modelling and simulation, multi-criterion evaluation of variants, fuzzy logic

Sławomir KUKLA*

FUZZY LOGIC IN RATIONALIZATION OF PRODUCTION SYSTEMS ON THE BASIS OF SIMULATION PROJECT

Abstract

The present paper presents a systemic approach to foundry management. Thanks to production process modelling and simulation techniques, an attempt was made to synthesise many interconnected devices and numerous manufacturing stages into one production system. The sheets of multi-criterion evaluation were prepared, where criteria and variants were assessed by means of subjective point evaluation and fuzzy character evaluation. The paper presents an analysis example of finishing activities of castings realized in foundry and in cooperation.

1. Introduction

Modelling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious trade off between realism and simplicity.

Simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of the system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system that is represented. The model can be reconfigured and experimented with; usually, this is impossible, too expensive or impractical to do in the system it represents.

The operation of the model can be studied, and hence, properties concerning the behaviour of the actual system or its subsystem can be inferred. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time. Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance [1, 2, 5, 6, 8].

* Eng. PhD. Sławomir Kukla: Department of Industrial Engineering, University of Bielsko-Biala, ul. Willowa 2, e-mail: skukla@ath.bielsko.pl

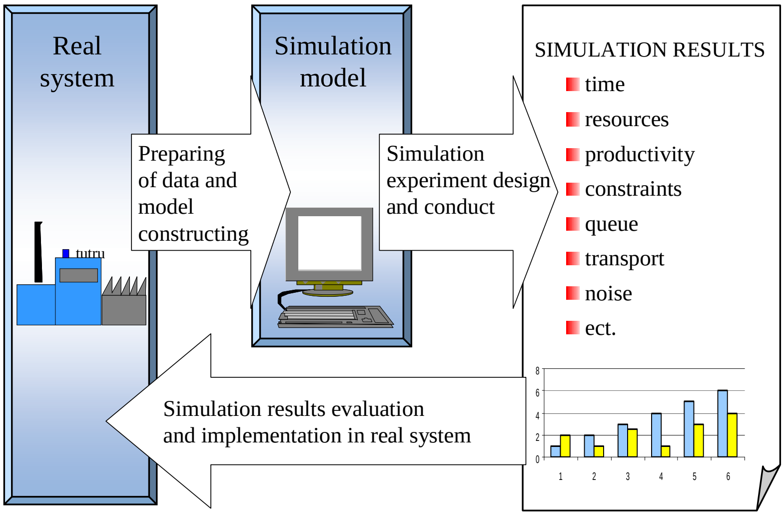


Fig. 1. Modelling and simulation of production systems

2. THE AIM AND RESEARCH METHODOLOGY

Decision making is certainly the most important task of a manager and it is often a very difficult one. The domain of decision analysis models falls between two extreme cases: deterministic and probabilistic. This depends upon the degree of knowledge we have about the outcome of our actions. Between these two extremes are problems under risk. In deterministic models, a good decision is judged by the outcome alone.

