THE COST MODEL AS AN IMPORTANT PART OF A COST CONTROLLING IN INDUSTRIAL ENTERPRISES

Martin MRÁZEK [a], Lenka FIRKOVÁ [b], Pavel BABIŠ [c]

[a] VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU, martin.mrazek86@gmail.com

[b] Vítkovice Heavy Machinery, Ostrava, Czech Republic, EU, lenka.firkova@seznam.cz

[c] Huisman Konstrukce, Sviadnov, Czech Republic, EU, pbabis@huisman-cz.com

Abstract

Within the survey focused on perceptions and use of controlling in Czech industrial companies, it was found that the most commonly used form of controlling is the cost controlling. Currently all enterprises are trying to be cost-effective. For a number of industrial enterprises it is the question of keeping production and preserving the effectiveness of the company. It follows management efforts to reduce costs. In this case, it is necessary to focus on separate manufacturing or working task (production stage). For this recognition and control of costs appear to be most appropriate to use the Cost model. Detailed recognition and cost allocation using the Cost model gives enterprises the opportunity to model possible situations and their impact on the production phase. This article presents initial work on the development of a complex cost model of cast production. It represents the different stages of cast production and costs that arise during this process. This article is based on previous works in this area, mainly from PROJECTS I-XIV prepared by expert committee in Czech foundry society. This works were focused on specific production phase and created partial cost models. Detail recognition of costs and their proper allocation give us opportunity to measure and control them.

Keywords: controlling, cost model, casting, foundry

1. INTRODUCTION

The survey focused on perceptions and use of controlling in Czech industrial companies, which took place mainly during the 40th meeting of the economic expert committee of the Czech foundry society [1] found that the most established form of controlling is the cost controlling. Cost controlling is also considered as the most important kind of controlling. The general objective of cost controlling is to monitor the costs, analyze the effectiveness of their use, and eliminate bottlenecks. Bottleneck is called areas where there is inefficient consumption of costs. Currently, all businesses are trying to be cost effective. It follows the effort of controlled reduction of costs. In this case, it is necessary to focus on separate manufacturing or task (production stage). You need to focus on a production stage, where the restrictive intervention will not cause negative impacts. Otherwise, it may ultimately lead to such negative impacts that exceed the original planned positive contribution. For this recognition and control of the costs seems to be most appropriate to use the cost model. The cost model is used to measure and control costs. The goal is at least a prevention of their uncontrolled growth, at best, finding areas where it may be reduce. This is achieved mainly by clarifying the costs of the production stage. Detailed knowledge of costs and their correct assignment allows the measurement and control. Certainly applies here well-known axiom that what businesses do not measure, it also does not control. Detailed recognition and allocation of costs with the help of cost model gives the opportunity to model possible situations and their impact on the production stage. Ultimately, it is possible to model the effect on the entire company. Therefore, a properly defined cost model is very important for controlling risks. For a number of foundries it is a question of keeping production and preserving the effectiveness of the company. Often we have seen unsystematic efforts to "investigation" without a comprehensive assessment of the costs and benefits of possible solutions. It is necessary for efforts to reduce the costs based on their in-depth knowledge

and analysis of the specific conditions of the production. The production flow analysis is the need to use appropriate methods for monitoring their own operating costs.

This article is focused on complex cost model of casting. In the following chapters will be described individual phases of the cast production and costs, which rising during this process.

2. METHODOLOGICAL BASE

2.1 Phases of the cast production

Whole production must be divided into single production phases, which can be tracked. Production of the cast is made in these phases:

1. Production of liquid metal
2. Preparation of molding mixtures
3. Production of molds
4. Casting into the mold
5. Finishing

2.2 Cost of the enterprise

The costs, as it is commonly known, are monetized practical and purposeful handling of money and labor during the economic activities of the company. It is a consumption materialized and human labor for the production and implementation of production expressed by money. Costs are economic indicators of production units. They reflect the production, supply, sales activities of the enterprise and its technical, economic and organizational level [2].

