Configuration of management accounting information system for multi-stage manufacturing

S V Mkrtychev, A V Ochepovsky, O A Enik

Togliatti State University, 14 Belorusskaya St., Togliatti, 445020 Russia

E-mail: sm5006@yandex.ru

Abstract. The article presents an approach to configuration of a management accounting information system (MAIS) that provides automated calculations and the registration of normative production losses in multi-stage manufacturing. The use of MAIS with the proposed configuration at the enterprises of textile and woodworking industries made it possible to increase the accuracy of calculations for normative production losses and to organize accounting thereof with the reference to individual stages of the technological process. Thus, high efficiency of multi-stage manufacturing control is achieved.

1. Introduction

Among small and medium-sized businesses, enterprises with multi-stage manufacturing are widely represented utilizing the sequential processing of raw materials into finished products within a technological process consisting of several individual stages. These include enterprises of textile, metalworking, woodworking and other industries.

Among the main features of such enterprises, it is necessary to highlight large material consumption and the presence of so-called inevitable or normative production losses, i.e. production wastes that are difficult to avoid even if the production standards and regulations and the rational use of raw materials are strictly observed. Normative production losses are calculated with the help of normative technological coefficients determined from the routing map of a technological process.

Practice shows that to ensure the effective management of an enterprise with multi-stage production system, reliable accounting and analytical information is required on the level of normative losses at each stage of the technological process [1]. To solve this problem, management accounting information systems (MAIS) are used [2]. They provide the automated calculation and registration of normative production losses based on the aforementioned coefficients. However, in some cases, when a raw material supplier is replaced, for example, the actual technological coefficients may differ significantly from the set values. This leads to incorrect calculations of normative production losses and to a decrease in the efficiency of multi-stage manufacturing control.

Thus, it is necessary to develop a configuration of MAIS that will allow us to solve this problem.

2. Background

It should be noted that the existing studies in the area of multi-stage manufacturing management are mainly focused on the problems of production costs minimization and on enhancing the quality of finished products [3, 4]. The mathematical models and algorithms described in such papers were developed to optimize the technological process parameters and were aimed at ensuring a minimal value of the total system cost (TSC) [5, 6]. At the same time, the absence of a link between normative production losses and specific storage locations at particular stages of the technological process complicates the problem of such losses accounting and its solution, and encumbers the obtaining of qualitative information to make correct management decisions.

In the research paper [7], the approach to optimization and calibration of the MAIS model for multi-stage manufacturing is described. This approach is based on the object-structured methodology that uses the representation of a multi-stage production system in the form of an object-structured model, elements of which are virtual heirs to the following basic classes of the technological ontology [8]:

- class “Aggregate”, objects of which change the state of a material flow element (raw materials, semi-finished products etc.);
- class “Warehouse”, objects of which store material flow elements and register their movement within a technological process.

This model is a variation of a semantic network and can be simply described by an oriented graph [9, 10].

However, the presented solution is intended for technological processes in which the value of production losses at the stages can be determined by the physical inventory of production wastes at individual stages by weighing the remains thereof accumulated during the reporting period, which is difficult to achieve for some multi-stage production systems utilized in textile and woodworking industries.

3. Solution approach

Figure 1 shows the object-structural model proposed for the configuration of MAIS for *n*-stage manufacturing.

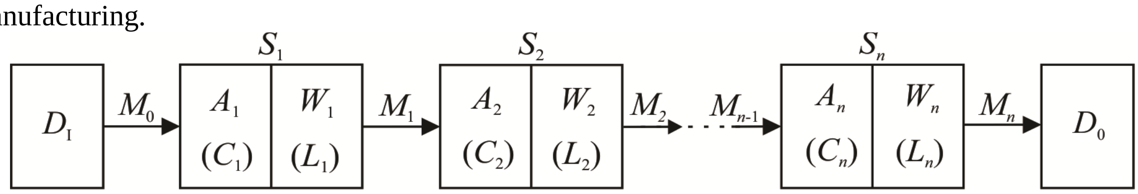

Figure 1. An object-structural model of the configuration of MAIS for *n*-stage manufacturing.

