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MATERIAL FLOW COST ACCOUNTING (MFCA) – APPLICATION IN A COMPANY MANUFACTURING CERAMIC TILES

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This article presents an application of the Material Flow Cost Accounting method (hereinafter the "MFCA") within a manufacturing plant of the largest manufacturer of ceramic tiles in the Czech Republic – the company Lasselsberger. It shows the importance of data acquired from the MFCA system as well as their application for an optimization of manufacturing processes for specific conditions of a manufacturing plant of the company.

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Principal Concept of MFCA

The MFCA represents a key tool of the management approach referred to as the flow management, the objective of which is, in particular, to manage manufacturing processes with regard to the flows of materials, energy, and data so that a manufacturing process can proceed efficiently and in compliance with any set targets [1,4,5].

The principal concept of the MFCA is based on the chart shown in Fig. 1.

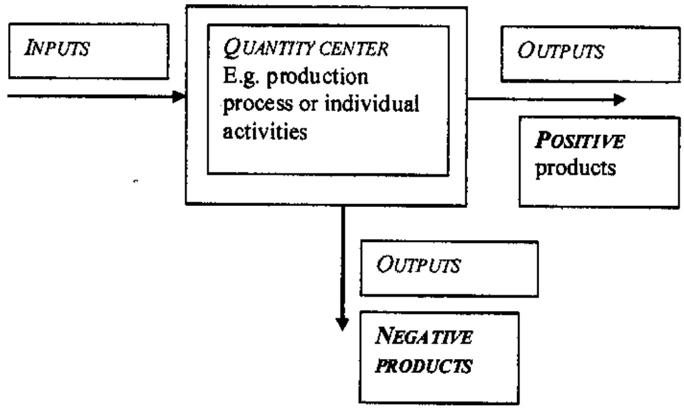

Fig. 1 MFCA chart (Source [9] and our research)

Any and all inputs (materials, energy, water, and other inputs) and outputs (primary products / byproducts, wastes, wastewaters, emissions) are determined within a quantity center, and a calculation is carried out in respect of material, energy, and system costs incurred for positive and negative products. The term positive product refers to any product transferred to the next manufacturing stage (a quantity center) as suitable and/or leaving the company as a final product. In terms of the MFCA, the term negative product is not only seen in the narrow sense, but it refers to any and all invested materials, energy, and other economic resources, which were not transformed into positive products and leave unused as wastes.

The MFCA concentrates on material flows and associated costs. Not only does the system provide data in physical units, it also shows the value of individual materials flows. Material costs are an important part of the material flow costs; these costs represent an important cost item in manufacturing companies. The usage of materials is monitored in physical units and it is also shown in monetary units (material costs) within the MFCA. The material flows are reconstructed within a quantity center, and data are ascertained in order to determine which part of the materials flows to positive products and which part of the materials leaves as negative products.

The MFCA also monitors energy costs, i.e. costs of all energy sources used within the respective quantity center. Furthermore, system costs are allocated to positive and negative products. The system costs are defined as any and all costs, which are incurred when handling material flows within a company (e.g. personnel costs, depreciation costs). Each material flow of a company may be treated as a carrier of system costs — whether it concerns raw materials, work in progress, products, or material losses. The system costs are always allocated to output flows, and they are retransferred to subsequent flows and stock of materials. Negative products, which leave a quantity center, must also be allocated waste disposal costs.

The MFCA represents an accounting method that provides the management as well as other stakeholders with absolutely new data, which can be used in support of the decision-making (see, e.g., [2,3,6,7,10,11,12]). Using the MFCA data, it is possible to seek "corrective actions" for material flows and to propose measures that might lead to a lower consumption of materials and a higher efficiency of manufacturing processes.

Characteristics of Company[2] and Description of Manufacturing Process

The company Lasselsberger, s.r.o. has been operating in the Czech Republic since 1998, when the Austrian company Lasselsberger GmbH acquired a majority share in the company Chlumčanské keramické závody, a.s. and consequentially in the joint-stock company Calofrig Borovany. Just a year later, the company Keramika Horní Bříza became part of the newly formed group, later followed by the company Kemat Skalná, s.r.o. Dynamic expansion of the company continued with an acquisition of the company Cemix Čebín, s. r. o., and it was completed in 2002 upon an acquisition of the joint-stock company RAKO. As of 2002, the group thus included all of the most important Czech manufacturers of ceramic tiles. At the end of 2007, the company was divided into new separate entities operating in the area of ceramic tiling (Lasselsberger, s.r.o.), in the area of mining and processing of raw materials (LB Minerals, s.r.o.), and in the area of production of dry mortar and plaster mixes (LB Cemix, s.r.o.).