2.3 Incomplete own costs calculation

For direct monitoring and subsequent management cost consumption was gradually introduced calculation of incomplete own cost (NVN). This is the kind of calculation that takes into account only the costs directly related to the production phase. This means that considers only those costs that may economic centers (work crew) directly affected by its activities. So simply, i.e. direct materials, direct labor and other direct costs. Calculation of NVN from classical type costing model based on complete own cost is differing mainly because it does not include overheads items (production, sales or administrative overhead).

3. INDIVIDUAL PHASES OF CAST PRODUCTION AND RELATED COSTS

3.1 Production of liquid metal

NVN cost model of liquid metal usually has the following form:

a) Material costs:
   - Cost per batch
   - Cost of the metal additives
   - Cost of non-metallic additives

b) Processing costs:
   - Cost of energy used for melting (electricity, natural gas, oxygen, argon, etc.)
   - Cost of proportional to the melting time (personal costs, masonry of furnace, pans, etc.)
   - Other processing costs (analysis of metal, slag, temperature metal, etc.)

By the sum of both items we receive incomplete own costs of liquid metal production. Calculation unit is usually a ton of liquid metal. The above outlined a costing formula result in the equation (1) to calculate the *NVN*.

$$NVN = MN + ZN \quad [CZK/t] \tag{1}$$

NVN … incomplete own expense [CZK/t]
MN … material costs [CZK/t]
ZN … processing costs [CZK/t]

Calculation of material costs

Material costs, which include cost per batch, metallic and non-metallic additives make up about 60-70% of the *NVN* of liquid metal. Determination of material costs is performed by equation (2):

$$MN = NC_{vs/t} + NC_{kp/t} + NC_{nkp/t} \quad [CZK/t] \tag{2}$$

MN … material costs [CZK/t]
$NC_{vs/t}$ … overall cost of the charge in the furnace [CZK/t]
$NC_{kp/t}$ … overall cost of metallic additives embedded in a furnace and the pan [CZK/t]
$NC_{nkp/t}$ … total cost of non-metallic additives embedded in a furnace and the pan [CZK/t]

First there are calculated costs of smelting [CZK/batch], followed by conversion to the fixed cost unit - a ton of liquid metal [CZK/t].

Batch includes all metallic and nonmetallic component inserted into the furnace prior to the actual switching (scrap return material, various kinds of metal and non-metal waste, pig iron, etc.). In calculating the costs of the batch start from batch quantity of the component embedded in a furnace and its price. Batch participates in largest share on the material costs.

Metallic additives are a group of ingredients that are in the furnace and then added to the pan during the melting process. To determine the cost of metallic additives is necessary to know the price of metal components and weight. Metallic additives are the second largest item of material costs.

Non-metallic additives represent a group fluxes. These are mainly coke, fluorspar, lime and other fluxes. The cost evaluation of non-metallic additives is similar to the other components of the material costs and expected knowledge of prices and quantities consumed non-metallic additives. Non-metallic additives occupy the smallest share of material costs of production of liquid metal.

Calculation of processing costs

The second group is the processing costs. Those involved in the production of liquid metal by 30-40% from NVN. Processing costs are assessed the cost of melting energy (e.g. electricity) cost related to the duration of melting (personal costs, and lining furnaces etc.) and other processing costs (metal temperature measurement, cost analysis and other metal) by equation (3). A special case is at EAF cost of graphite electrodes, the amount of which is modelled according to the time of melting and electricity consumption.

$$ZN = N_{ee/t} + N_{ge/t} + N_{os/t} + N_{vv/t} + N_{vp/t} + N_{ak/t} + N_{mt/t} \quad [CZK/t] \tag{3}$$

ZN … processing costs [CZK/t]
$N_{ee/t}$ … the cost of electricity consumption [CZK/t]
$N_{ge/t}$ … the cost of consumption of graphite electrodes [CZK/t]
$N_{os/t}$ … personal costs [CZK/t]
$N_{vv/t}$ … the costs of masonry of the furnace lid [CZK/t] - for electric arc furnaces
$N_{vp/t}$ … the costs of masonry walls of furnace [CZK/t]
$N_{ak/t}$ … the costs of analysis of metal and slag [CZK/t]
$N_{mt/t}$ … the costs of temperature measurement of metal [CZK/t]

Similarly to the material costs are first determined the cost of smelting [CZK/batch], which are subsequently converted to the chosen calculation unit, which is a ton of liquid metal [CZK/t].

