Advanced Logistic Systems Vol. 10, No. 2 (2016) pp. 71–78.

COMPUTER ALGORITHM FOR DETERMINATION OF MATERIAL FLOW RELATIONS

PÉTER TELEK[1]

Abstract: First step of the design of a materials handling process is the analysis of the required material flow to determine the base parameters, which depend on the materials handling relations of the system objects. Materials handling relation means a special connection between two objects, which contains any kind of handling activity. The problem with the relations is the determination procedure, because there are no direct transformation possibility between the technology and handling parameters. In this paper a computer algorithm is described, which is suitable to determine the handling relations and matrices of an existing materials handling system, based on technology data and to demonstrate the process, and beyond them one solution possibility for the realisation of the computer method for the calculation procedure is also presented.
Keywords: *materials handling, relation matrix, computer design, algorithm*

1. INTRODUCTION

Design procedure of materials handling contains numerous, different and exactly defined steps which enable effective (in certain cases: optimal) solving methods for the tasks [1]. First step of the design of a materials handling process is – in most of the cases – the analysis of the required material flow to determine the base parameters, which depend on the materials handling relations of the system objects. It means that the definition, characterisation and examination of the relations are the basic tasks for the design processes.

This research is focusing to the determination possibilities of materials handling relations, which is not a simple task in most of the cases. There are given methods to determine the relations [2], but the process is in generally very complex and requires much time and suitable knowledge level.

In this paper the algorithm and characterisations of a computer calculation method are presented which is served for the determination of materials handling relations and give some overview about one realization possibility.

2. MATERIALS HANDLING RELATIONS

The most important task of handling processes is the moving and its related activities (loading, storing etc.) of goods among the objects. All individual moving activities have to be linked to two given system objects, which is named as material handling relation and these relations are the basis for all of the design steps (equipment selection, location planning etc.) of the materials handling processes [3].

Materials handling relation means a special connection between two objects (production or service objects), which contains any kind of handling activity. Handling relations can be defined by the two linked objects and one handling parameter existing among them [3].

[1] PhD, University of Miskolc
alttelek@uni-miskolc.hu
H-3515 Miskolc-Egyetemváros, Hungary

In the aspect of handling requirements, handling relations can be always described between one source and one destination object, however at the realisation of the handling tasks we can also determine relations between two source or two destination objects (e.g. collection systems) [4].

Handling relations in generally involve one handling parameter (e. g. materials and their quantities, distances and routes among the objects etc.) and its value describes the characterisation of the object relation during the design and operation of the handling process [3]. Materials handling relations can be defined and demonstrated by different methods, e. g. handling process charts, materials handling graphs or matrices etc. [2].

The most important application field of handling relations is the design of materials handling devices and processes. If all of the handling relations are described in every detail, then the design steps can be realised. The main problem of this concept is the determination of the matrix elements, because the input data do not contain the required parameters directly. In generally, there are different methods for determining the handling relations with suitable knowledge and designer experiences, but the process depends on the given objects and their characterisations.

General procedure of the determination of the handling relations can be described by the next steps [2]:

1. Uncovering the technology abilities
2. Analysis of the product parameters
3. Definition of the served objects
4. Description of the relations among the objects
5. Determination of the values of the materials handling matrices

The most often used device to define the relations among the objects of a handling system is the application of materials handling matrices. The simplest materials handling matrix is the relation matrix, which contains only the existence of the relations, but it is the basis of other handling matrices (material flow-intensity matrix, route-matrix, performance-matrix etc.). Different materials handling matrices require variant parameters [2], so the determination procedure will also be different.

The most applied materials handling matrix is the material flow-intensity matrix [2], which contains the quantity of the material flow between the objects of the given relation during an exact time interval:

$$\underline{\underline{Q_{ij}}} = \begin{array}{c} \\ 1 \\ \vdots \\ i \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & \cdots & j & \cdots & n \end{array} \\ \begin{bmatrix} & & & & \\ & & & & \\ & & q_{ij} & & \\ & & & & \\ & & & & \end{bmatrix} \end{array} \tag{1}$$

where

n – number of the served objects [pcs],

q_{ij} – value of the material flow-intensity matrix [kg/s].

