

THE ANALYSIS OF MATHEMATICAL METHODS FOR THE LOGISTICS AT INTELLIGENT MANUFACTURING SYSTEMS

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ABSTRACT

As I analyze the Intelligent Manufacturing Systems we can realize that the fundamental of the machining parts the main element is the holon/element. If we look at the logistical science the fundament is the supply chain. In mathematics the fundament is the mathematical formulas equations. In this article my main objective to analogize these 3 parts in an other objective [5][6].

Keywords: machine production, logistics, informatics, coordinate-geometry

PREWORD

At University of Miskolc **Prof. Dr. Illes Dudas**, **Dr. István Cser** and **Prof. Dr. Tibor Tóth** established the bases of the research of Production Engineering, alloyed with the science of Informatics and realized the production systems at 2 Institute. **Prof. Dr. József Cselényi** and **Prof. Dr. Béla Illés**, (former deans) founded the fundamentals of Logistics, and they created the practice and established Institute and laboratory in the Faculty of Mechanical Engineering with so many experts from the Institute [14][15]. All of these researchers founded the fundamentals of these kind of science fields. These kind of sciences have an addition with Quality Assurance. At University of Miskolc, **Dr. Tibor Csermely** has established the main bases of the industrial quality assurance, who is a great scientific supervisor and TÜV-Rheinland auditor.

We can analogize the mathematical Fourier row, series with the main logistical formulas. The Intelligent Manufacturing Systems at Industry 4.0 has bigger significance with logistics. The logistical supply chains can be connected with rows. The mathematical modelling of the Intelligent Manufacturing System is researchable area, which can create the suitable connection with these two kind of science borderlines. The analyzing of Intelligent Manufacturing Systems with neural nets have been already researched. My imagination is to adapt the Fourier's, and other mathematical rows (series) to the logistical part of the manufacturing system in the close future.

1. INTRODUCTION

The Production Engineering and the logistics have been developed in a parallel platform, this kind of symbiosis established the production –organization at inside/and outside of the firm. These sciences alloys with the informatics, which realized the Intelligent Manufacturing systems. The Intelligent Manufacturing Systems have been developed by so many steps in the near past. At first there was the Intelligent Manufacturing Systems (IMS), then the next station was the Flexible Manufacturing Systems (FMS), nowadays the Holonic Manufacturing Systems have bigger significance (HMS) [7]. The difference of this kind of classification is that the automatization level. Usually, the Intelligent Manufacturing system has any kind of human intervention. Nowadays, the most modern Flexible/ Holonic Manufacturing Systems have not needful any kind of human intervention, except only just the maintenance. If we look at the order number of the inside of the usual firm, we can realize the semi-products as an input parameter. If we

observe the rows, I have to define, what can be the minimum element until we define the maximum (lines) point. So we can adapt the mathematical rules and formulas to the Intelligent Manufacturing Systems with logistics. As we define what can be the mathematical equation of the input and outputs.

We should look at another mathematical background, which can be connected with the logistical planning. There are so many problems, which can be solved by the optimization methods. I think the mathematical optimization method can be adapted for the logistical problems inside of the Intelligent Manufacturing System. If we think about the order number at the firm, that could be a factor, which can be maximized for example to grow the benefits of firm. Another example can be the manufacturing cost could be a minimalized factor. Naturally, there are so many parameter, which can be optimized inside of the Manufacturing System. For example, another case can be the number of human resources. This factor can influence the main part of the costs. At this point I have to mention that the technical infrastructure too. By the way it is enough to mention that how many CNC-machine can be operatable at the given firm. If we consider the number of other parameters, like the logistical- machines at the firm, or it can be rentable from other companies, to spare costs, it is an other factor, which can be optimized.

The suitable models are important to give an abstract for the planning of Manufacturing System, or the new logistical way. The optimization of the logistical way is one of the most important task of the planning, The company has spar so many dollar if it can minimize the costs. The creation of the shortest way inside/outside of the firm.is requirement, because all of energy source (gasoline, electricity) getting more expensive . Per a year an average company can spare more million dollar if it is optimal at the manufacturing processes. The Manufacturing System processes have so many levels. The levels form could be the manufacture at each product, and the transport of the semi-products, raw –material has to be in a given time, given place. It is important to mention, that between the neighbor work station’s has connection, action-reaction and feedbacks. The different kind of work stations cooperate with each other, especially at the Flexible Manufacturing System, because it is needful to improve the subordinated elements to collaborate. The cause of this the central part has to supervise the whole manufacturing process. In this point, I have to mention that the Holonic Manufacturing System has a fundamental, it defines the holon. The fundamental of Neural networks like neuron. At other Intelligent Manufacturing System (for example: CIM,FMS) has also a fundamental like the element. The analysis can happen with Manufacturing geometry. The analysis of geometry could happen with matrice-algebra. The design –and manufacturing of worm gear-drives could planning with help with coordinate-transformation geometry. The coordinate-transformation geometry has an expert in University of Miskolc, **Dr. habil Zsuzsanna Balajti** apalicate with Monge-projection [10] [13].