Electricity is consumed in electric furnaces during melting batch and additives. In determining the cost of electricity is expected understanding of the amount of electricity consumed and its price. Electricity is the largest cost item group processing costs.

Graphite electrodes constitute a major part involved in the economics of operation in liquid metal production. Personnel costs, labor costs, which the crew of the furnace directly involved in the production of liquid metal.

Walling of the lid and furnaces represent another of the items that cost model includes production of liquid metal. Their incorporation into costing formula is trying to express the cost of wear.

Analysis of the liquid metal is another item which cost model within the processing costs assessed. Through these analyses, it is determined by the chemical composition of the liquid phase, depending on the quality produced twice or more for melting.

Measurement of the temperature of the liquid metal is the last of the items described generally considered cost model. The temperature of the liquid metal in electric furnaces is measured using removable probes to measure the temperature.

Through cost model is for example possible to determine how much the IWC of concrete quality metal, what proportion of these costs form the batch, additives, electricity, graphite electrodes, etc. Based on this information we obtain a detailed overview of the cost effectiveness of each melt.

3.2 Preparation of molding mixtures

Incomplete own costs are again defined as costs which include the main direct costs of production process of preparing molding materials, which are directly or determinable and crew management of the center can directly affect their spending. These include the direct costs of inputs such as grog, connective system, additives, all costs of energy, transportation, wages, etc. In addition, the cost of secondary raw materials - thus regenerate and return mixture, etc. Return the mixture was valued only the cost of handling and editing reversible mixture.

Determination of NVN main production phase of preparation molding mixtures is based on its division into the production phase [4, 5, 6]:

1. Acquisition, handling and preparation of new grog. The output of the production phase is costs of acquisition, handling and preparation of new grog - grog transported to the mixer.
2. Regeneration. Calculation unit is 1 ton regenerate usable to the production of relevant new molding mixture. The output of production stage is cost of producing regenerate.
3. Handling of return mixture. The output are the costs of transport and "adjust" returnable mixture (calculation unit is 1 t return of the mixture) and its transport into the mixer.
4. Connective system. The output of this phase are the costs to purchase and transport of binder (calculation unit is 1 t binder) and its transportation to the mixer.
5. Handling of carbonaceous additives. Calculation unit is 1 ton of carbon additives. The output of the production phase is the cost of purchase and manipulation of carbonaceous additives (including their transport into the mixer).
6. Preparatory work - premix. Calculation unit is 1 tonne of produced premix. The output of stage of production the cost of premix composition.
7. Mixing of the components in a mixer. Calculation unit of the production phase is 1 tonne of produced molding mixture. The output of stage of is production cost of mixing the components in a mixer.
8. Technological properties of produced molding mixture. Calculation unit is 1 ton of produced molding mixture. The output of the production phase is the cost of testing the technological properties of manufactured molding mixture.
9. Deponie. Calculation unit is 1 ton of waste generated during the manufacture of molding mixture. The output of stage of production is the cost of 1 ton of waste.

3.3 Production of molds

Determination of the cost of molds production is based on, as well as in the previously solved phases of casting, a detailed description of all related operations [7, 8]. The phase (that include both manual and mechanical production method of molds) includes:

1. Preparation of the model for formation
2. Production of the lower half-mold
3. Production of the upper half-mold
4. Composition of molds
5. Move mold to casting field
6. Production of cores
7. Production of auxiliary parts

3.4 Casting into the mold

This production phase hasn´t been investigated yet.

3.5 Finishing

The final main phase of production of the casting is finishing or cleaning the casting. The phase contains next operations [9, 10, 11]:

1. Transport and removal of molding mixtures
2. Mechanical cleaning (blasting)
3. Heat treatment (TZ)
4. Removing risers and gating (cutting, burning, insulting, etc.)
5. Adjustment after removal of risers and gating system, rough grinding
6. Preserve defects
7. Fine grinding
8. Ironing of weld defects
9. Grinding welds

4. DETERMINATION AND ANALYSIS OF CASTING COSTS

Costs of single production phases have been described during last 15 years in 14 analyses called PROJECTS I-XIV:

The liquid metal phase Project I., V. and VI.:

- Comparison of technologies and their costs in the liquid iron production phase - liquid iron with lamellar and spheroidal graphite and cast steels, year 2000.
- Potential for cost reduction in the production of liquid phase in the Czech iron foundries, year 2004.
- Opportunities for cost savings in the production of liquid phase in the Czech steel and iron foundries, year 2005.