The company Lasselsberger, s.r.o. currently presents the largest manufacturer of ceramic tiling in the Czech Republic, and it is one of the major players on the European markets. The company has been maintaining and developing the historical traditions of the ceramic manufacturing. The brand RAKO, currently celebrating its 125th anniversary, represents comprehensive sets of wall and floor tiles, including extensive range of bathroom, kitchen, and house

[2]See http://www.rako.cz/cz/predstaveni_spolecnost

interior floor accessories. From the perspective of lifestyle, the company targets end users with high demands in the area of design and utility value of offered materials.

The MFCA method has been applied in the manufacturing plant RAKO III, which is part of the company Lasselsberger, s.r.o. This plant manufactures interior ceramic tiles, which are mainly characterized by a variety of sizes and designs.

The flow of materials throughout the manufacturing process starts with the delivery of inputs (several types of ceramic clays and raw kaolin) into covered storage boxes, where the materials are accepted and their parameters are checked. The manufacturing process itself involves several stages. The initial stage is the pulverization and homogenization of inputs, using the wet grinding process. The homogenized ceramic deposits are pumped from drum mills into storage tanks, from which they are subsequently piped to spray driers. The drying process results in granulate of about 5.5 % humidity, with defined granulometry. From the drying plant, granulate is transferred to a reservoir via a belt conveyor. The next manufacturing stage involves the pressing process. Granulate is transformed into the final product — tile — with the required shape and size. After passing through a tray drier, the semi-finished tiles — pressings — are transferred to another manufacturing process stage via conveyors. This next stage involves glazing, which is performed on the so-called glazing lines. Engobe as well as a layer of glaze are applied onto the pressings. This manufacturing stage mainly requires a high level of cleanliness of input semi-finished products, because any dust applied together with the glaze results in defect products during the next (fifth in total) manufacturing stage — i.e. burning process. Overall, the aforementioned manufacturing stages (pressing and glazing) result in wastes of approximately 2 % area of the total production. The production is monitored in both m^2 and tons, specifically for the plant producing such wastes.

The glaze and engobe applied on glazing lines are prepared during a separate manufacturing stage called the glaze preparation. The inputs (frit and washed kaolin) are first ground and then transformed into a suspension, which is applied onto a face side of tiles during the glazing process. The amount of wastes is not monitored during the process of glaze preparation. It is estimated at about 9.5 % of glazes and engobes input in mills and subsequently 5 % of suspensions produced in a glaze preparation plant.

Another manufacturing stage, which follows after the glazing stage, is the above-mentioned burning process. It takes place in gas roller kilns and it is characterized by high energy consumption. The time of burning and the firing curve depend on the tile size and the applied glaze type. The whole burning process lasts for about 40 - 50 minutes.

The whole manufacturing process is completed by a checkout and sorting of manufactured products. Products are divided into three categories, in line with EN CSN 14411 – i.e. quality class I, quality class II, and wastes. According to the company, the inspection process results in losses of approximately 5% of the total area of final production. The sorting process is followed by packaging and transfer into the final products storage.

The ceramic manufacturing is characterized by nonexistence of negative products. The entire solid component of negative products is recycled and used as input in the first production stage. Due to this, the costs associated with negative products in traditional management accounting methods only refer to disposal costs of the packaging used to transfer the glazes.

The whole manufacturing process is divided into three cost centers (see Fig. 2) within the existing company management accounting system:

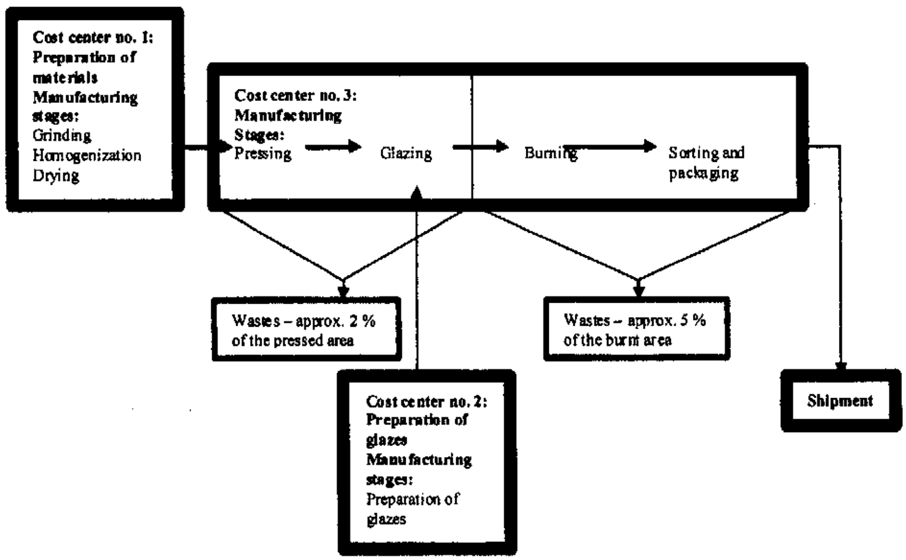

Fig. 2 Manufacturing process chart including individual cost centers according to Ref. [9]

- Preparation of materials. The costs associated with this center are incurred in connection with grinding and homogenization of inputs, their subsequent drying and the production of granulate. This cost center uses the basic but not the most important expensive materials.
- Preparation of glazes. The center deals with the preparation of glazes, which are applied using glazing lines during the manufacturing process. The important cost items include energy costs and costs of inputs (raw materials). Since different types of glazes are required for various tiles, the preparation of glazes takes places discontinuously — a special type of glaze is prepared for each tile type. Estimated losses of materials associated with this cost center amount to approximately 9.5% of the materials used in mills. Other negative products result from the need to wash out mills, filter presses, and tanks before each batch of glaze.

- Manufacturing. This center ensures the pressing of materials arriving from the cost center Preparation of materials, glazing performed on glazing lines, burning of tiles, and subsequent sorting and packaging.

Application of MFCA Method

Application of the MFCA method in the manufacturing plant RAKO III took place in three stages: preparation, data collection, and calculation.

Preparation

The MFCA method has been applied to the complete manufacturing process of the RAKO III plant. Six manufacturing formats were selected for the purpose of monitoring; each in both matte and glossy glaze. The costs of positive and negative products were monitored for the period of 12 months (the 2008 calendar year). The whole manufacturing process was subdivided into four quantity centers:

- Preparation of materials. This quantity center corresponds to the cost center Preparation of materials; therefore, the identification and allocation of energy and system costs will be based on the profit and loss statement of this center. Almost all negative products consist of water evaporated during the drying process.
- Preparation of glazes. This center, like the previous quantity center, also fully corresponds to the cost center Preparation of glazes. The center is not too large, and it is thus suitable for the monitoring of material flows within the MFCA method. The identification and allocation of energy and system costs will be based on the profit and loss statement of the cost center as well.
- Pressing and glazing. This quantity center does not correspond to the cost centers created within the existing management accounting. The reason for its formation is the need to acquire a more realistic view of the material flow corresponding to the assessment of arising negative products.
- Burning, sorting, and packaging. The reason for the formation of this quantity center is the need to specify the monitoring of material flows. The only negative product of the burning process is the water evaporated from the pressings; other negative products result from the sorting process on sorting lines.

Figure 3 shows a simplified chart of material flows in the RAKO III manufacturing plant.

Data Collection

During the data collection process, it was necessary to perform the reconstruction of material flows by individual quantity centers (weight units). Some data required for the MFCA method had to be calculated based on the knowledge of the manufacturing process and using the company formulas.

However, the reconstruction of material flows on the part of individual quantity centers in the units of weight only represented the first stage of the data collection process that had to be performed. The knowledge of the material flows and the prices of raw / other materials were then used to determine the material costs of positive and negative products — i.e. the prices of materials, which leave for other quantity centers (or to customers) as part of positive products or as part of negative products — waste flows. It applies that the material costs of positive products are equal to the material costs of positive products produced in the last quantity center. The material costs of negative products were obtained as the sum of costs of negative products throughout the whole manufacturing process (i.e. for all quantity centers).

