

## PLANNING OF MATERIAL CONSUMPTION IN SERIAL PRODUCTION OF THE CASTINGS

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The production of castings can be considered as production in transport. It is necessary to plan and supply the huge quantity of different materials. The expenses of these materials reach 80 % of all expenses which give the importance to planning of working materials for serial production. To perform all mentioned in planning phase of production is necessary to define satisfactory method of determination of kind and quantity of working materials and carriers of necessary information for planning. As entrance have information from Operational sheet, List of operations and List of tools.

**Key words:** *casting, serial production, planning, material*

**Planiranje utroška materijala kod serijske proizvodnje odljevaka.** Proizvodnju odljevaka može se promatrati kao proizvodnju u transportu. Potrebno je planirati i nabaviti velike količine materijala izrade. Troškovi materijala dosežu 80 % svih troškova što daje važnost planiranju materijala izrade kod serijske proizvodnje. Da bi naprijed navedeno bilo moguće napraviti u fazi planiranja proizvodnje potrebno je definirati zadovoljavajuću metodu za određivanje vrste i količine materijala kao i nosioce potrebnih informacija. Kao ulazne podatke postoje informacije iz Operacijskog lista, Popisa operacija i Popisa alata.

**Ključne riječi:** *odljevak, serijska proizvodnja, planiranje, materijal*

### INTRODUCTION

Looking into the production of the castings, it can be said that none of the production process phases in foundry will give the product which is to be used outside the foundry. However, any phase of the production process has sense when the casting is made. The production of the castings is production in a transport because huge quantities of different materials have to be moved and used. Thus, for producing 100 t of the casting, both the production process of foundry and consumption of different materials are presented in [1]. The costs of material in industry vary from 40 - 80 % of total production costs [2], whereas for foundry and metallurgy, the costs of working materials are above 80 % of total production costs [3]. By planning the supply and consumption of different materials at different phases of production process, both the rational, economical production, and competitiveness and high market level can be ensured.

In practice, there is a common material consumption planning. Quantities of basic working materials are pre-

scribed for one single charge of composite materials i.e. cast, molding sand or core. Material calculation for daily, weekly or monthly production is not made. Purchasing is, however, based on recent consumption and warehousing documentation. That means the stocks of materials have to exist for all materials used in the past and have to be bigger than necessary so as to prevent production standstill. Needed quantity of composite and basic working materials are not based on production plans for the next period but on the average past consumption of materials multiplied by correction coefficient for either bigger or smaller production plan with relation to similar past production programs of the castings. On the modern, globally open market, where production plans change and where quantities of castings, fast and precise planning of working materials start to be crucial for surviving due to market changes, huge costs of surplus of materials, the costs of warehousing, manipulations or shortage of materials can consequently either give rise to shortage in contractual quantity or term obligations or can result in losing the market. Successful realization of all production plans depends upon early supplying of all working materials in exactly defined quantity. All this has to be adjusted to plans and terms of production process [4].

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**TECHNOLOGICAL BACKING FOR PLANNING OF MATERIAL CONSUMPTION IN SERIAL PRODUCTION OF CASTINGS**

Operational department has to [5]:

- list all necessary specifications for materials which have to be ensured to accomplish production plans,
- check the exist stocks on time and reserve all needed materials in warehouse,
- define the terms of coming in for all materials.

To accomplish the planning process, due to Vila, A., it is necessary to specify materials. For this reason, documents have to be prepared which precisely determine kind and quantity of materials that are to be used in production of a specific casting. Roughly, materials can be divided into working materials, technological fuel and supporting materials. In this article we are interested in working (row) materials and technological fuel. In technological (manufacturing) process they are spent on the product (the casting). How can necessary basic - quantity production of working materials be calculated in the production of one single casting?

**List of materials**

Based on design drawings of the casting i.e. drafts of the casting model, the technologist will define the kind of materials necessary for producing each single casting. After that he will define the molding box and his dimensions before starting to define technological procedure for the

casting. Molding boxes have standard dimensions. Their volumes are constant and equal to the sum of volumes of all material which are in (metal, molding sand and core sand). When introducing technological process, the technologist will measure the weight of metal and weight of all cores. The weight of the molding sand will be calculated from inside volume of the casting box and specific weight of the cast iron, the cores and the molding sand.