On the cast were focused Project II. - IV.:

- Comparison of the cost of ferrous metals casting, year 2001.
- The issue of ongoing monitoring of costs in the Czech casting foundries, year 2002.
- Validation of the model of continuous monitoring costs in the Czech casting foundries, year 2003.

Preparation of sand mixtures was the main theme of the projects VII. - IX.:

- Creation of a cost model for preparing molding materials, year 2006.
- The issue of assessing the cost of molding materials, year 2007.
- Enhanced cost model for preparation of molding materials, year 2008.

Production of forms in the project X. and XI.:
- Cost assessment methodology of production preparation phase of forms, year 2009.
- Development of forms production cost evaluation, year 2010.

Finishing part in three recent projects XII. - XIV.:
- Development of a cost model for the finishing of castings, year 2011.
- Development of a cost model for finishing of castings (II. Stage), year 2012.
- Development of a cost model for finishing of castings (III. Stage), year 2014.

Outlined above cost models have been developed in past years by research teams and are used in real life. It was found that the largest part of total costs, respectively full own costs of cast (40-60 %) are made during liquid metal production (smelter). The following is the process of formation, which has 10-25% of the full own cost. The rest of the cost is divided into the activities of other sections which are also involved in the production of castings (in material, pattern shop, dry cleaning, etc.). The partial cost models independently solve each production phase. Operational managing of casting and especially optimization of the cast production cost requires complex cost model.

5. COMLEX COST MODEL OF CAST

The need for a method that will evaluate cast production costs in the shortest possible time unit (day, week) compared with the available tools for measuring consumption costs - accounting (financial-year period), cost controlling (quarter, month) is significant. Another requirement is to determine the actual cost of the "direct" method, if it is possible, without (or with minimal) allocation bases and relative quantities and to each specific cast. Development of a complex cost model of cast production is the following task whose solution is in front of foundry experts.

5.1 Possible variants of establishing a complex cost model for casting production

The first way is connection of all existing cost models, which have already been developed and their verification in the real life. This connection must also bring their simplification. Another way is to investigate an approach that was outlined in the Project III. “Issue of ongoing monitoring costs in the Czech casting foundries”. It means come out from the experience gained in that time and attempt the verification.

Currently, it is preparing the first verification of selected phases of a complex cost model in a one selected foundry. The goal is to verify, on a relatively simple steel cast, if it is possible to set up maximum and minimum costs. Consequently find out the cost difference and evaluate possibility of using this approach.

5.2 Expected use of the complex model

In the development of the cost model were identified following options for using:
- Calculating the cost of casts for comparing to the offered price.
- Using of the calculated costs for strategic intentions of foundries, planning the amount of profit, determination of the break event point, etc.
- Using the calculation formula for the analysis of the cost of individual operations, the conditions for possible cost reductions.
- Compare the cost of selected casts produced at different sites.
- Using the calculation formula for comparison of different foundry technologies.
- Comparison of standard costs for the actual period of time (shift) to analyze the losses in production. Monitoring of compliance with the prescribed technology for individual operations. Daily analysis in production.

CONCLUSION

This article is focused on complex cost model of casts. It gives information about separate costs which rising in single phases during cast production. Further are introduced PROJECTS, which have been focused for long time on monitoring of cast production costs.

REFERENCES

[1] BABIŠ, P. Zpracování průzkumu, rukopis, Frýdek-Místek 2012.

[2] VOZŇÁKOVÁ, I., JANOVSKÁ, K., MYNÁŘ, M., SIKOROVÁ, A. Ekonomika podniku. Ostrava, VSB - Technická univerzita Ostrava, 2008, ISBN 978-80-248-1760-6.

[3] KOVÁČ, J., KUPKA, A. Effect of Silicon on the Magnetic Properties of Sheet. Steel sheets, 1998, vol. 49, no. 11, p. 1.