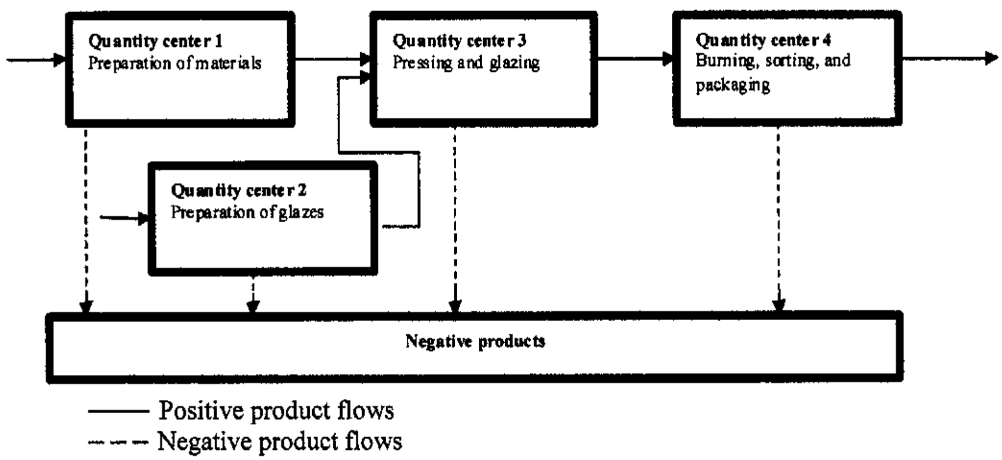

Fig. 3 Basic chart of material flow (Source: Own research)

During the data collection stage, it was also necessary to identify and determine energy and system costs incurred by individual quantity centers during the period in question.

The second stage of the MFCA method application resulted in the material balances of all quantity centers and the whole manufacturing process — both in the units of weight and in CZK (see Tables I-III) — and in the data on energy and system costs for individual quantity centers (see Table IV).

The overall balance of material flows of the RAKO III plant is based on the following logical assumption: Positive products of the RAKO III plant (i.e. the

Table I Materials within the MFCA method (Source: Company data and own calculations)

Item	Quantity center No. 1	Quantity center No. 2	Quantity center No. 3	Quantity center No. 4
Positive products (total materials in t)	85 838	11 464	95 356	86 803
Share in the total usage of materials in center	66 %	90 %	98 %	91 %
Negative products (total materials in t)	44 282	1 292	1 946	8 553
Share in the total usage of materials in center	34 %	10 %	2 %	9 %

Table II Material costs within the MFCA method (Source: Company data and our own calculations)

Item	Quantity center No. 1	Quantity center No. 2	Quantity center No. 3	Quantity center No. 4
Positive products (materials costs in CZK)	48 376 652	82 838 388	128 590 739	137 265 624
Share in the total material costs of center	92 %	87 %	98 %	92 %
Negative products (material costs in CZK)	4 064 707	12 671 519	2 624 301	11 533 808
Share in the total material costs of center	8 %	13 %	2 %	8 %

Table III Materials and material costs within the MFCA method (the RAKO III plant. Source: Our calculation)

Item	Total materials, t	Share in the total usage of materials	Material costs, CZK	Share in the total material costs
Positive products	86 803	61 %	137 265 624	82 %
Negative products	56 073	39 %	30 894 335	18 %

whole manufacturing process, for which material flows were monitored, and to which the MFCA method was applied) correspond to the positive products of the last quantity center (i.e. the center Burning, sorting, and packaging). Negative products amount to the sum of the negative products incurred in all quantity centers (see Table III).

The data about energy and system costs were obtained from the profit and loss statements of individual cost centers. The system costs did not reflect all the costs items that were reported in the statements of individual cost centers, but only the costs immediately relating to the material flows. Table 4 summarizes the data on energy and system costs for individual quantity centers during the period under review.

Table IV Energy and system costs (in CZK)

Item	Quantity center No. 1	Quantity center No. 2	Quantity center No. 3	Quantity center No. 4	Total
Energy costs	50 442 411	1 347 688	27 618 558	81 386 446	160 795 103
System costs	30 799 108	6 943 541	49 955 013	49 357 003	136 604 665
Total	81 241 519	7 841 229	77 573 571	130 743 449	297 399 768

MFCA Calculation

During this stage, it is necessary to allocate the material, energy, and system costs to positive and negative products, and to determine the total costs associated with individual material flows. The allocation must be performed within each quantity center based on the ratio of the material content in positive and negative products. The MFCA calculation is easier for the first two quantity centers (Preparation of materials / Preparation of glazes). These centers do not use the input in the form of positive products of other centers — the energy and system costs of the previous manufacturing stages do not have to be considered in the calculation. On the other hand, the calculation of the other two centers must consider the energy and system costs incurred in connection with the positive products in the previous quantity centers. The material flows, which result from the previous manufacturing stage (i.e. the output of the preceding quantity center), are the carriers of the energy and system costs allocated to them based on the ratio of the material content in positive and negative products making up the output of such preceding quantity center. The energy and system costs, which were incurred during the following manufacturing stage (quantity center), must be allocated based on the ratio of the material content in positive and negative products making up the output of the given manufacturing stage.