Above mentioned measurement will be performed on significant size of sample of the castings, depending upon quantity of series, technological complexity and size of the casting. In order to collect data we should be extremely precise and ensure statistically correct average weight of measured materials.

Based on this measurement technologist will prescribe the number and weight of basic working materials and technological fuel. These entire data technologist will put in a form as List of materials. List of materials define all working materials (name, mark and weight) for producing the each single casting [6], Table 1.

**Specification**

In the List of materials the basic working materials which are directly going into the mould are given. Besides, the composite materials and their quantity in the single casting are also given. It is necessary now to create the structural tables of composite materials or the form named Specification for material.

These tables can be made in Technology department of iron foundry for one kilo of different sand mixture (for mould or core) or one kilo of a Charge for different quality of the casting melted in the furnace. For each one kilo of the composite materials, all basic working materials and their weight's share [7], are to be defined which can be distinguished from the Charge, where the total weight of basic materials is defined which are to be poured either into one Charge of melting furnace or into sand mill.

**Planning of material consumption in serial production**

Operational department has possibility to calculate consumption of the working material for each Work order on the basis of the following forms: List of mate-

Table 1. **Proposal form for List of materials**  
 Tablica 1. **Prijedlog izgleda popisa materijala**

List of materials		Product:	Draft:	Page:
No.	Name	Mark	Weight / kg	Pages:
1	2	3	4	5
1.	Bentonit	xxx xxx xx	xxxx	10
2.	Water coat	xxx xxx xx	xxxx	
3.	.....	xxx xxx xx	xxxx	
4.	.....	xxx xxx xx	xxxx	
1.	Moldersand	xxx xxx xx	xxxx	20
2.	Lining	xxx xxx xx	xxxx	
3.	.....			
1.	18	xxx xxx xx	xxxx	30
2.	....	xxx xxx xx	xxxx	
1.	xx xx	xxx xxx xxx	xxxx	40
Date:		Made by:	Verified by:	

rials and Specification for materials. If we have middle or big serial production, for all Work orders in some period (day or week), it is convenient to plan the same or similar kind of composite materials i.e. the castings which need the same or similar kinds of the composite materials [8]. In this way, the same basic materials and even the technological fuel will be used during the same period. For all Work orders issued for the same period from above mentioned technological documents, it will be possible to take data necessary for calculation of needed quantity basic and composite working materials in the all organizational units of foundry:

$$G_u = | G_1, G_2, G_3, \dots, G_k, \dots, G_m |, \tag{1}$$

where:

- $G_u$  - total mass of all necessary working materials for all Work orders at same period,
- $G_k$  - total mass of all necessary working materials for Work order – RNk,
- Rank = Work order –  $k, k \in \{1, \dots, m\}$ .

Further, the mass of all working material has to be calculated for accomplishing the Work order –  $k$ :

$$G_k = \begin{pmatrix} g_{k_1} \\ g_{k_2} \\ \vdots \\ g_{k_i} \\ \vdots \\ g_{k_n} \end{pmatrix} \times Q, \tag{2}$$

Table 2. Proposal of form for Specification for GG18  
 Tablica 2. Prijedlog izgleda normativa za kvalitetu SL18

Doc's No.		SPECIFICATION for material GG18		List:
				Lists:
No.	Name of material	Mark	%	Weight / (kg/kg)
1	2	3	4	5
1.	Steel	xxxxx	20	0,208333
2.	Pig iron	xxxxx	45	0,56875
3.	Return metal trash	xxxxx	35	0,354583
4.	Coke	xxxxx	25	0,229166
5.	Limestone	xxxxx	3	0,03125
6.	Eskaloy	xxxxx	0,14	0,001458
7.	Ferrosilicon	xxxxx	1	0,010416
8.	Ferromanganese	xxxxx	0,28	0,002976
9.	CaC <sub>2</sub> 50/80	xxxxx	2	0,02083
10.	% burn away	xxxxx	4	
11.	Pig iron	GD	96	1,00
Date:	Made by:		Verified by:	

where:

- $g_{k_i}$  - the mass of the single basic (elementary) working material or the composite working material due to List of materials for Work order – RNk,  $i \in \{1, \dots, n\}$ ,
- $Q$  - the quantity of the castings in production process by Work order – RNk,

Further, the mass of all working material has to be accounted for the composite materials:

$$g_{k_i} = | g_{k_{i1}}, g_{k_{i2}}, \dots, g_{k_{ij}}, \dots, g_{k_{ip}} |, \tag{3}$$

where:

- $g_{k_{ij}}$  - the mass of  $j$  - basic working material which coming out from Specification of  $i$  - composite material and calculated for  $k$  – Work order,  $j \in \{1, \dots, p\}$ .

If the matrix (3) is put in the matrix (2) will come out the next matrix:

$$G_k = \begin{pmatrix} g_{k_{11}} & g_{k_{12}} & \dots & g_{k_{1j}} & \dots & g_{k_{1p}} \\ g_{k_{21}} & g_{k_{22}} & \dots & g_{k_{2j}} & \dots & g_{k_{2p}} \\ \vdots & \vdots & & \vdots & & \vdots \\ g_{k_{i1}} & g_{k_{i2}} & \dots & g_{k_{ij}} & \dots & g_{k_{ip}} \\ \vdots & \vdots & & \vdots & & \vdots \\ g_{k_{n1}} & g_{k_{n2}} & \dots & g_{k_{nj}} & \dots & g_{k_{np}} \end{pmatrix}. \tag{4}$$

The matrix data are taken from the following documents: Work orders, Lists of materials and Specifications. Ordering the working materials due to the single Work order will be

not practicable because the job of the Operational department, the warehousemen, the operational managers and the Supplying department will be multiplied. It will be interesting to calculate the all necessary basic working materials for all composite and elementary materials:

$$G_{k_j} = \begin{pmatrix} g_{k_{1j}} \\ g_{k_{2j}} \\ \vdots \\ g_{k_{ij}} \\ \vdots \\ g_{k_{nj}} \end{pmatrix}, \tag{5}$$

where:

$G_{kj}$  - the mass of  $j$  - basic working material for  $i$  - composite material  $k$  – Work order;

will come out:

$$G_j = |G_{1j}, G_{2j}, G_{3j}, \dots, G_{kj}, \dots, G_{mj}|, \quad (6)$$

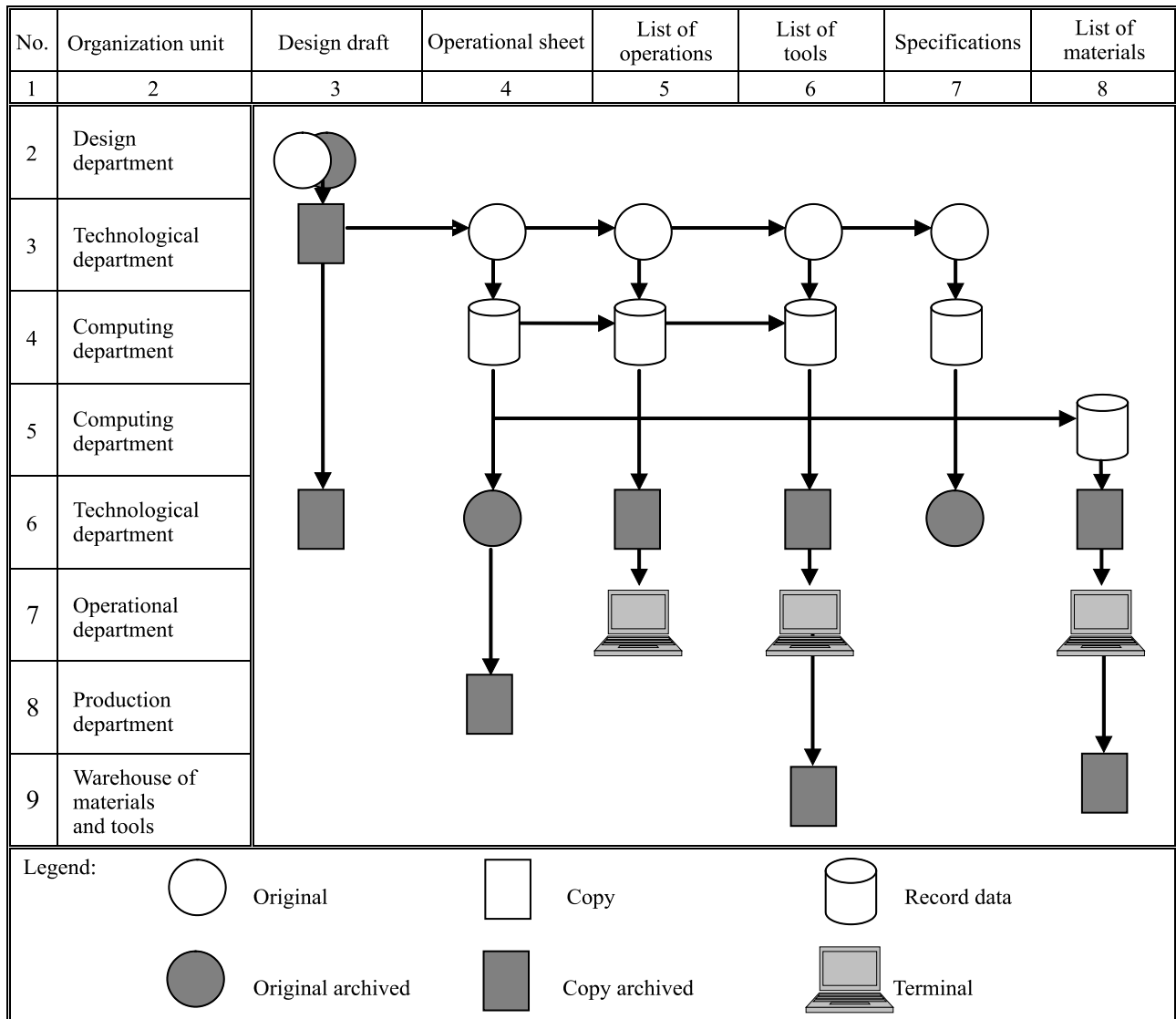
where:

$G_j$  - the mass of  $j$  - basic working material of  $i$  - composite material for all Work orders in some operational period. This data has to be put in warehouse document to release the same.

**Review of flow of basic technological documents**

In Table 3., the columns are given the sequence of appearance of the basic technological documents whereas the flow of the same documents is shown between the organizational units in rows. The scheme is presented for imaginary macro organization of enterprise and its foundry which produces the castings for internal enterprise needing. It is necessary to ensure computing for all necessary working materials precisely and in time because of huge number of variables for production process in fixed period (different castings, different technological processes, different quantity of production series, and different stocks of each material in warehouses...).

Table 3. Scheme of technological documents flow  
 Tablica 3. Shema protoka tehnoloških dokumenata



## CONCLUSION

The presented method shows the possibility of performing the exact calculations and planning of needed working materials for complex production program of foundry during any operational period. The essential requirements are to be defined by usual technological documents at the introducing phase of the new castings into the production program i.e. by Operational sheet which define the equipments, work place and conditions of processing, by both List of operations which define the technological procedures for manufacturing of the casting and List of tools which define necessary tools for technological procedure of the casting processing. Besides, two documents are necessary to be defined for the reason of planning and purchasing: List of materials which define all necessary basic working materials (mark, quantity, shape) which are directly involved in production of the castings and Specification which define content and weight of the basic working materials for each composite material involved in production of the castings. The specification of all basic working materials for one kilo of the casting is ensured in this way.

Necessary quantities of basic and composite materials may be calculated from above mentioned two documents for all issued Work orders in one period and for all organization units of foundry. To make all mentioned calculations on the time is necessary to computing all the data.

By this approach foundries were given an opportunity to be involved as a partner in the integral application of Simultaneous Engineering from designing the product to its warehousing [9], and to put their knowledge of produc-

tion process and demands at the disposal to designers in using the CAD/CAM/CAE technology, fast producing the new products, central data managing [10].

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