IMPROVING INDUSTRIAL SYSTEMS PERFORMANCE BY MONITORING QUALITY COSTS

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Abstract: *In industrial systems, raw material consumption has a major share in total expenditure. Also the quality of raw materials is essential to obtain a final product that meets the demanding requirements of customers. In this regard, analysis, evaluation and monitoring of consumption of raw materials is a vital condition for the existence of society. This paper aims to present a model for monitoring the consumption of raw materials in the industrial system that produces and sells milk products. The model developed allows highlighting of raw material consumption and the existing losses through every technological stages, helping to improve enforcement measures.*

Keywords: *cost, raw materials, monitoring, specific consumption, losses.*

INTRODUCTION

The correct determination of the performance of an industry is needed to decipher the relationship between industry structure and efficiency of its specific activities and the determinants of the growth or of the shrinkage of them [1]. The cost and earnings are primary performances of businesses and industries from which derive other indicators able to reflect the ability of firms to ensure benefits and high quality products for customers [2]. In this situation a major role is owed by quality costs through whose strict monitoring, organizations can increase profits and also can adjust their costs.

Quality costs expresses all costs incurred in the design, development, production, delivery and after delivery, to prevent, assess and maintain the quality, as well as expenses due to non-quality [3]. Quality costs are the costs involved in ensuring adequate quality and needed to give confidence, as well as losses due to failure of adequate quality [4].

Quality cost approach involves systematic actions [5]:

• Measurement / evaluation of quality costs (collection, processing and registration)

• Analysis of quality costs

• Establish lines of business improvement

Costs related to quality is an important tool for process optimization and quality of relevant activities. Through these costs the company is able to identify inefficient activities, critical points in the development process. Thus the corrective actions or improvements necessary in a particular sector of the company, can be more robust, ensuring the assessment and tracking the effectiveness of measures taken. On the other hand, knowing the financial impact of failures found in different sectors, they can be more easily analyzed, correlated with the leaders, setting the priority measures to be applied.

An effective quality management based on cost of quality includes:

- Establishing a system for measuring the quality costs;
- Developing long-term trend analysis ;
- Establishing annual targets for improving total cost of quality ;
- Monitoring the progress of each goal and initiate corrective action when goals are not achieved.

The most common classification of costs related to quality distinguishes the following four categories:

▪ ***Prevention costs*** are costs incurred in order to keep costs and assessment failures to a minimum. They are generated by activities taken to prevent or reduce defects.

▪ **Assessment costs** are costs involved in determining compliance with quality requirements. These are generated by activities for assessing product conformity to the requirements established by identifying defects.

▪ **Internal defects** costs are costs incurred by the organization as a result of defects identified before delivery to the customer. They are costs that disappear if there is any defect in the goods before delivery.

▪ **External costs** are costs incurred defect in the organization as a result of defects found after product delivery to the customer. They are costs that would disappear if there was no defect.

2. MONITORING RAW MATERIAL COSTS

The costs of quality can occur in all phases of the product life cycle, and in all operational levels of the organization. Any organization take measures to avoid failures that can occur in products; These measures can be pre-or post-factum.

Ante-factum approaches involve the adoption of measures to prevent the occurrence of defects and their detection in a time efficient manner. The loss decreases for all products and operational phases of the organization. Evidence of the quality and cost analysis involves the use of indicators, tools and specific documents. For example, the balance cost with quality, which presents the summary of these costs by category (cost of prevention, evaluation, these costs of internal and external failures) in absolute terms and as a share of production value.

The presentation below is intended to illustrate some aspects of quality management effects on raw material costs.

Orientation towards these costs are justified given the large share of raw materials in product costs. The case study is conducted on a company that produces and sells milk products in order to apply a model to monitor the consumption of raw materials on technological phases.

Table 1 shows the calculation of cost for the product "Yogurt" in the amount of 375 g, during the year, which shows that the largest share in the costs have costs of raw materials and materials, that is over 60%.

Table 1. Cost calculation for product "Yogurt"

	Items of expenditure	Unit cost (Lei)	Share of cost (%)
1.	Raw materials	12 328	60,5
2.	Cost of goods sold	1 223	6
3.	Salaries	1 817	8,9
4.	Taxes	142	0,7
5.	Amortization	896	4,4
6.	Energy and water consumption	810	3,9
7.	Supplies (packing aids)	2 354	11,6
8.	Interest	529	2,6
9.	Other expenses	280	1,4
	TOTAL UNIT COST	20 379	100

