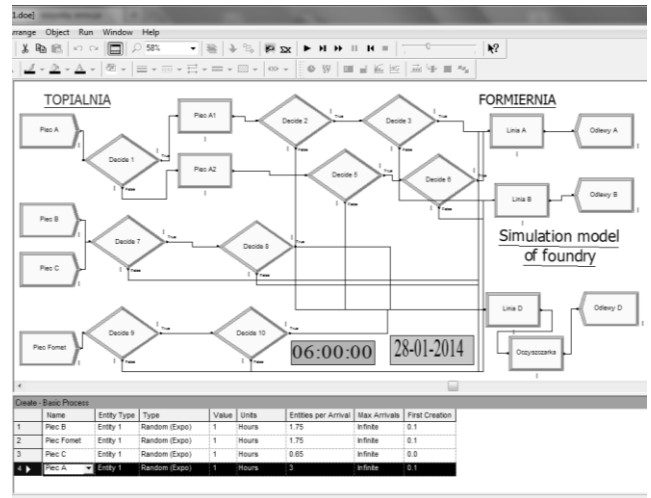


Fig. 3. A simulation model of melting shop and smeltery in the ARENA packet

Estimation of manufacturing prime costs was performed according to the principles of product type costing (fig. 4) [13-15].

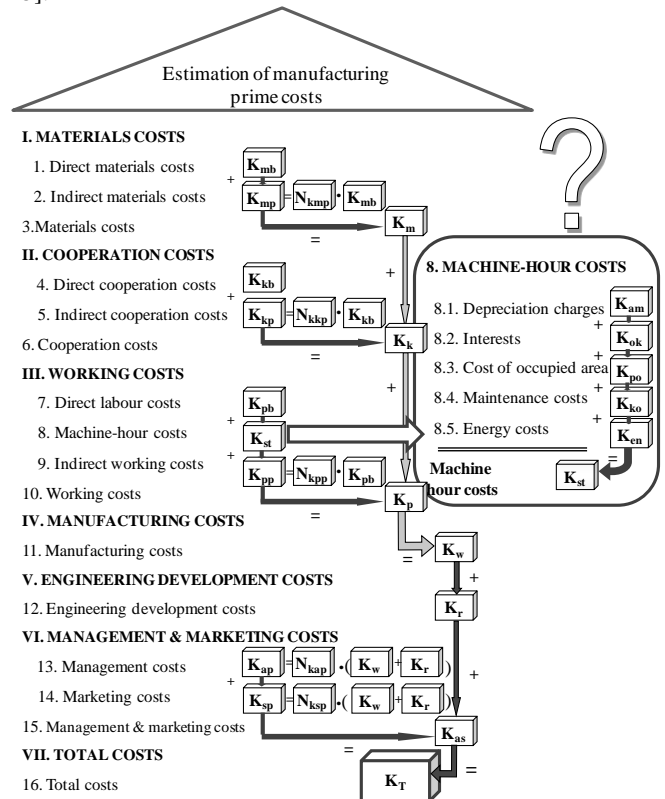


Fig. 4. Determining prime costs of iron casts manufacture

3. Description of the obtained results

Scheduling started with dividing casts into groups. Figure 5 presents exemplary tree-graphs representing variants of the course of processes related to liquid alloy preparation and pouring casts on automated foundry lines starting from the most elastic group of casts (G1: liquid alloy may be prepared in each kind of furnace and pouring can proceed on any line), and finishing with the group of casts poured only on the Disamatic line, for which grey cast iron is prepared only in mains frequency induction furnace (Gn Group).

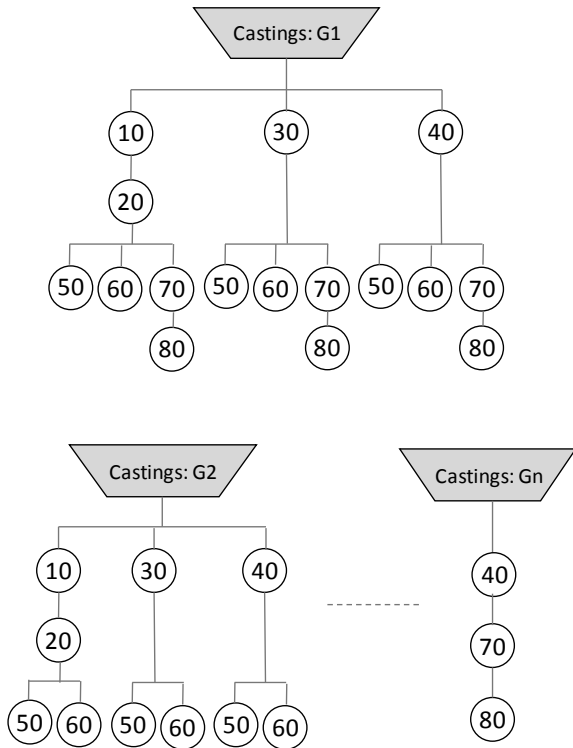


Fig. 5. Exemplary models of the manufacturing process of castings: G1, G2,..., Gn

Table 1. Operations realized in melting shop and smeltery (for figure 5)

Nr op.	Name of operation
10	Melting metal in arc furnace A
20	Keeping alloy in an induction furnace A1 or A2 after pouring from arc furnace A
30	Melting and keeping metal in medium frequency induction furnace B or C
40	Melting and keeping metal in Fomet type induction furnace with capacity of 60 tones
50	Forming and pouring on a horizontal line A
60	Forming and pouring on a horizontal line B
70	Forming and pouring on the Disamatic line
80	Cleaning casts from the Disamatic line

Some casts may be made interchangeably on two or three lines, and the lines can be powered from different furnaces. Horizontal lines A and B use common match plate and do not practically differ when it comes to technology. The Disamatic line with vertical mould division is characterized by higher efficiency (measured by the number of moulds poured in one hour), but the mould can house fewer models than a traditional mould box on a horizontal line. Differences are noticed also in the weight of metal poured into the mould.

