

Optimization of Production Flow through the CRAFT Method

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The article describes usage of the CRAFT method and its influence on the optimization of flow logistics. The method helps to reduce the cost of basic material flow determination in production, assembly of production units, material handling, storage of individual parts and the transport of finished products. By using the method, long traffic routes, unproductive times and warehouse inventory that unnecessarily increase our costs were removed. In today's competitive environment, it is necessary to improve continuously all processes not only in production, and this method enables us to effectively achieve defined business goals.

Keywords: CRAFT, logistics, production, optimalization, manipulation

1 Introduction

The Computerized Relative Allocation of Facilities Technique (CRAFT) is used to determine the spacing of workplaces, workshops and warehouses to minimize total material flow costs. The manufacturing process goes through a certain sequence of machines or workplaces and this order is given by the technological process. Workplace placement has an impact on handling distances that deliver higher transport costs and reduce productivity. Mathematical representation of the cost of handling the product between workplaces per unit of distance:

$$C_{ij} = U_{ij} \cdot V_{ij} \quad (1)$$

where:

U_{ij} - the cost of moving the load unit per unit of distance between workplaces i and j

V_{ij} - the number of load units moving between workplaces i and j

The cost of handling the entire product between workplaces per unit of distance written in the form of a matrix:

$$C = \begin{bmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{n1} & \cdots & C_{nn} \end{bmatrix} \quad (2)$$

With chances to workplace layout distance between them also choices:

L_{ij} - distances between centers of workplaces i and j

These distances can be expressed by using a matrix:

$$L = \begin{bmatrix} L_{11} & \cdots & L_{1n} \\ \vdots & \ddots & \vdots \\ L_{n1} & \cdots & L_{nn} \end{bmatrix} \quad (3)$$

The cost of any workplaces layout solution is then given by:

$$N_k = \sum_{i=1}^n \sum_{j=1}^n C_{ij} \cdot L_{ij} \quad (4)$$

where:

C_{ij} - the cost of handling the product between the workplaces

L_{ij} - distances between centers of workplaces i and j

The goal is to minimize this function. The basic procedure is based on the arbitrary deployment of the workplaces and the workplace is gradually exchanged until the most economical variation in the placement of workplaces is found. When solving tasks, it is necessary to respect the local conditions, the allocation of workplaces or building restrictions.

2 Analysis of the Problems

In the current competitive environment, it is necessary to produce products efficiently and with low production costs. Twice this is true in the automotive environment, where automotive standards are expected to be met by automotive standards and high productivity.

A well-known Czech Trucksproducer producing custom-made vehicles for a number of specific bodies and for use in very difficult terrain has decided to increase productivity on the trucks frame assembly line. The line is divided into preparatory workplaces and own assembly line. On this line welded frame engine unit, clutch and transmission gear, exhaust system, hydraulics, tire, accessory brackets, power tools, reservoirs, winches, cable harnesses are mounted.

After a thorough analysis of the all activities on the line and in the preparatory workplaces, the equipment of the line, the staff and the flow of information, a task was assigned to increase logistics performance, to eliminate material accumulation and to eliminated downtime, to increase utilization of production capacities:

Find the most cost-effective placement of workplaces on which truck frames with the following input data are installed: Costs CZK 10 per unit of distance per unit, 6 positions of workplaces, workloads (production volume) 5 types of products and building constraints.