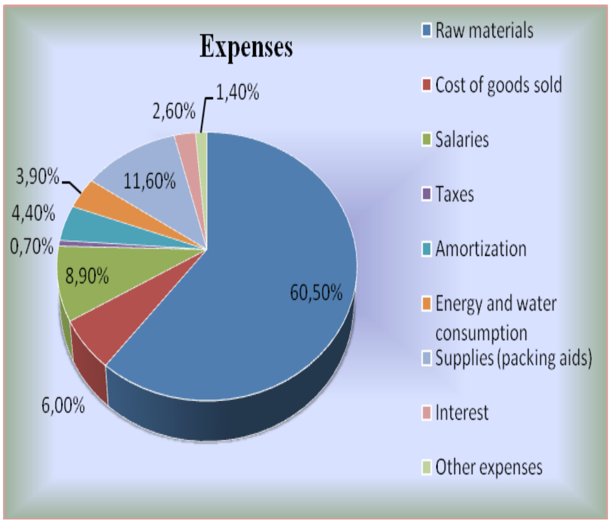


Fig.1 The cost structure for the product "Yogurt"

Changing raw materials with other materials, cheaper, it is a solution to reduce costs, but it could have serious consequences for the quality of the finished product. Most appropriate would be to find ways to reduce these costs by a greater concern for minimizing losses on the entire flow, from receipt of raw materials to product completion.

The main aspects of monitoring the effects on costs of raw material and materials are:

- Monitoring of the procurement process;
- Inventory control of materials;
- Determination of costs and deviations from norms.

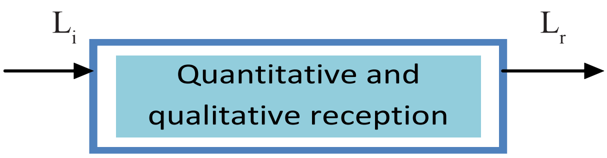
The last aspect will be further developed on an example of loss of material appearing on processing flow.

2.1. Determination of raw materials consumption To determine the consumption of raw materials and losses, we will use each technology stage of processing the product yogurt with a fat content of 2.8%, highlighting some of the management costs of the company.

Thus, before normalization, calculating the amount of milk for manufacturing stages, knowing the amount of whole milk as 4500 kg (corresponding production of a day) and losses in these steps:

- Reception, filtering, cooling, storage: p = 0.05%;
- Normalization: p = 0.20%;
- Pasteurisation: p = 1%;
- Sowing, thermostating: p = 0.1%;
- Mixing: p = 0.5%;
- Packing: p = 0.3%

a.



where: L_i = amount of milk before reception;
L_r = amount of milk after reception;
P_r = losses at reception;

$$L_r = L_i - Pr = 4\,500 - 2{,}25 = 4497{,}75 \text{ kg} \quad (1)$$

$$P_r = 0{,}05\ \%\ x\ L_i = 0{,}05\ \%\ x\ 4\,500 = 2{,}25\text{kg} \quad (2)$$

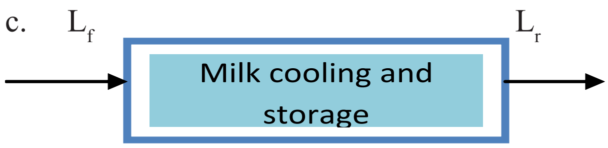
b

where : L_f = amount of filtered milg
L_r = the amount of milk received
P_f = losses at filtering process

$$L_f = L_r - P_f \quad (3)$$

$$L_f = L_r\ x\ (1-\frac{P_f}{100}) = 4497,75\ x\ (1 - \frac{0{,}05}{100}) = 40495{,}5\text{kg/day} \quad (4)$$

c.



where: L_f = the quantity of filtered milk;
L_r = the amount of cold milk;
P_r = losses found in milk cooling

$$L_r = L_f - P_r \quad (5)$$

$$L_r = L_f\ x\ (1 - \frac{P_r}{100}) = 4495{,}5\ x\ (1 - \frac{0{,}05}{100}) = 4493{,}25\ \text{kg/day} \quad (6)$$

d.

The fat content of whole milk received is 3.5% and the yogurt will have a fat content of 2.8%, being a fat yogurt category. In order to reduce the amount of fat it would be added skimmed milk.

where : L_n = quantity of milk normalized;
L_f = the quantity of filtered milk;
L_s = the amount of skimmed milk;
P_n = losses of normalization step;

$$L_n = L_f + L_s - P_n \quad (7)$$

C_n = quantity of milk normalized;
G_l = fat content of the normalized milk;
G_{ln} = the fat content of the standardized milk;

$$L_s = \frac{C_n\ x\ (G_l - G_{ln})}{G_{ln}} = \frac{4493{,}25\ x\ (3{,}5-2{,}8)}{2{,}8} = 1123{,}3\ \text{kg/day} \quad (8)$$

$$L_n = 4493{,}25 + 1123{,}3 - P_n \quad (9)$$

$$P_n = 0{,}20\ \%\ x\ (Lf + Ls) = 0{,}20\ \%\ x\ (4493{,}25+1123{,}3) = 11{,}23\text{kg/day} \quad (10)$$