Basing on previous data, an average level of faults by manufacturing four exemplary casts on different lines powered by an arc furnace was presented in figure 6.

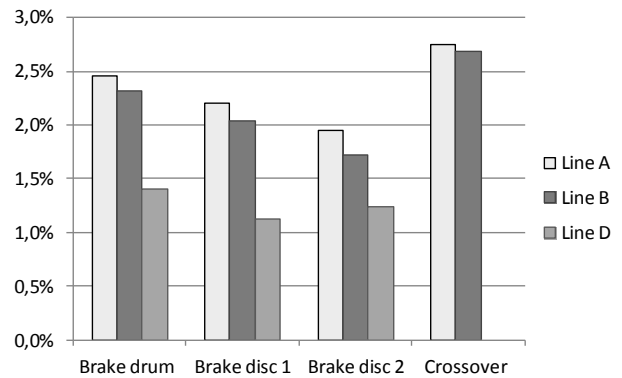


Fig. 6. The observed average level of faults by manufacturing exemplary casts on particular foundry lines

While planning the order of casting and pouring, large basic cyclical production orders for the automobile industry were treated as a priority (fig. 7).

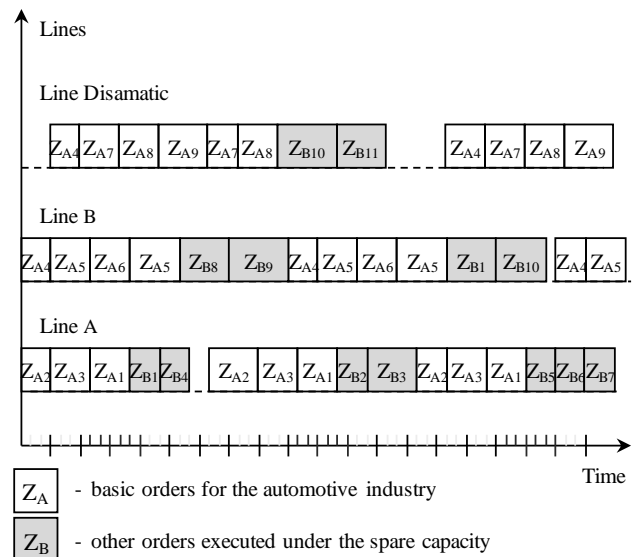


Fig. 7. Scheduling iron casts manufacture on automated foundry lines

For the assessment of the production schedule variants, the Pareto analysis was applied (fig. 8).

Manufacturing prime costs and time of particular orders realization were adopted as assessment criteria. Solutions which did not fall within the set of feasible solutions due to the cost or failure to meet deadlines were rejected in the first place. Processes of manufacturing casts involve a high risk of distortions and quality problems, so the research assumed a time reserve in case such situations occurred.

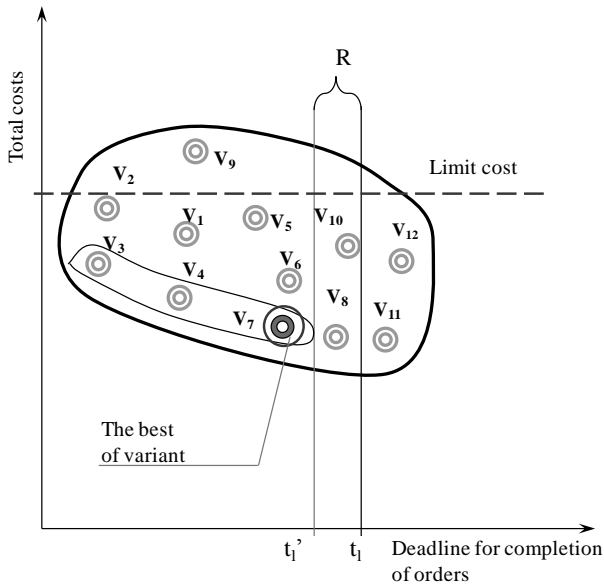


Fig. 8. Assessment of variants based on analyzing solutions in the Pareto sense

As a result of the presented procedure, the most advantageous variant was chosen from among the analysed group, taking into account the adopted assessment criteria.

4. Conclusions

The present work presented a possibility of cost accounting in the assumed reporting period on the stage of production scheduling, depending on the choice of furnace and line, workload on workstations, where particular lots of orders will be performed, as well as on the size of lots and the order of their realization.

Conducting cost analyses, which allow for taking decisions related to the problem of multi-variant process character depending on order backlog and organizational conditions is vital as early as on the stage of manufacture planning. Failure to meet deadlines, production of defective casts or production to the warehouse generate unnecessary costs. Using modeling and simulation of production systems in cast manufacture scheduling allows to analyze different decision situations, without the need of experimenting on a real system.

Quality management of iron casts performed by proper production organization can contribute to maintaining quality on a high and constant level, and, at the same time, can be the key to lowering manufacturing costs. Management through quality eliminates the need of producing to the warehouse and contributes to minimizing operations without added value.

In order to further improve manufacturing processes of iron casts on automated foundry lines, it is necessary to enhance processes by optimizing the charge, rationalizing liquid alloy preparation processes, eliminating production stoppages, increasing reliability of lines and furnaces operation and minimizing risk factors.

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