At complex production processes, the value of the material flow-intensity matrix can be calculated by the equation below [2]:

$$q_{ijk} = \sum_{l=1}^{p} o_{lj} \cdot a_{jk} \cdot f_{ik} \tag{2}$$

where

l – type of the product,
p – number of the types of the products [pcs],
o_{lj} – element of the production matrix linked to the given object [pcs],
a_{jk} – element of the requirement matrix linked to the given object [pcs],
f_{ik} – element of the resource matrix linked to the given source object.

As the determination of the materials handling relations and their parameter values is in generally very complex and long procedure (see [2]), mainly at large handling systems with many objects and tasks, so it is expedient to use computer method for the realisation of it.

3. COMPUTER ALGORITHM FOR THE DETERMINATION OF THE HANDLING RELATIONS

The advanced design and operation tasks in generally cannot be realised without computer devices, because of the large number of the system elements and influencing parameters. However there are many advantage of using computers also at the solution of simple processes in the aspects of the determination of the optimal operation parameters [6].

Computer software has already played important role in the field of materials handling from decades, mainly in the simulation of handling processes and systems. There are several materials handling and logistics software in the market, which were developed for specifically handling processes to increase their effectiveness (e. g. ExtendSim [7], FlexSim [8] etc.). In the international literature many papers deal with computer solutions and optimisations of logistic and handling tasks [9, 10, 11]. Many of the papers use also the handling relations as input parameters for the solution of given design tasks [12], but there is not any computer algorithm for the determination of the relations.

The main advantages of computer software used for the determination of the handling relations are the linking possibility of the technology and logistic processes and the using in education processes of logistic experts, where the main aims are the transformation of the technology and handling parameters, and the presentation of the existing relations.

The first step of the development of computer software for the determination of the handling relations is the defining and describing of the algorithm of the process.

Definition of the algorithm [13]: the algorithm is a well determined calculation process based on a given parameter value or value-set, which results another value or value-set as an output parameter. Adopted this definition for the materials handling processes, we can say, that the algorithm is a chain of related steps (calculations, logical decisions etc.), based on certain input parameters of the handling system, which results handling parameters or activities as output values.

In this research, the relations, as handling matrices are taken into consideration, so the input and output parameters have to be also used in matrix form.

3.1. Input parameters.

Input parameters of the determination process of the handling relations are the data of the production system, where there are four main parameter groups:

- parameters of the raw materials and the elements,
- parameters of the interoperation semi-finished units,
- technology object parameters,
- parameters of the finished products.

The given parameter groups require the application of different matrices which has effect to the steps of the algorithm. Parameter needs of the determination of the relations are the object types, the element types and relations, the semi-finished unit types and the produced quantities (see *Table 1* and *2*).

Table 1
Input matrix of the interoperation semi-finished units

Unit name	**Required quantities of elements (A) and semi-finished units (F)** [pcs]					
	A_1	…	A_x	F_1	…	F_y
F_1						
F_2						
F_3						
…						
…						
F_y						

Table 2
Input matrix of the technology objects

Objects	**Technology process**	**Maximal production of semi-finished units** [pcs]				
		F_1	F_2	F_3	…	F_y
1.	Operation A					
2.	Operation B					
3.	Operation C					
4.	…					
5.	…					
6.	Operation N					

3.2. General algorithm of the process.

Based on the input parameters, a general algorithm can be built, which is suitable for the determination of materials handling parameters *(Figure 1).* To realize the algorithm three different activity types has to be realized:

- determining of the structure of the data,
- determining of the matrix-structure,
- calculation of the values of the matrix.