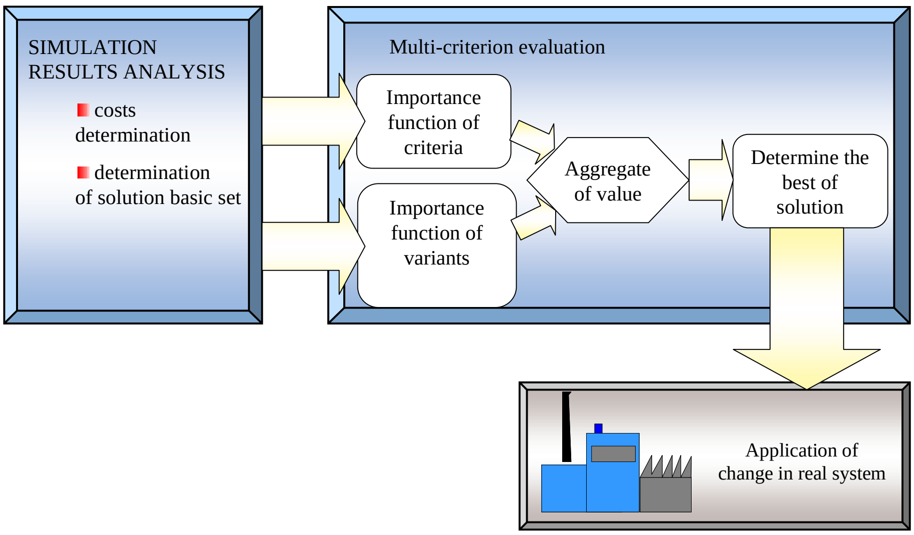


Fig. 2. Research methodology - multi-criterion evaluation of solution

However, in probabilistic models, the decision maker is concerned not only with the outcome value but also with the amount of risk each decision carries.

When analyzing production systems performance, we need to take into consideration numerous criteria and evaluate their importance. In production practice, next to variant evaluation according to precise criteria, there is also probabilistic evaluation and evaluation according to fuzzy criteria (fig. 2).

The input data in the method of multi-criterion evaluation described above is [9, 10]:

- number of criteria m,
- number of variants of production process n,
- elements of value matrix of particular criteria $B = [b_{ij}]$,
- elements of table $C = [c_{ij}(e)]$, which are normalized point evaluation of i-th variant according to the j-th criterion given by p-expert.

Further, one summary matrix of criteria importance is created. For this matrix, a proper vector *Y* is looked for, which fulfills the following matrix equation:

$$B\,Y = \lambda_{max}\,Y \tag{1}$$

Coordinates of the proper vector, called the weights, express the importance of particular criteria and they have been estimated by means of special software (fig. 3).

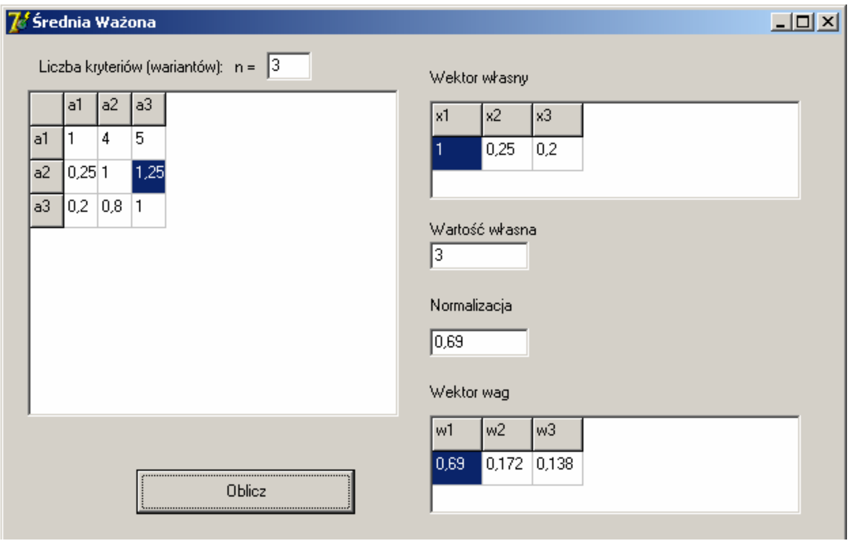


Fig. 3. Coordinates and value of the proper vector

Aggregate of variants and criterions:

$$Z_i = F(B_{i1}, B_{i2}, ..., B_{im}\ , w_1, w_2, ..., w_m) \tag{2}$$

Z_i – fuzzy set $\langle 0,1 \rangle$

F – aggregate function

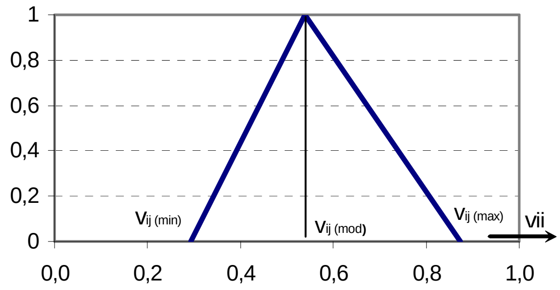


Fig. 4. Fuzzy set – affiliation function

Aggregate of affiliation function (fig. 4) – example:

$$z_i = \frac{\sum_{j=1}^{m} v_j r_{ij}}{\sum_{j=1}^{m} v_j} \tag{3}$$

Arranging of fuzzy set and selection of best solution:

$$sw_i = \frac{\int_0^1 (z\ \mu_{z_i}(z))dz}{\int_0^1 \mu_{z_i}(z)dz} \tag{4}$$

3. DESCRIPTION OF THE OBTAINED RESULTS

The paper presents the application of computer simulation to show the behaviour of production system, as well as the use of multi-criterion tools for variant evaluation in rationalization of manufacturing processes of iron castings on the example of finishing treatment [3, 4, 7]. Considering the method and the place of realization of finishing activities, the following variants of solutions were suggested:

- variant W1: all castings are treated in cooperative plants,
- variant W2: castings are ground in a foundry according to accessible resources, the rest in cooperation,
- variant W3: all castings are treated on foundry premises equipped additionally with presses used for cast finishing,
- variant W4: all castings are treated on the premises of a plant with traditional methods after installing additional grinding workplaces.

For importance evaluation of criteria and for evaluation of variants experts are employed. Each expert is responsible for building matrices of importance evaluation for criteria according to Saaty’s method, which consists in comparing subsequent pairs of the assumed criteria (fig. 5, 6 ,7).

Expert 1

	k1	k2	k3
k1	1	2	2
k2	0,5	1	1
k3	0,5	1	1
lambda=	3	wsp.kons	0

Expert 2

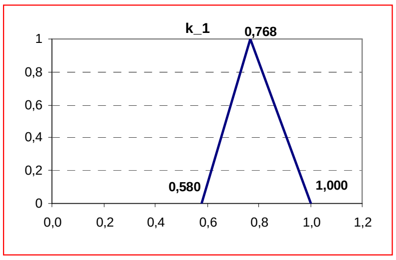
	k1	k2	k3
k1	1	1	2
k2	1	1	2
k3	0,5	0,5	1
lambda=	3	wsp.kons	0

Expert 3

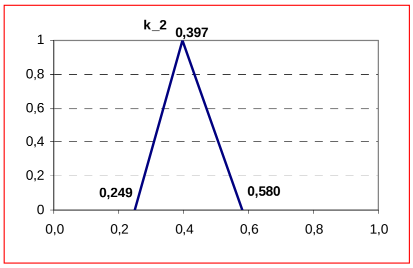
	k1	k2	k3
k1	1	4	5
k2	0,25	1	1,25
k3	0,2	0,8	1
lambda=	3	wsp.kons	0

	Vmin	*Vmax*		*Vmod*
k_1	0,5797	1,0000	0,7246	**0,768**
k_2	0,2493	0,5797	0,3623	**0,397**
k_3	0,2000	0,3623	0,2899	**0,284**

Criterion **1**



Criterion **2**



Criterion **3**

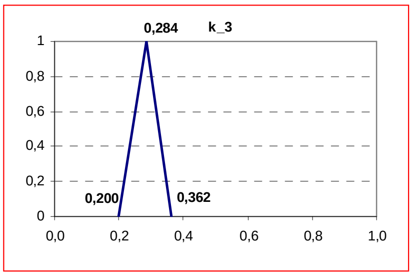


Fig. 5. Evaluation for criteria according to Saaty's method

The following criteria were suggested for evaluation of subsequent variants of solutions for finishing processes:

- cost of finishing activities in the analyzed period,
- length of the production cycle,
- quality of activities.