2. THE RAISE OF THE PROBLEM

At the beginning of the new research I just raise the problem, which will discussed in the next article. The starter logistical transport planning has an equation. The starter mathematical equation will be adapteted for a logistical problem.

3. THE OPTIMIZATION LOGISTICS PROBLEM

The Mathematical optimization or **mathematical programming** is the selection of a best element, with regard to some criterion, from some set of available alternatives [3].

The Optimization problems can be divided into 2 categories, which depending on whether the variables could be continuous or discrete. An optimization problem with discrete variables is known as a discrete optimization, in which an object such as an integer, permutation or graph, must be found from a countable

set. A problem with continuous variables is known as a continuous optimization, in which an optimal value from a continuous function must be found. They could include constrained problems and multimodal problems [3].

The optimization problem can be represented in the following way:

Given: a function $f: A \rightarrow \mathbb{R}$ - from set A to the real numbers.

Sought: an element $\mathbf{x}_0 \in A$ such that $f(\mathbf{x}_0) \leq f(\mathbf{x})$ for all $\mathbf{x} \in A$ ("minimisation") or such that $f(\mathbf{x}_0) \geq f(\mathbf{x})$ for all $\mathbf{x} \in A$ ("maximisation").

This kind formulation is called an optimisation background or a mathematical programming problem (a term not directly connected to computer programming, but still in use for example in linear programming). Many real-world and theoretical problems may be modeled in this general framework.

Since the following is valid:

$$f(x_0) \geq \leftrightarrow -f(x_0) \leq -f(x),$$

It suffices to solve only minimisation problems. However, the opposite perspective of considering only maximisation problems would be valid, too. The problems formulated using this technique in the fields of physics may refer to the technique as energy *optimisation*, minimisation, speaking of the value of the function f as representing the energy of the system being modelled. In machine learning, it is always necessary to continuously evaluate the quality of a data model by using a cost function where a minimum implies a set of possibly optimal parameters with an optimal (lowest) error. Usually, A is some subset of the Euclidean space.

$\{\mathbb{R}\}^n$, often specified by a set of constraints, equalities or inequalities, that the members of A have to satisfy. The domain A of f is called the search space or the choice set, while the elements of A are called candidate solutions or feasible solutions [3].

The function f is called, variously, an objective function, a loss function or cost function *optimisation* (minimisation), a utility function or fitness function (maximisation), or, in certain fields, an energy function or energy functional. A feasible solution that minimises (or maximises, if that is the goal) the objective function is called an optimal solution. In mathematics, conventional optimisation problems are usually stated in terms of minimisation [3]. A local minimum x^* is defined as an element for which there exists some $\delta > 0$ such that:

$$\forall x \in A \text{ where } \|x - x^*\| \leq \delta, \text{ the expression } f(x^*) \leq f(x) \text{ holds,}$$

that is to say, on some region around x^* all the function values are greater than or equal to the value at that element.

4. THE TRANSPORT NETWORKS

The following equations (below) present that case, there are exists when the logistical way and the input parameters, like the semi- products (product). The manufacturing firm orders different kind of raw-

material, semi – products, which can insert its profile, Naturally, the firm has to design the optimised logistical way of semi-products inside and outside of the firm, to be cost optimised (effort) for the management.

A connectable directed graph could define the transport networks, if it contains 2 determined point the Q source and S is the gulper (Q could be the manufacturing firm and S could be the customer) and it has these kind of features [4]:

- It can exists an u_1 arc, which show S to Q direction and u_1 the only arc, which is starts from the S intersection and the only which has Q intersection the objective point..
- Every u_1 arc has a different u_i arc a real number $c(u_i) \geq 0$ the capacity (the possible logistical input parameters) has been added for the arc, while the capacity of $u_1 = \infty$. Those kind of φ graph, which orders a real number for every element of G graph could define continuum and it is true for every intersection that:

$$\sum_{(u,v) \in G} \varphi(u, v) = \sum_{(v,w) \in G} \varphi(v, w) \tag{1}$$

The

$$\sum_{(Q,v) \in G} \varphi(Q, v) \tag{2}$$

addition is the strength of the continuum. A φ continuum could be comparable with capacities , if it is true for every element for u_i arc, that $0 \leq \varphi(u_i) \leq c(u_i)$.

5. THE FORD AND FULKERSON MAXIMALISED CONTINUUM ALGORITHM

With these algorithm, we can tell that a φ continuum maximalised or not. The logistical network can be G and the v_i strengthened continuum with φ capacities. The algorithm to marking the intersections, contains the following steps, which after that doing can readable, what kind of size can getting grow the strengthend the continuum the functions the chosen marking steps.

