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# MODIFIED ASSESSMENT OF MATERIAL FLOWS IN TERMS OF TIME TRANSPORT

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***Abstract:*** *This paper describes the problem of evaluating material flow when optimizing the spatial arrangement of a production system. The issue is focused on large engineering companies engaged in production of small series or individual pieces. The requirements of these businesses and the issues, which thereby arise are pointed out. The standard analysis of material flows provides a solution to these barriers, which are modified in the parameters of transport routes to distance quantify the time-consuming aspect. The Conclusion describes the verification method in a case study of spatial arrangement of newly introduced production at Skoda Transportation, Inc. and gives the concrete benefits of this analysis.*
***Key words:*** *layout, transportation, performance, handling time, material flow*

## 1. INTRODUCTION

Currently, due to the economic and financial crisis, companies have made greater efforts to increase their advantage in the struggle with their competitors. Therefore they are looking for ways to save costs and increase their ability to quickly respond to market needs. An option is to use digital factory tools. These tools are however primarily designed for mass and large-series production and predominantly in the automotive industry, but are possibly beginning to penetrate industries with a similar character of production (e.g. the electrical industry). There are other sectors for which these methods are not designed, but which would like to reap the benefits of these tools. These are companies with piece and small batch production which produce large mechanical components such as locomotives, large machine tools, trams etc. One area is the creation of layout and optimization based on material flow analysis. But these companies have different requirements from large-series and mass production. It especially speeds up the time from entering into rollout and greater utilization of production capacity (to eliminate waiting for a product). It can be used to expedite the handling between workplace. These conditions can be easily fulfilled by simulation. The disadvantage of simulation is the complexity of the default model. This means that the creation of the model is time-consuming and thus expensive, both in terms of internal resources (own simulation software and pay their own experts) and external resources. We therefore resorted to the step of modifying the way the material flow was evaluated, so as to reflect the intensity of material flows and time-consuming manipulation between workplaces (Šimon & Černý, 2009).

## 2. CURRENT METHOD

During the observation of the manufacturing process as a whole, we find that in terms of dynamics it is a movement. If the movement during technological operations is disregarded, we are usually left with a larger non-technological portion, which is called the material flow. This movement is in space and time, which determines the direction, intensity and frequency, and its character is determined by the spatial arrangement (layout). Using these parameters, material flow is measured, evaluated and optimized (Němec, 1998).

Material flow analysis proceeds in several steps. The basis is to identify physical characteristics and the quantities of material, for which we set restrictive conditions for manipulation. Then follows the creation of layouts, determining the distribution of individual workplaces and the location and nature of the transport routes between workplaces. The last step before the actual analysis is based on production volume and material properties determine the size of the intensity of material flow. Material flow analysis based on all the identified input data can then be carried out (Tupa & Basl, 2006).

It is convenient to graphically illustrate material flows. The Sankey chart and I-D diagram are frequently used. The Sankey diagram is drawn straight into the drawing layout, where the width of the link between workplace is the size intensity of the material flow and the length in scale corresponds to the actual distance of manipulation. The I-D diagram shows the various material flows using points. The I-D diagram expresses the relationship between the distance and the intensity of carriage, when it is preferable to have the materials flow with great intensity at smaller distances. Another parameter very suitable for comparison of material flows is the size of the transport performance (Philips, 1997).

## 3. PROPOSED METHOD

Given that the current method is not completely versatile and companies with piece and small batch production have different requirements, and especially the character of production, methods began to be developed for modifying their purposes. These companies try to implement proven methods of mass production, therefore, a departure is seen from the technological structure of production and the introduction of cellular manufacturing components and parts manufacturing are formed on the principles of the production line. The main requirement is for speed and flexibility of production, when it is necessary to minimize the handling time between workplaces.

### 3.1 A modified procedure for the analysis of material flows

As already mentioned, material flow can be understood as a movement in space and time. At the moment time dimension is used to detect the intensity of material flow when you need to know how long is set for the used value of intensity. Moreover, it is necessary to enter the parameter time of shipment to the analysis of material flows. Manipulation time can easily be calculated based on the parameters of the handling equipment.

The problem arises when you preview a portfolio of manipulated material when you manipulate anything from small screws to locomotives. Each course carries the possibility of using a wide variety of handling devices. Indeed, it is also necessary to use more types of handling equipment on some routes and here appears time for reloading (Harris et al., 2003).