Data-structure of the process is determined by the input matrices involved in *Table 1* and *2*, which specify the order of the loading of the data. The dimensions of the relation matrices are depend on the numbers of the objects and the flowing material types.

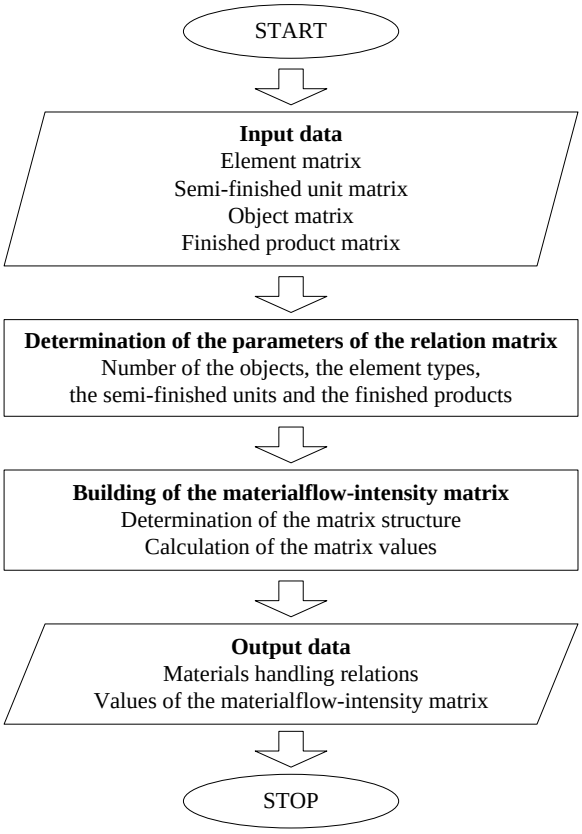


Figure 1. General algorithm of the determination process of the relations

Structure of the material flow-intensity matrix can be described:

$$\underline{\underline{Q}}_{ijk} = \begin{array}{c} \\ 1 \\ \vdots \\ i \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & \cdots & j & \cdots & n & \end{array} \\ \left[\begin{array}{ccccc} & & & & \\ & & q_{ijk} & & \\ & & & & \\ & & & & \\ & & & & \end{array}\right] \\ 1 \end{array} \begin{array}{c} \\ \\ \\ k \\ \\ \\ m \end{array} \tag{3}$$

where

n – number of the objects [pcs],

m – total number of the flowing material types [pcs]:

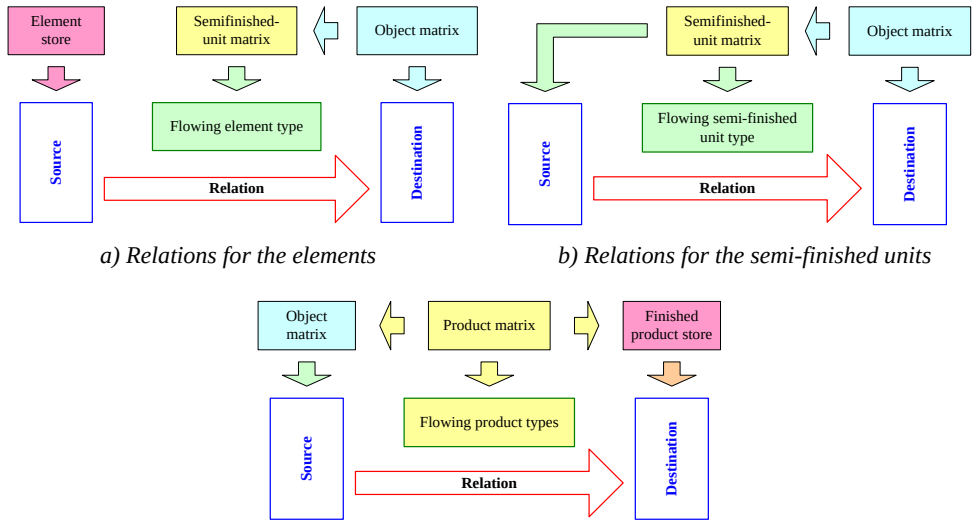
$$n = x + y + z \tag{4}$$

x – number of the elements [pcs],
y – number of the semi-finished units [pcs],
z – number of the finished products [pcs].