- a. Let's mark the Q intersection, and $\varepsilon(Q) = \infty$
- b. If the $e_i = (x,y)$, arc exists, where the x is the marked and the y means the non-marked intersection $\varphi(e_i) \leq c(e_i)$, then let's mark the x intersection and set up the $\varepsilon(y) = \min((\varepsilon(x) - c(u_i) - \varphi(u_i))$ value, then let's continue with step b. or continue with step c.
- c. If the $e_i = (x,y)$, arc exist, where x is not exists, y has already marked y, $\varphi(u_i) \geq 0$, $u_i \neq u_1$, then let's mark x the intersection (x,y) arc, and let's set up the following equations: $\varepsilon(x) = \min((\varepsilon(y), \varphi(u_i))$ value and then let's set up the point b. By the way we should finish the flow. If the G graph 's S is the gulper has been marked, and the G graph $e(S)$ flow can be repeatable. If we do not mark the S gulper then the flow is maximalised.

5.1. The logistical example

An industrial firm manufacture z product: F_1, F_2, F_3, F_z .. The number of consumer marked: r: V_1, V_2, V_3, V_r ..The given period the F_i firm s_i product manufacture, and in parallel V_i consumer t_i unit manufacture. The circle between, from Q until S means the Intelligent Manufacturing System. The Inside of circle, there are so many action-reaction and feedback between 2 –or all of the points. The whole circle between Q and

S means The concretized Intelligent Manufacturing System. In front of the Q point there is the raw material from the mine or somewhere else, and the S point means that point where the logistical vehicles could take the products to the shops or other consumers. The point of this can be seen at *Figure 1*. As we can see on the *Figure 1* for example, c_{11} can show the direction (distance) between F_1 and v_1 . This distance like, c_{11} , c_{12} , ... etc. could show the way between 2 point, which could be 2 workstation, for example from the store to the CNC Manufacturing System. This could be the another topic, that in one station what kind of movement could be inside of a CNC Manufacturing Centre (more than one movement). It could be examined too.

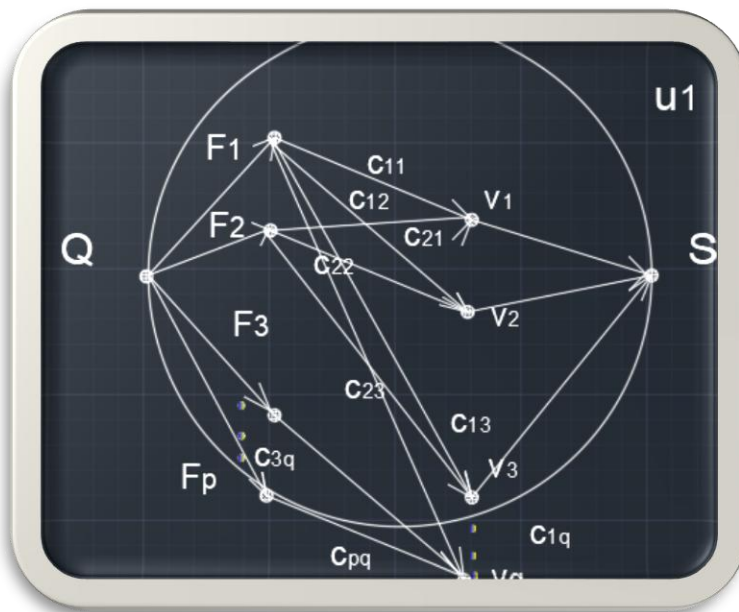


Figure 1. The logistical solutions inside the Intelligent Manufacturing System (the source has made by the author in Autodesk AutoCAD 2021)

6. CONCLUSIONS

The multi-national companies has so many fundamental working strategies. The 3 most important keyword are the following: The Quality Assurance, Informatics and Logistics. These 3 process have to cooperate with each other to operate the firm. At University of Miskolc there are great tradition to educate and research the sciences of Production Engineering and logistics. This article is about there is significance to alloy these kind of sciences, especially at Industry 4.0. I recognised that the Intelligent Manufacturing Systems and the science of logistics are developing in paralel method. This article is the beginning of this research. The discussion of the theoretical background is very important, If we look at the reform of Industry 4.0 form. The Mathematical theories supplied the practical side. I think the practical adaptation of the mathematical theories could be a new trend, because all of the developments has an mathematical model. The creation of Mathematical model is the fundamental base all of construction and manufacturing process. The description in an explicit form is the fundamental of every design. All of the technological thesis are depend on the mathematical expresses. Using the Ford and Fulkerson maximalised continuum algorithm, we can adapt an logistical express inside of the Intelligent Manufacturing System.

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