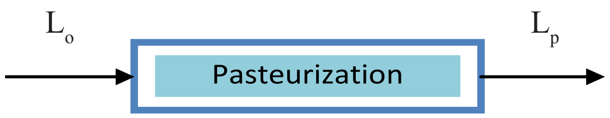
$$L_n = 4493{,}25 + 1123{,}3 - 11{,}23 = 5605{,}32\ \text{kg/day} \quad (11)$$

e.

where : L_n = quantity of milk normalized
L_o = the amount of homogenized milk
P_o = loss of homogenization step;

$L_o = L_n - P_o$ (12)
$P_o = 0{,}05\,\%\ x\ L_n = 0{,}05\,\%x\ 5605{,}32 = =2{,}8$ kg/day (13)
$L_o = 5605{,}32 - 2{,}8 = 5602{,}5$ kg/day (14)

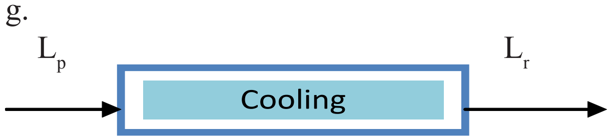
f.



where : L_o = the amount of homogenized milk;
L_p = quantity of pasteurized milk;
P_p = loss of pasteurization step;

$L_p = L_o - P_p$ (15)
$P_p = 1\ \%\ x\ L_o = 1\ \%\ x\ 5602{,}52 = 56{,}02$ kg/day (16)
$L_p = 5602{,}52 - 56{,}02 = 5546{,}5$ kg/day (17)

g.



where : L_p = quantity of pasteurized milk;
L_r = the quantity of cooled milk;
Pr = loss at cooling stage;

$L_r = L_p - P_r$ (18)
$P_r = 0{,}05\ \%\ x\ L_p = 0.05\ \%\ x\ 5546{,}5 = 2{,}77$ kg/day (19)
$L_r = 5546{,}5 - 2{,}77 = 5543{,}7$ kg/day (20)

h.

where : L_r = quantity of cooled milk;
CB = the quantity of cultures that is added to milk to obtain yogurt;
$L_{\hat{i}}$ = the amount of milk sown;

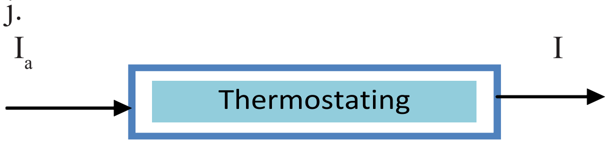
$L_{\hat{i}} = L_r + CB - P_{\hat{i}}$ (21)
$CB = 1{,}5\ \%\ x\ L_r = 1{,}5\ \%\ x\ 5543{,}73 = =83{,}15$ kg/day (22)
$P_{\hat{i}} = 0{,}1\ \%\ x\ (L_r + CB) = 0{,}1\ \%\ x\ (5543{,}73 + 83{,}15) = 5{,}62$ kg/day (23)
$L_{\hat{i}} = 5543{,}73 + 83{,}15 - 5{,}62 = 5620{,}5$ kg/day (24)

i.

where : $L_{\hat{i}}$ = the amount of milk sown;
I_a = quantity of yogurt packed;
P_a = losses identified on packaging;

$I_a = L_{\hat{i}} - P_a$ (25)
$P_a = 0{,}3\ \%\ x\ 5620{,}5 = 16{,}9$ kg/day (26)
$L_a = 5621{,}3 - 16{,}9 = 5604{,}4$kg/day (27)

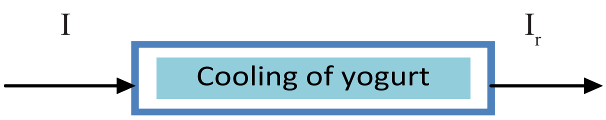
j.



where: I_a = quantity of yogurt packed;
I = yogurt;
P_t = losses at thermostating;

$I = I_a - P_t$ (28)
$P_t = 0{,}1\ \%\ x\ 5604{,}4 = 5{,}6$ kg/day (29)
$I = 5604{,}4 - 5{,}6 = 5598{,}8$ kg/day (30)

k.



unde : I = yogurt;
I_r = cooled yogurt;
P_r = loss identified on cooling stage;

$I_r = I - P_r$ (31)
$P_r = 0{,}05\ \%\ x\ 5598{,}8 = 2{,}8$ kg/day (32)
$I_r = 5598{,}8 - 2{,}8 = 5596$ kg/day (33)

1.

unde : I_r = cooled yogurt;
I_d = stored yogurt;

$$I_d = I_r - P_d \quad (34)$$
$$P_d = 0,05\ \%\ x\ 5596 = 2,8\ kg/day \quad (35)$$
$$I_d = 5596 - 2,8 = 5593\ \ kg/day \quad (36)$$

The quantity of yogurt produced annually is:

5593 kg/day x 255 days/year = 1 426 215 kg yogurt/year (37)

Specific consumption [6], liter of milk normalized to 2.8 of fat for 1 kg yogurt is:

$$C_s = \frac{L_n}{d\ x\ I_d} = \frac{5605,3}{1,029\ x\ 5593} = 0,97\ l/kg\ milk \quad (38)$$

where : d = normalized milk density;
L_n = normalized milk;
I_d = stored yogurt;

Loss balance is shown in Table 2 and Figure 2.