The objects of the system contain not only the technology workplaces, but the storages of the handling process.

Main task of the algorithm is the determination of the matrix values, which cannot be solved by a general method, because of the different parameters and calculation procedures of the individual matrices.

In this paper the main steps of the determination process of the values of the material flow-intensity matrix are presented. For the determination of the matrix values *Equation (2)* is applied, but the computer process uses a different method. It is important that it has to be used different calculation methods for the different material types of the handling process *(Figure 2).*



a) Relations for the elements *b) Relations for the semi-finished units*

c) Relations for the finished products

Figure 2. Method for the determination of the values of the material flow-intensity matrix

In the aspect of the elements the source object of the individual relations is always the element store, the destination object and the flowing material type has to be determined based on the object matrix and the semi-finished unit matrix *[Figure 2 a]*.

The relations of the semi-finished units can be calculated based on also the data of the object and the semi-finished unit matrix, the source and the destination of the relations are technology objects in every case *[Figure 2 b)]*.

At the other side, the destination object of the relations of the finished products is always the finished product store, the source object and the flowing product type has to be determined based on the object matrix and the finished product matrix *[Figure 2 c)]*.

4. EXAMPLE FOR THE REALISATION OF THE ALGORITHM

Realisation process of the algorithm described on *Figure 1* and *2* will be different on different program languages or computer software. In this paper, a simple application of this algorithm in Microsoft Excel running environment is developed, using Visual Basic (VBA) program language. Form of the input matrices and the input process of the parameters are demonstrated on *Figure 3.*

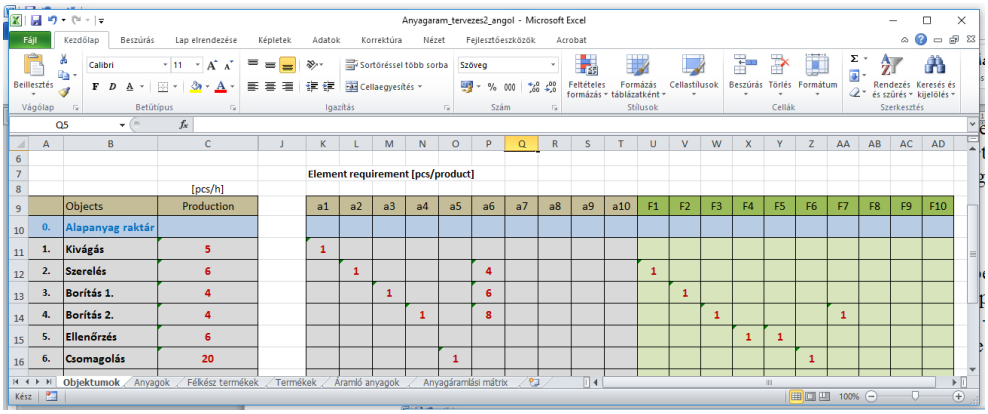


Figure 3. Input parameters and matrices for the objects

In our simple example, we analyse a quasi-linear production procedure with a small number of products and elements. Elements are stored in one central store and the finished products also collected in one store. The relations between the objects can be realised directly. The uploading of the data can be realised on the normal Excel worksheet, and the matrix structure can be also realised easily. The program calculates the material flow-intensity matrix and presents it on a worksheet *(Figure 4).*