This model is described in the form of graph G (D, S, M) oriented towards the material flow, where:

- $D = \{D_I, D_O\}$ – a set of nodes denoting the real warehouses of raw materials and finished products respectively;
- $S = \{S_1, S_2,..., S_n\}$ – a set of nodes denoting the stages of the technological process;
- $M = \{M_0, M_1,..., M_n\}$ – a set of arcs loaded with the elements of the material flow, where M_0, M_n - weights of the raw material and the finished product respectively.

Each stage is simulated with a pair:

$$S_i = < A_i, W_i >, \text{ where:}$$

- i – stage index, i = 1,2, …, n.
- A_i – an object of the “Aggregate” virtual class loaded with normative output coefficient $0 < C_i \leq 1$ defined as the relationship between output and input products values respectively at each stage given in a common unit of measurement (for example, kg):

IOP Conf. Series: Journal of Physics: Conf. Series **1015** (2018) 042039 doi:10.1088/1742-6596/1015/4/042039

$$C_i^{(k)} = \frac{M_i^{(k)}}{M_{i-1}^{(k)}}, \text{ where } k \text{ - product index.}$$

- W_i – an object of the “Warehouse” virtual class loaded with normative production losses L_i.

Virtual warehouses implemented in MAIS as real storage locations allow us to use standard inventory accounting operations and linear models of material balance to control normative product losses directly at the technological process stages [11].

The transaction of the automated calculation and registration of normative production losses is initialized by the transaction of the raw material consumption within the production process and is committed immediately after the finished product acceptance.

Then, the value of normative losses at each stage can be calculated using the following equation:

$$L_i^{(k)} = UM_0\left(1 - C_i^{(k)}\right), \text{ where:} \quad (1)$$

$$U = \prod_{j=1}^{i-1} C_j^{(k)}, \text{ where } U = 1 \text{ for } i = 1$$

Hence, the total value of normative production losses at the stages is:

$$L_{\mathrm{T}}^{(k)} = \sum_{i=1}^{n} L_i^{(k)} \quad (2)$$

As follows from equation (1), in order to ensure a qualitative accounting of the normative production losses at the stages, it is necessary to set correct values of the normative output coefficients.

Let us propose an approach to solving this problem based on the assumption that for each individual product made from a homogeneous raw material; within a short-run production, the linear relationships between the normative output coefficients at individual stages of the particular technological process do not change regardless of the raw material supplier. Let us also assume that all other losses can be neglected.

Then, for $i > 1$, the following equation holds:

$$C_i^{(k)} = R_{i-1}^{(k)} C_{i-1}^{(k)}, \text{ where:}$$

$R_{i-1}^{(k)}$ – a coefficient defining a relationship between the normative output coefficients at stages i-1 and i.

After a simple transformation, the equation (1) for each k takes the following form:

$$L_i = Q_i M_0\left(1 - ZC_1\right), \text{where:} \quad (3)$$

$$Z = \prod_{j=1}^{i-1} R_j, \text{ where } Z = 1 \text{ for } i = 1;$$

Q_i is calculated using the following expression:

$$Q_1 = 1, Q_2 = C_1, Q_3 = C_1^2 R_1, \ldots, Q_n = C_1^{n-1} R_1^{n-2} R_2^{n-3} \cdots R_{n-2}$$

Thus, the task of MAIS configuration is reduced to the selection of a correct value of coefficient C_1.