3 Concept of CRAFT

Input data for CRAFT calculation:

a) Costs - CZK 10 per unit of distance per 1 piece

- b) Workplace layout diagram - 6 positions and distances between centers of workplaces
 c) Load (volume of production) - 5 types of products in a given volume and with the technological process
 d) Restrictive conditions

- a) Costs of material handling between workplaces i and j per unit of distance

In this case was expected a constant handling cost of CZK 10 per unit of distance and piece.

$$U_{ij} = \begin{bmatrix} - & 10 & 10 & 10 & 10 & 10 \\ . & - & 10 & 10 & 10 & 10 \\ . & . & - & 10 & 10 & 10 \\ . & . & . & - & 10 & 10 \\ . & . & . & . & - & 10 \\ . & . & . & . & . & - \end{bmatrix} \quad (5)$$

- b) Layout of initial placement of workplaces

In this case was calculated with 1 to 5 length units

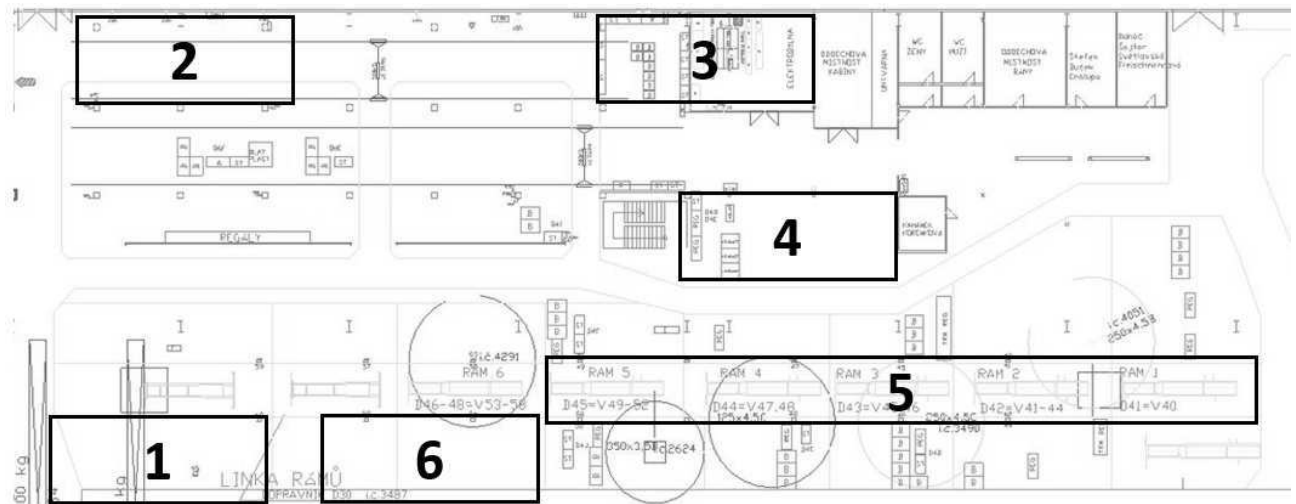


Fig. 1 Layout of initial placement of workplaces

- c) Load (volume of production)

Tab. 1 Load of workplaces

Product	Annual production in pieces	Technological process
A	300	1-2-4-5-6
B	700	1-2-3-4-5-6
C	100	1-2-4-6
D	600	1-2-3-4-5-6
E	300	1-2-5-6

- d) Restrictive conditions

Workplace 1 will always be the entrance, changing the place is impossible.

Workplace 3 is technological, no change of the place.

Workplace 6 will always be output, changing the place is impossible.

The cost of moving the workplace is CZK 25 000 / workplaces.

The change in the production process for next 4 years is not expected.

U values are flat-rate values related to distance.

Based on the initial deployment diagram of the workplaces was calculated the distances and add to the matrix the distance between centers of workplaces:

$$L_{ij} = \begin{bmatrix} - & 2 & 4 & 3 & 4 & 1 \\ . & - & 3 & 3 & 5 & 2 \\ . & . & - & 1 & 2 & 3 \\ . & . & . & - & 1 & 2 \\ . & . & . & . & - & 3 \\ . & . & . & . & . & - \end{bmatrix} \quad (6)$$

- 2) Assemble the matrix of production quantity

Based on the annual quantity of production and technological process we fill in the matrix V:

$$V_{ij} = \begin{bmatrix} - & 2000 & . & . & . & . \\ . & - & 1300 & 400 & 300 & . \\ . & . & - & . & . & . \\ . & . & . & - & 1600 & 100 \\ . & . & . & . & - & 1900 \\ . & . & . & . & . & - \end{bmatrix} \quad (7)$$