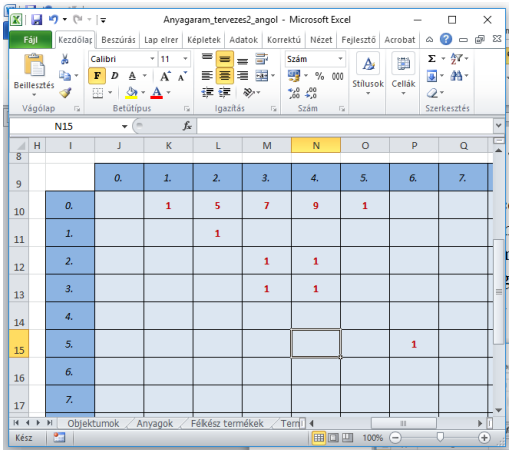


Figure 4. Result matrix of the program

5. SUMMARY

Relations are very important parts of the design process of materials handling systems, they can be used for many purposes. The biggest problem with the relations is the determination procedure, because there are no direct transformation possibility between the technology and handling parameters. In this paper a computer algorithm is described, which is suitable to determine the handling relations and matrices of an existing materials handling system, based on technology data. The most important result of this research is to realize a possibility, which enables to link the technology and logistic processes and transform the technology parameters into handling parameters. At the end of this paper some pictures about a realisation possibility in MS Excel are shown, but this simple example is only the first step of our aim to make usable and effective software to calculate, demonstrate and apply the handling relations in the design process of materials handling systems.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691942. This research was partially carried out in the framework of the Center of Excellence of Mechatronics and Logistics at the University of Miskolc.

References

[1] CSELÉNYI, J.–ILLÉS, B. (eds.): *Logistic systems (in Hungarian).* Miskolci Egyetemi Kiadó, Miskolc, 2004.
[2] TELEK, P.: Material flow relations in the design process of materials handling. *Advanced Logistic Systems,* Vol. 10, No. 1 (2016), 53–64.
[3] CSELÉNYI, J.–ILLÉS, B. (eds.): *Design and control of material flow systems I. (in Hungarian).* Miskolci Egyetemi Kiadó, Miskolc, 2006.
[4] CSELÉNYI, J.–TELEK, P.: Mathematical modelling of collecting logistic system of used electronic products. In: CSELÉNYI, J.–BÁNYAI, T. (eds.): *Modelling and Optimisation of Logistic Systems – Theory and Practice*. University of Miskolc, Miskolc, 1999, 1–12.
[5] FELFÖLDI, L. (ed.): *Materials handling handbook (in Hungarian).* Műszaki Könyvkiadó, Budapest, 1975, 1512.
[6] CSELÉNYI, J.–ILLÉS, B.–KOVÁCS, GY.–BÁLINT, R.: Network of North-East Hungarian Logistical Centres and Logistical Clusters. *Logistics and Supply Chain Management in a Globalizing World*. *Proc. of the 3rd Int. Log. and Supply Chain Congress.* Istanbul, Galatasaray Univ. and Log. Association, 2005, 605–610.
[7] http://www.extendsim.com/
[8] https://www.flexsim.com/hu/
[9] FISHER, E. L.–FARBER; J. B.–KAY, M. G.: MATHES: an expert system for materials handling equipment selection. *Engineering Costs Prod. Econ.*, Vol. 14 (1988), 297–310.
[10] MATSON, J. O.–MELLICHAMP, J. M.–SWAMINATHAN, S. R.: *EXCITE:* Expert Consultant for In-Plant Transportation Equipment. *International Journal of Production Research,* Vol. 30, No. 8 (1992), 1969–1983.
[11] PARK, Y. B.: *ICMESE:* Intelligent Consultant System for Material Handling Equipment Selection and Evaluation. *Journal of Manufacturing Systems,* Vol. 15, No. 5 (1996), 325–333.
[12] WU, L. H.–MOK, P. Y.–ZHANG, J.: An adaptive multi-parameter based dispatching strategy for single-loop interbay material handling systems. *Computers in Industry*, Vol. 62 (2011), 175–186.
[13] CORMEN, T. H.–LEISERSON, C. E.–RIVEST, R. L.: *Algorithms (in Hungarian).* Műszaki Könyvkiadó, Budapest, 2001.