Table 2. Material balance

Operation	Entries (kg / day)	Losses (%)	Output (kg / day)
Reception	4 500	0,05	4497,7
Filterng	4497,8	0,05	4495,5
Cooling and storage	4495,5	0,05	4493,2
Normalization	4493,2 1123,3	0,20	5605,3
Homogenization	5605,3	0,05	5602,5
Pasteurization	5602,5	1	5546,5
Cooling	5546,5	0,05	5543,7
Sowing	5543,7 83,1	0,1	5620,5
Automatic Packaging	5620,5	0,3	5604,4
Thermostating	5604,4	0,1	5598,8
Cooling	5598,8	0,05	5596
Storage	5596	0,05	5593

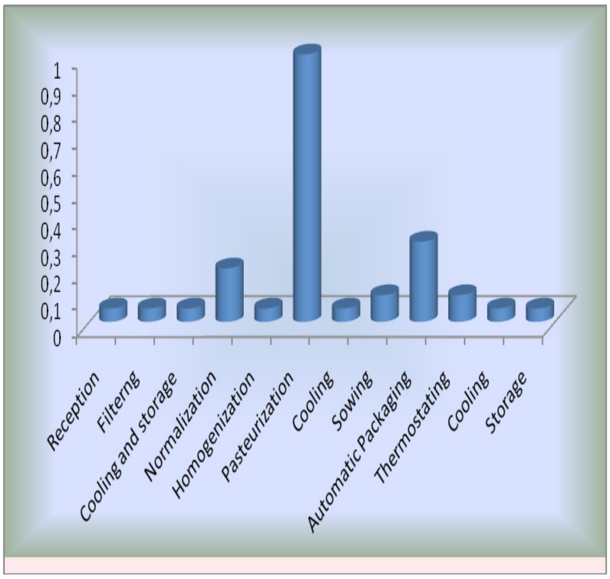


Fig.2 The record of losses in each of the phases of the manufacturing process

The overall losses rises to 113 kg per day, which is about 1,98% of the input. Valuable daily losses are about 244 lei, and the annual output is over 70 000 lei.

Thus, before the start of the manufacturing process shall establish rules on the types of expenses, such as time consumption of materials for the product to be manufactured. Actual cost is determined by adding the losses during the manufacturing process and to modify the rules.

To reduce waste and in the same time the quality costs, investments must be made in the modernization of techniques and technologies that will lead to the reduction of nonconformities, respectively a rigorous control during the manufacturing process. There will be create new categories of costs, depending on the effort that the firm makes investment and add existing ones.

Regarding the cost of raw materials it is necessary to follow all the movements of consumption and quantity of materials involved in the production.

By comparing the data taken from the deposit materials, that can be entered in a form of consumption, with the situation of production achieved, it aims to frame the material consumption within the limits of the standardized consumption, in order to identify the loss or non-conformities, while being able to take the best decisions in this regard.

To watch these losses is necessary to improve the system by drafting documents tracking situations such losses by developing lists to standardize the use of materials and other expenses.

CONCLUSION

Industrial systems performance is focused on the performance of technological processes and also through the quality of raw materials and of the obtained products. Quality of raw materials is critical in any manufacturing activity. Also, due to extremely high share of costs of raw materials in each production activity, it is imperative to implement a system by which to monitor and analyze constantly the consumption of raw materials for production [7].

Thus, this paper has aimed to highlight the importance of creating and implementing a monitoring system for the raw materials consumption. In this sense, in the first part of the work we performed a theoretical exposure in terms of definition and classification of quality costs, as in the second part of the work to achieve an applicative exposure, a study case concerning the determination of the consumption of raw materials and losses related to each stage of the technological process of manufacturing of yogurt.

Because there are no records in the company on the cost of quality, we presented some aspects about the costs of raw materials, revealing the methodology of calculation of raw materials consumption and technological losses coefficients.

Using the mass balance we determined the consumption of raw materials and the losses that were recorded in every stage of the manufacturing process, their reduction can be achieved through a stricter control, as the improvement of the manufacturing technology. It was found that most of the losses occurred during pasteurization stage. In the end of the paper we also presented some improvements measures that may be applied in order to improve industrial system performance.

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