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COMPLEMENTARY ECONOMIC VALIDATION ALGORITHM IN OPTIMIZING MANUFACTURING ARCHITECTURES

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Abstract: *The main goal of this paper is to present a new discrete material flow economic validation algorithm based on a cost/use value report. This algorithm is meant to be a part of our product and manufacturing design optimization research studies regarding different modelling and simulation techniques. The research results illustrating this optimization algorithm are based on reports provided by different simulation models, using Witness software for a manufacturing cycle of a milling machine main shaft. In order to obtain this optimised manufacturing architecture we focus on identifying & eliminating bottlenecks, generating increased production rates without unjustified investment expenses.*
Key words: *production costs, use value, manufacturing architecture design, optimization algorithm*

1. INTRODUCTION

Our optimizing algorithm takes into account that before any manufacturing process starts we use the marketing studies to include the customer demands in the preliminary product modelling phase. Then we use the CAE module to simulate the real product behaviour in exploitation in order to validate our preliminary product virtual prototype.

When this 3D model validated we need to study in detail the product manufacturing processes determining the necessary tools and machines as elements of the preliminary manufacturing architecture. In order to optimize and eventually validate this preliminary manufacturing architecture the next step is to virtually simulate the material flow in order to identify and eliminate eventual flow concentrators that slow down or even block the production.

For the analysis that will be made in order to eliminate the concentrators we need to choose between a functional remodelling; (it consists in changing some of the machines placement, the order of some operations, the speed of some conveyor belts or manufacturing times) and a technological remodelling; (it consists in reconsidering all the manufacturing structure system data: the type of the machines, tools, transport and transfer facilities etc). The new system is remodelled and a material flow simulation for the system is done (Anghel et al., 2009). We define diffused manufacturing systems as architectures with more than two working points connected by transport and transfer systems and using buffers (Coulouris et al., 1995). When taking in consideration concentrated systems we can define them as architectures based on a single work point surrounded & assisted by transport, transfer & deposit facilities (Cotet & Dragoi, 2003).

If technological remodelling is chosen, after using an economical analysis to compare the necessary investment with the increasing productivity benefits we finally validate the product as well as the manufacturing architecture design (Cotet et al., 2009). Here we are.

If the classical economic validation algorithm uses mainly net present value based analysis in our new methodology we include also a cost/ use value report.

2. A FEW STEPS IN MANUFACTURING ARCHITECTURE ECONOMIC VALIDATION ALGORITHM

We will briefly present here the cost/use value report methodology used twice in our economic validation algorithm.

In order to illustrate this algorithm we will use a study case for remodelling the manufacturing architecture of a milling machine main shaft without increasing the production expenses.

In our case study we optimize a diffused manufacturing system (Chiscop et al., 2010). The easiest way of doing that is by using functional remodelling, changing some of the machine placement in the production site, the order of some operations, etc. Of course if this doesn't work we will have to consider technological remodelling, modifying the manufacturing architecture. A new simulation must be performed to validate the optimized manufacturing architecture.

For our study case we use the manufacturing cycle of a milling machine main shaft. We will start by determining the manufacturing processes required in order to obtain the shaft starting from a blank with a diameter of 80 mm and length equal to 345 mm. Then we must calculate the manufacturing time needed in order to establish the number and type of the machine tools used in the production site.

For calculating the necessary time we must know some technical parameters from the machines used, like the cutting speed, rotation parameter, as well as the crossing numbers for each process, stroke, the blank's diameter, etc.

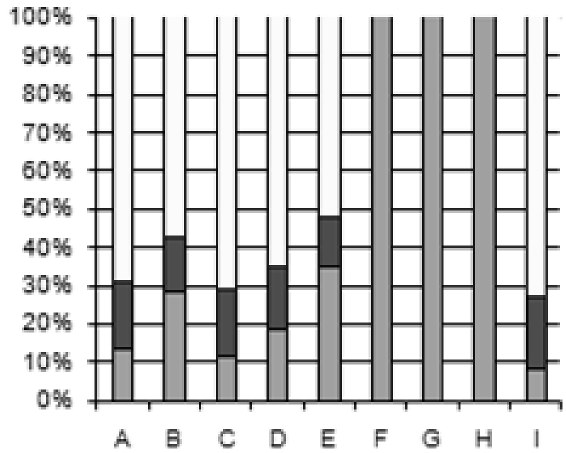
It is very important to do a correct calculus of the necessary times because these will lead to a correct parameterization of the machines when running the simulation. If the necessary times are not calculated correctly the results obtained from the simulation are incorrect and so the manufacturer can't rely on them.