For 3 criterion

	W1	W2	W3	W4
W1	1	0,5	0,25	0,5
W2	2	1	0,5	1
W3	4	2	1	2
W4	2	1	0,5	1

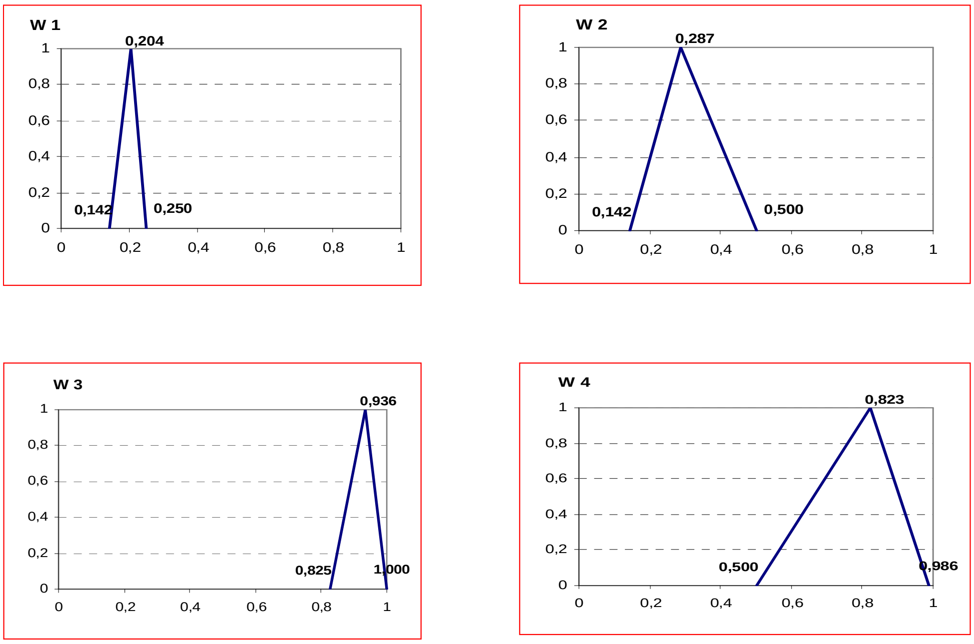


Fig. 6. Evaluation for variants according to Saaty's method

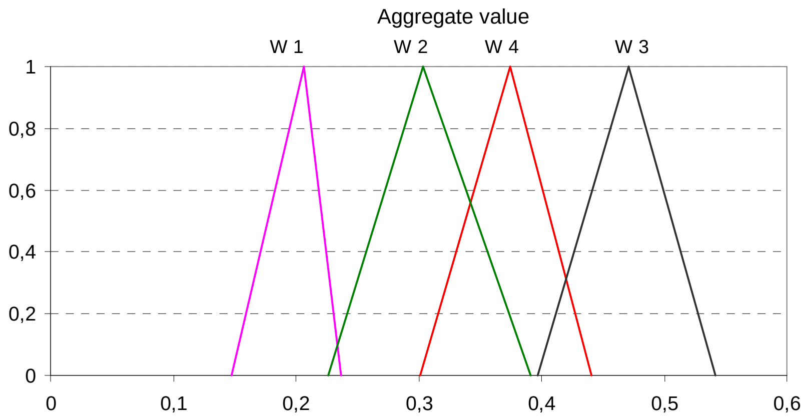


Fig. 7. Multi-criterion evaluation – aggregate value

Results of this research, which were presented on figure 7, show that the preferred variant of the process of the finishing process for castings is variant 3.

Variants	Importance of value before normalization	Importance of value after normalization
W 1	0,213	0,436
W 2	0,304	0,623
W 3	**0,488**	**1**
W 4	0,392	0,803

Fig. 8. Results of project

4. Conclusions

By observing enterprises dealing with casting manufacture we can notice that in the sphere of construction and technology, cost cutting possibilities are more and more limited. More faults which influence the formation of manufacture own costs should be looked for in the domain of production organization, planning and production tasks management.
Thanks to simulation experiments it will be possible to determine the order and size of production lots from the point of view of assumed and forecast order portfolio, which can have a significant influence on own cost formation in manufacturing iron castings.
In order to reduce costs, it is advisable to use resources rationally and aim at maintaining production reserves on minimal permissible level.
There exists a possibility of efficiency increase of finishing treatment in case of some castings by using presses for such activities. Presses are more expensive and more complex in operation, but using them in finishing increases the efficiency of activities several limes in comparison to traditional methods. A disadvantage here is the need to clean the castings again.
Thanks to modelling and simulation it will possible to check different scenarios of solutions related to the course of finishing of castings without the need to experiment on the real system. Simulation results can undergo multi-criterion evaluation and the best solution can be chosen, according to the assumed criteria.

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