Table V shows the allocation of energy and system costs to positive and negative products leaving individual quantity centers as well as the determination of their total costs.

Findings Resulting from MFCA Method Application in RAKO III Plant

Economic results achieved by the RAKO III plant in 2008 are mainly attributable to the technology used for the manufacturing of tiles. In total, the plant produced 86 803 tons of positive products and 56 073 tons of negative products during the period under review; the costs associated with the negative products amounted to approximately CZK 86 million.

Table V Costs of positive and negative products (in CZK) (Source: Our calculation)

Item	Quantity center No. 1	Quantity center No. 2	Quantity center No. 3	Quantity center No. 4
Positive products:				
Share in the total usage of materials in center	66 %	90 %	98 %	91 %
Material costs	48 376 652	82 838 388	128 590 739	137 265 624
Energy costs	33 276 091	1 211 204	60 863 736	129 491 204
System costs	20 317 703	5 835 923	74 586 466	112 826 493
Total costs	101 970 446	89 885 515	264 040 941	379 583 321
Negative products:				
Share in the total usage of materials in center	34 %	10 %	2 %	9 %
Material costs	4 064 707	12 671 519	2 624 301	11 533 808
Energy costs	17 166 321	136 484	1 242 117	12 758 977
System costs	10 481 405	657 618	1 522 173	11 116 976
Total costs	31 712 433	13 465 621	5 388 591	35 409 761

Based on the MFCA calculation, it is possible to recommend to the company to mainly concentrate on the processes taking place within the quantity center Preparation of materials, which produced the majority of negative products. Negative products mainly occur during the manufacturing process of drying, and they result from the method of processing raw materials at the beginning of the material flow. In 2008, the existing initial stages of the manufacturing process resulted in 44 282 tons of negative products; the production of the negative products is directly associated with costs of approximately CZK 32 million. The recommendation relates to the method of processing raw materials, i.e. the method of grinding of raw materials. One solution would be to replace the discontinuous mills with continuous mills. The use of continuous mills should lead to a lower consumption of water, which is the main component of the negative products. Even though the negative products are recycled within the company, the energy and system costs incurred in connection with their production are irrecoverably lost. The remaining quantity centers work very well, with only a small potential for improvement. Specifically the quantity center Pressing and glazing is highly effective.

The manufacturing of ceramic tiles represents a traditional production with a familiar manufacturing process. In general, it is very difficult to propose any improvements for these technologies, because they tend to be very sophisticated from the perspective of technology. The MFCA method could contribute to the development of new technologies, which would eliminate or mitigate deficiencies of traditional technological processes. It is apparent that it is not possible, for various reasons, to completely prevent the production of negative products. However, it is useful to try reducing the value of negative products as much as possible while preserving the product quality desired by customers.

Conclusion

The MFCA method represents one of the management accounting methods (environmental management accounting). Unlike traditional methods, the MFCA monitors materials flows and costs associated with positive and negative products. In the case of negative products, it does not only target the disposal costs of such negative products, but any and all economic resources, which were expended (used) in connection with such negative products. The data acquired during the process contribute to the fact that management is able to propose such measures, which would lead to more effective production and lower the volume of negative products. Such measures increase the economic effectiveness of production and, at the same time, positively affect the environment.

When applying the MFCA method within a plant manufacturing ceramic tiles of different sizes, colors, and glazes, the reconstruction of material flows was mainly based on the detailed knowledge of the manufacturing process and its individual stages. At the same time, data from the company information system and company formulas were used. In spite of this, the identification of the material flows in physical units did not present a simple task, especially in those manufacturing stages which use materials already preprocessed in other centers. The application of the MFCA method revealed that the quality of information output is mainly affected by the selection of quantity centers. For this reason, it is necessary to specify an optimum size of each quantity center, in order to prevent losses of important data and time/money-consuming collection of the relevant data. Furthermore, the quality of obtained data is greatly affected by an identification of energy and system costs and, above all, their correct allocation to individual quantity centers.

During the application of the MFCA method, it is useful (see, e.g., [8]) to proceed from relatively simpler processes and productions – with relatively easier improvements – to more complex processes and productions, which require more difficult implementation. In this matter, it is possible to gradually acquire experience, which is especially necessary for the correct execution of the first two stages (preparation and data collection) in the case of more complex manufacturing processes.

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