3.1 Calculation

To calculate the total cost of initial placement will be need:

- 1) Matrix of distances between centers of workplaces L

- 3) Costs of manipulation of production between workplaces i and j

It is based on the matrix of manipulation costs between the workplaces and the matrix of production quantity and are given by:

$$C_{ij} = U_{ij} \cdot V_{ij} \quad (8)$$

Resulting matrix:

$$C_{ij} = \begin{bmatrix} - & 20000 & . & . & . & . \\ . & - & 13000 & 4000 & 3000 & . \\ . & . & - & . & . & . \\ . & . & . & - & 16000 & 1000 \\ . & . & . & . & - & 19000 \\ . & . & . & . & . & - \end{bmatrix} \quad (9)$$

4) Calculation of the total costs of the initial workplace placement

$$N_{k1} = \sum_{i=1}^n \sum_{j=1}^n C_{ij} \cdot L_{ij} \quad (10)$$

$$N_{k1} = 181\,000 \text{ CZK}$$

The highest load is between workplaces 1-2, 2-3, 5-6, the least used is workplace 4-5.

3.2 Relocation of workplaces and cost calculation

Proposed new workplace deployment:

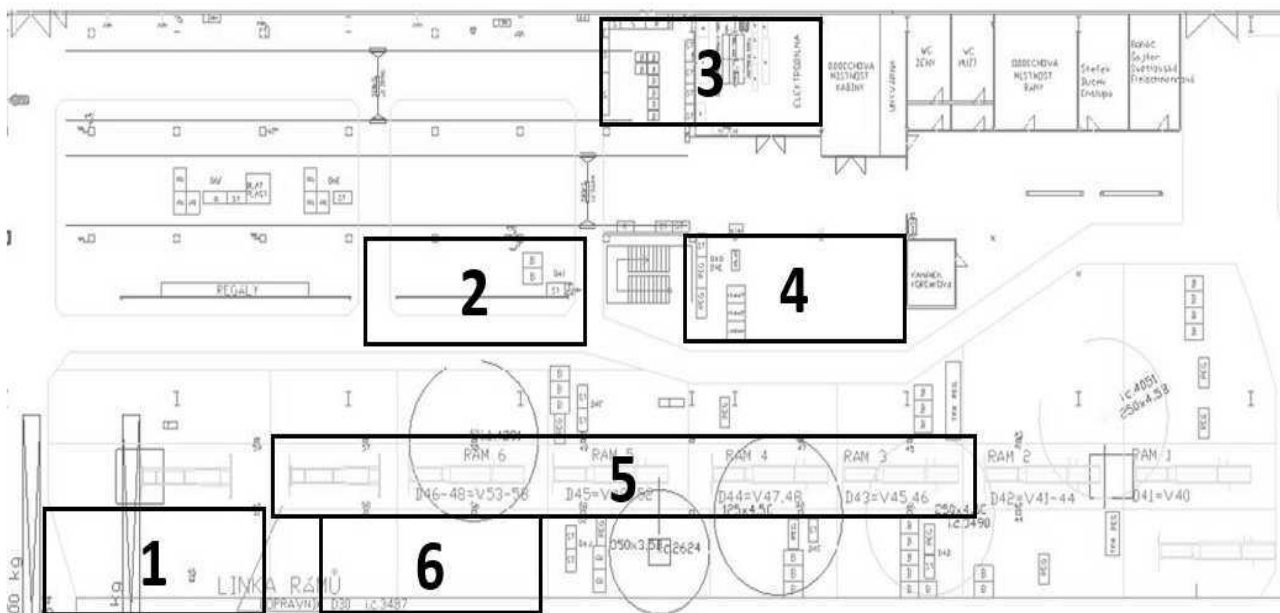


Fig. 2 Layout of new workplace deployment

To calculate the total handling costs of the new deployment will be needed:

1) Matrix of distances between centers of workplaces

L_{ij}

$$L_{ij} = \begin{bmatrix} - & 2 & 3 & 4 & 3 & 1 \\ . & - & 1 & 1 & 1 & 1 \\ . & . & - & 1 & 2 & 3 \\ . & . & . & - & 1 & 2 \\ . & . & . & . & - & 1 \\ . & . & . & . & . & - \end{bmatrix} \quad (11)$$

2) Production quantity matrix V

The annual production quantity and technology process will be identical to the original location:

$$V_{ij} = \begin{bmatrix} - & 2000 & . & . & . & . \\ . & - & 1300 & 400 & 300 & . \\ . & . & - & . & . & . \\ . & . & . & - & 1600 & 100 \\ . & . & . & . & - & 1900 \\ . & . & . & . & . & - \end{bmatrix} \quad (12)$$

3) Costs of manipulation of production between new workplaces i and j It is based on the matrix cost of manipulation between the workplaces and the matrix of production quantity. This is given by the relation:

$$C_{ij} = U_{ij} \cdot V_{ij} \quad (13)$$

Resulting matrix:

$$C_{ij} = \begin{bmatrix} - & 20000 & . & . & . & . \\ . & - & 13000 & 4000 & 3000 & . \\ . & . & - & . & . & . \\ . & . & . & - & 16000 & 1000 \\ . & . & . & . & - & 19000 \\ . & . & . & . & . & - \end{bmatrix} \quad (14)$$

4) Calculation of the total cost of the new workplaces location:

$$N_{k2} = \sum_{i=1}^n \sum_{j=1}^n C_{ij} \cdot L_{ij} \quad (15)$$

$$N_{k2} = 97\,000 \text{ CZK}$$

The highest load is between workplaces 1-2 and 5-6, which are places of interest for further cost reduction.

4 Contributions

The calculated total handling costs of the initial workplace location are ... 181 000 CZK

The calculated total handling costs of the newly proposed deployment are ... 97 000 CZK, which represents an annual saving of ...

$$N_{k1} - N_{k2} = 181,000 - 97,000 = 84\,000 \text{ CZK}$$

Total handling savings for 4 years ...

$$84,000 \times 4 = 336,000 \text{ CZK}$$

Cost of moving the workplace ...

$$2 \times 25\,000 = 50\,000 \text{ CZK}$$

Net cost savings over 4 years ...

$$336,000 - 50,000 = 286,000 \text{ CZK}$$

Time of reimbursement of the cost of relocating workplaces ... $50,000 / 84,000 = 0,59$ years

The calculations achieved using the CRAFT method are very clear and understandable for a broad portfolio of users.

A big advantage can be seen in the possibility of automatic calculation and comparison of several variants of the solution and the choosing an optimal variant for the company.

5 Conclusion

The CRAFT method and its use in the company's processes by the trucks assemblies have been chosen by the company's management due to rising labor costs and prolonging production deadlines. The method works with defined costs and distances, and restrictive conditions can be set. Thanks to the use of computer technology, many models can be modeled at a low cost and the most suitable one can be chosen. There are several types of assembly

lines in the production area, and with the correct and successful implementation of the pilot project, this method can be easily applied to other assembly lines. The implementation of the pilot project for the optimization of assembly lines was given to the department of industrial engineering. The company's motivation is to achieve significant savings on assembly lines and the goals of these business changes should be to gradually improve business processes, making corporate operations more efficient and better using of available resources. By relocating workplace 2 and partially moving workplace 5. Company logistics can significantly reduce handling costs. Using the CRAFT method, it is possible to model different deployment variants and comprehensively compare the achieved benefits of these variants with the mathematical expression of the improvement in the new workplaces deployment. The CRAFT method approach has a positive impact on business practice. It can show clearly the benefits of the steps taken and will help to drive financial investments into fast return projects.

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