To solve this, let us propose an algorithm that includes the following steps:

- Step 1. An array of particular product output accounts selected from the MAIS database for the same amount of raw material M_0 from a particular supplier and an accounting period is created. For each row of the array, a total value of normative losses at the stages is calculated using the formula:

$$L_T = M_0 - M_n$$

- Step 2. Based on equations (2), (3) and the value of L_T, coefficient C_1 is selected and the output coefficients at the next stages of the technological process are calculated for each row of the array.
- Step 3. As shown in table 1, the resulting values of the output coefficients are defined as average of their calculated values in the array if the following condition is fulfilled:

$$V \leq V_W \text{, where:}$$

V, V_W - calculated and allowable values of the weight coefficient variation for a particular multi-stage manufacturing respectively [12].

Table 1. Normative output coefficients for the technological production process of the upholstery fabric “Striped Velvet” (the raw material is coarse fabric, M_0 = 200 kg, R_1 = 1.2, R_2 = 0.917, V_W = 15%).

	Stage 1 Clipping **C_1**	Stage 2 Stabilization **C_2**	Stage 3 Doubling **C_3**	L_T, kg
Average	0.80	0.96	0.88	65
Standard Deviation				8
V				12 %

The values of parameters R, V_W can be determined from the technological documentation of a particular multi-stage manufacturing.
This procedure can be implemented with the use of the Microsoft Excel analytical tool based on the data imported from MAIS [13].

- Step 4. A configuration of MAIS with new settings of the normative output coefficients is developed.

4. Conclusion

Based on the proposed approach, a configuration of MAIS for multi-stage manufacturing has been implemented on the platform “1C: Enterprise 8.x” [14].

The use of MAIS with the described configuration at the enterprises of textile and woodworking industries made it possible to increase the accuracy of calculations for the normative production losses and to organize accounting thereof with the reference to individual stages of the technological process.

Thus, the presented configuration of MAIS provides high efficiency of multi-stage manufacturing control.

References

[1] Shi J J, Yue X and Zhao Y 2014 *Naval Research Logistics* **61** 144–154
[2] Rom A and Rohde C 2007 *Int. J. of Accounting Information Systems* **8** 40-68
[3] Bai G, Kajiwara T and Lui J 2016 *J. of Management Accounting Research* **28(1)** 1-26
[4] Shetwan A G, Vitanov V and Tjahjono B 2011 *Computers and Industrial Engineering* **60** 473 -

484

[5] Goyal S K, Gunasekaran A, Martikainen T and Yli-Olli P 1993 *Int. J. of Production Planning and Control* **4** 239–252

[6] Lee H L and Yano C A 1985 *Production control in multi-stage systems with variable yield losses* Technical Report 85-32 DIOE (Ann Arbor Michigan: University of Michigan)

[7] Mkrtychev S V, Melnikov B F and Galochkin Y E 2013 *In the World of Scientific Discoveries / V Mire Nauchnykh Otkrytiy* **47.10** 15-22

[8] Mkrtychev S V 2014 *Bulletin of Tomsk Polytechnic University* **325 (5)** 66–71

[9] Muckstadt J A and Roundy R O 1993 *Analysis of multistage production systems* Graves S C, Rinooy Kan A H G, Zipkin P H eds. Logistics of Production and Inventory (Amsterdam: North-Holland) 59–131

[10] Nomura J and Takakuwa S 2004 *Module-based modeling of flow-type multistage manufacturing systems adopting dual-card Kanban system* In Simulation Conference Proc. of the 2004 Winter vol 2 1065–1072

[11] Saxena R S 2009 *Inventory Management: Controlling in a Fluctuating Demand Environment*. (New Delhi: Global India Publications Pvt Ltd) p 310

[12] Prakash J and Chin J F 2014 *Production and Manufacturing Research* **2(1)** 477-500

[13] Albright S C, Winston W and Zappe C 2008 *Data Analysis and Decision Making with Microsoft Excel* (Cengage Learning) p 1104

[14] Radchenko M and Khrustaleva E 2009 *1C:Enterprise 8.2. A Practical Developer's Guide. Examples and Standard Techniques* (Moscow:1C Company)