[4] FIGALA, V. Vývoj a aplikace metody technicko-ekonomické analýzy při výrobě tekutého kovu na elektrických pecích. Disertační práce, 2011, VSB - TU Ostrava.

[5] KAFKA, V., NYKODÝMOVÁ, V., FOŠUM, J., CHUDÁČEK, S., SZMEK, V., KNIRSCH, V., DOUPOVEC, D., LÁNA, I., FRYČ, P., NOVOBILSKÝ, M., JOCHIM, P., ŠENBERGER, J., MARTIŇÁK, R. Vytvoření nákladového modelu přípravy formovacích směsí. Závěrečná zpráva PROJEKTU VII., 2006.

[6] KAFKA, V., NYKODÝMOVÁ, V., FOŠUM, J., CHUDÁČEK, S., SZMEK, V., KNIRSCH, V., DOUPOVEC, D., LÁNA, I., NOVOBILSKÝ, M., JOCHIM, P., MARTIŇÁK, R. Problematika posuzování nákladovosti formovacích směsí. Sborník PROJEKTU VIII., 2008, ISBN 978-80-02-02001-1.

[7] KAFKA, V., NYKODÝMOVÁ, V., FOŠUM, J., SZMEK, V., KNIRSCH, V., DOUPOVEC, D., LÁNA, I., NOVOBILSKÝ, M., JOCHIM, P., MARTIŇÁK, R., NEUDERT, A., VESELÝ, P., ŘEHÁČKOVÁ, K., ŘEHŮŘKOVÁ, K., PAZDERKA, J., VOLEK, J. Rozšířený nákladový model přípravy formovacích směsí. Sborník PROJEKTU IX., 2008, ISBN 978-80-02-02129-2.

[8] KAFKA, V., NYKODÝMOVÁ, V., KNIRSCH, V., DOUPOVEC, D., LÁNA, I., NOVOBILSKÝ, M., MARTIŇÁK, R., VESELÝ, P., ŘEHÁČKOVÁ, K., ŘEHŮŘKOVÁ, K., PAZDERKA, MARKO, E., HERZÁN, M., VYLETOVÁ, B., JIŘIKOVSKÝ, J, HŘEBÍČEK, L. Metodika nákladového hodnocení výrobní fáze přípravy formy. Sborník PROJEKTU X., 2010, ISBN 978-80-02-02208-4.

[9] KAFKA, V., NYKODÝMOVÁ, V., DOUPOVEC, D., LÁNA, I., NOVOBILSKÝ, M., VESELÝ, P., HERZÁN, M., VYLETOVÁ, B., HŘEBÍČEK, L., POLOKOVÁ, O. Rozpracování nákladového hodnocení výroby forem. Sborník PROJEKTU XI., 2010.

[10] KAFKA, V., HERZÁN, M., JELÍNEK, P., LÁNA, I., LASÁK, R., NOVOBILSKÝ, M., PAZDERKOVÁ, V., POLOKOVÁ, O., STANÍČKOVÁ, G., VYLETOVÁ, B., DOUPOVEC, D. Vypracování metodiky nákladového hodnocení výrobní fáze apretace odlitků, PROJEKT XII, závěrečná zpráva, 2012, Česká slévárenská společnost Brno.

[11] KAFKA, V., LÁNA, I., NOVOBILSKÝ, M., HERZÁN, M., VYLETOVÁ, BRHEL, J., JELÍNEK, P., LASÁK, R., MIČA, R., STANÍČKOVÁ, G., STROUHALOVÁ, M. Vývoj nákladového hodnocení apretace odlitků (II. etapa). Závěrečná zpráva PROJEKTU XIII., 2012.

[12] KAFKA, V., LÁNA, I., NOVOBILSKÝ, M., HERZÁN, M., VYLETOVÁ, BRHEL, J., JELÍNEK, P., MIČA, R., FÍK, M., BRÁZDA, Z., MARKO, E., OBRTLÍK, J., MRÁZEK, M. Vývoj nákladového hodnocení apretace odlitků (III. etapa). Závěrečná zpráva PROJEKTU XIV., 2013.