A number of 23 manufacturing processes were established. For each manufacturing processes we calculated the manufacturing cycle time.

We determine the manufacturing times for all the operations, so in this phase we know the total amount of time that takes to manufacture the shaft. Now we can establish the machine tools used in the manufacturing process: debtor machine, lathe machine, milling machine, boring and grinding machine.

Symbol	Function name	U_v
A	Driving motion	20.99
B	Fixing elements	16.05
C	Positioning elements	16.05
D	Sealing	3.70
E	Allows access	1.23
F	Takes shocks	11.11
G	Bearing function	7.41
H	Takes loads	7.41
I	Centering elements	16.05

Tab. 1. Functions description



Up – labour costs
Middle – indirect costs
Down – materials costs

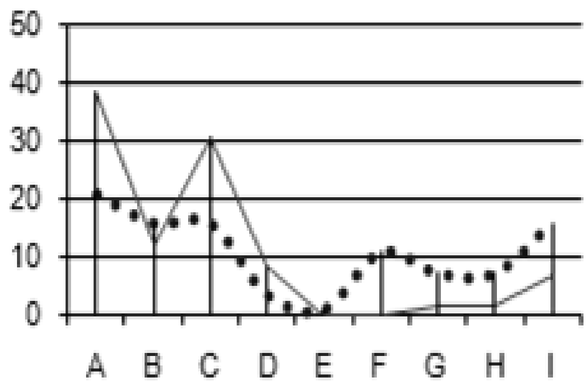
Fig. 1. Function histogram

Before starting any production cycle it is advisable to perform a cost/use value report analysis and then run a material flow simulation using dedicated software. The information gathered can be useful both for beneficiary and manufacturer. For example we can learn about the productivity rates, displacement of the work points, auxiliary manufacturing times, and human operators' role. For our case study we define 9 main functions. The calculated use values for those functions are presented in table 1. In figure 1 the structure of those functions associated costs is presented. The report of use value and costs is presented in figure 2. One can use this representation in order to check if for some functions the use value is smaller than the associated costs.

Using the data obtained we are going to build the model for the production site (figure 3). The elements presented in this model are: machine tools (debtor machine – D1, lathe machine – S1, milling machine – F1, boring and grinding machine – MAR1), each of them having an operator (L1 to L4) supervising the production cycle, conveyor belts (C1 to C4) used for transporting the blank (P1) from one work point to another and buffer (B2) for depositing parts.

For building the model and simulating the material flow we choose Witness simulation software. We agree here with the thesis that within the class of stochastic simulation models, one further distinction is necessary: simulations can be either terminating (sometimes called finite) or non-terminating in nature, with specific algorithms for each category.

After the model is finished we run a simulation for a finite period of the time (one month), 22 working days, 16 working hours a day and obtained a productivity of 138 pieces.



Line – costs
Interrupted line – use value

Fig. 2. Cost / use value correlation diagram

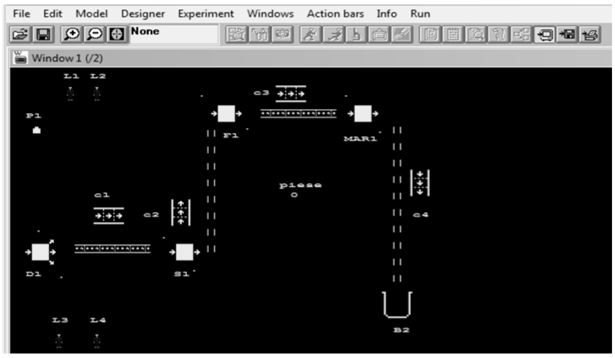


Fig. 3. Preliminary architecture of the production site

The first problem that we noticed was the bottleneck situated on S1 entrance caused by the big manufacturing times that this machine has. This means that the material flow is either slowed down or stopped causing problems throughout the whole system. The manufacturing time on S1 is 3 times bigger than the one of the D1.

3. CONCLUSIONS

After analysing the results obtained we can start thinking about optimising the system. And because the biggest problem represents the bottleneck on the S1 entrance after excluding functional remodelling due to ¼ reports of effective manufacturing times at D1 and S1 work points, we consider adding another lathe machine, two conveyor belts and a human operator.

After rebuilding the model we run a simulation for this new model and obtained an increasing of the productivity of over 30%. In this way we eliminated the bottleneck presented in the previous manufacturing architecture. In this point, before we can continue with the optimisation process aiming for higher productivity rates we must have in mind that by modifying the architecture, especially by adding work points we raise the production costs. That implies a second economic validation based on the cost/use value report.

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