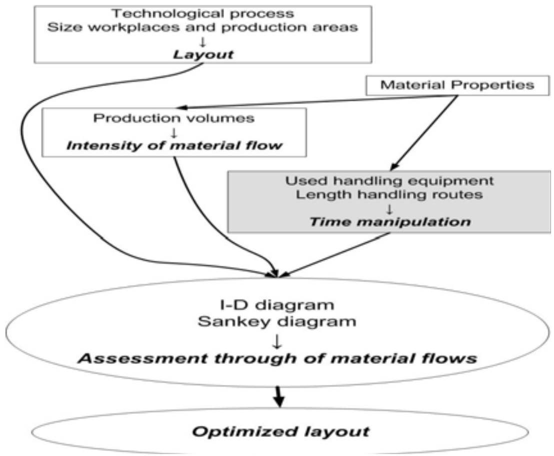


Fig. 1. A modified procedure for the analysis of material flows

The process of material flow analysis remains similar (Fig. 1), but it is necessary to modify some of the stages and process in more detail. This is because under detailed examination of various options for transportation, some manipulations in terms of length and time manipulation behave differently. In some cases, when comparing two variants, one is better in terms of the length of the route and the second in terms of the handling time. For example, when manipulating a 300 kg pallet with a forklift and a 300 kg workpiece by crane, we have a situation where we have the same length of route for both, but because of the different speeds, a completely different time.

This is why the procedure was modified. The first step remains the analysis of properties of materials and their production volume. However, it is necessary to examine the properties of materials more closely, because they form the basis for determining the means for handling the material. Creating the layout and determining the intensity of material flow is identical to the standard method. At this point a new step is introduced to finding time of manipulation. Then, using the length of route, speed and number of types of handling equipment we set the manipulation time between the workplaces. The input data for the analysis of material flows are the intensity of material flow, handling route length and time of manipulation. To calculate the time of handling the following formula is used

$$t = \sum_{k=1}^{m} r_k \cdot \frac{1}{v_k} + \sum_{j=0}^{n} t_j \qquad (2)$$

Where $t$ is time of handling, $t_j$ the time needed to move the handling means and the index $j$ is the number of such movements, $r_k$ is the length of the section of transport routes and the index $k$ shows the number of sections and $v_k$ speed of handling in a given section.

The same tools are used to view the material flows. The Sankey diagram can be drawn directly on to the drawing layout. However, it is necessary to take into account the relationship between intensity and time of manipulation. If we imagine the material flow diagram as a rectangle, the width is of the intensity, length is distance and area is transportation performance between workplace. Length and transportation performance must be maintained, but the intensity can be modified with respect to the capabilities of the most commonly used software. Therefore, the intensity is divided by the average speed of the entire route of manipulation, then we see material flows in the correct proportions. An I-D diagram is simply prepared, when the length of the transport is located, handling time is given. The same rules apply here as for the standard I-D diagram. Another variable that can be adjusted, the transportation performance, is now dependent on time, not on the length of the carriage. To calculate the transport performance the transport intensity in relation to the handling time is used.

$$P_t = Q \cdot t \qquad (3)$$

Where $P_t$ is transport performance, according to the manipulation, $Q$ is the intensity of material flow, which represents the amount of material transported per unit time, and $t$ is the time for handling the transmission route.

### 3.2 Case study

The proposed method of optimizing the layout using material flow analysis was verified on a case study of a new production line in company Škoda Transportation. The case study focused on the production of a tram skeleton. Manipulation from individual parts to the assembly of the skeleton takes place. Different handling equipment from pallet trucks to gantry cranes are used. The analysis was applied to the layout by a design company, which was created according to a revised proposal taking into account any shortcomings. Both variants respect the requirements of the company. For comparison the analysis was performed using the standard and the modified method. For both aspects - the length of runway and the handling time – the optimized version was better. Reducing transport performance in terms of handling time by 5% and in terms of length manipulation routes by 19%.

## 4. CONCLUSION

The proposed analysis of material flows is based on standard methods. Among its advantages are relative simplicity, speed and, compared to the simulation mentioned, lower costs. By contrast, it cannot fully replace the simulation. Its functionality was successfully tested on a case study in practice. The next step will be to modify existing software tools for creating and optimizing layouts.

In the future, we would like to develop this approach to production system design in more detail and to try to apply it in practice.

## 5. ACKNOWLEDGEMENTS

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