Discrete material Flow Management in Industrial Engineering

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ABSTRACT

This paper main goal is to illustrate our late research by proposing an algorithm to increase the productivity using the discrete material flow management.

Our previous results in increasing productivity are based on eliminating the flow concentrator using discrete material flow simulation without any changes for the manufacturing cycles describing the activity of each work point. The new algorithm presented in this paper is using the synchronous simulation of the process at the level of each work point of the manufacturing system & the material flow at the level of the entire manufacturing architecture. For this integrated synchronous model, we use the Butterfly Effect in order to change some of the manufacturing cycles.

The Butterfly Effect impact is due to introducing stochastic distribution laws and not fixed values for MTBF (the mean time between failure) or MTTR (mean time to repair) not only in discrete material flow but also in process simulation in order to increase productivity.

According with this algorithm one can analyze the results of the material flow simulation and identify the flow concentrator for each one of the manufacturing systems integrated in the two virtual simulation models. If an architecture modification is proposed as a solution for this problem a second simulation to validate the optimized architecture and the obtained increase of productivity is necessary.

Keywords: discrete material flow,, process simulation, integrated model.

1. INTRODUCTION During our research studies in the field we identified as one of the main difficulties in manufacturing systems architecture optimization the area of synchronizing process and material flow simulation.

Analyzing the different modeling behaviors for the process simulation and for the discrete material flow simulation we defined the “butterfly effect” as one of the most important theoretical models used to create optimizing algorithms.

We use the Butterfly Effect [2] in the material flow simulation because our modeling algorithm allowed us to change some of the manufacturing cycles introducing stochastic distribution laws and not fixed values for MTBF (the mean time between failure) or MTTR (mean time to repair).

In this case some of the manufacturing cycles will be different due to repair times who will personalize the total cycle’s process chain. In order to synchronize the material flow and process models of the manufacturing cycles we had to modify the CAM program in order to personalize the process simulation using the Butterfly effect approach because process simulation is a repetitive algorithm generating the same parameters for every manufacturing cycle.

The main goal of our algorithm is to increase productivity by improving the discrete material flow management using the process simulation as a preliminary data.

We analyze the results of the material flow simulation and we identify the flow concentrator for a preliminary manufacturing architecture based on process simulation results [1]. We propose a solution for eliminating flow concentrators. We perform a second simulation to validate the optimized manufacturing architecture by obtaining an increased productivity.

Some of the necessary data for the material flow simulation like cycle times for the work points defined in our models are provided form CAM simulations describing each work point manufacturing process.

The material flow simulator is integrating the process simulation results at the level at each work point in order to provide a complete model of the manufacturing system.

2. A PROCESS SIMULATION MODEL

In order to realize the integrated simulation model of the manufacturing system (as one can see in figure 1) we started with the process simulation using CAM NC Manufacturing Solutions.

That kind of software solution enabled us to define and manage NC programs dedicated to machining parts designed in 3D wire frame or solids geometry using 2.5 to 5-axis machining techniques corresponding with the work points in the discrete material flow model.

An integrated powerfull Post Processor engine allows the product to cover the whole manufacturing process from tool trajectory (APT source or Clfile) to NC data in a discrete IT process

We will illustrate the steps to be done for a milling machining work point.

The Machining simulation process can then be used by the discrete material flow software model for overall manufacturing process integration, simulation and optimization.

The main element of the Milling Machine application is a “CatPart” file containing the geometry of the work piece and the finite product.

This file must also contain the geometric profiles needed for defining the work surfaces. This file is associated in Milling Manufacturing application command tree with the part operation entry and as a result a new instance of the file is inserted into command tree.

This entry can be edited using the Mechanical Design application; all the modifications are than updated automatically in NC Manufacturing application.

Another “CatPart” file is needed for storing complementary geometrical elements like the 3D model of the work piece after each part operation.

So far so good as from the process simulation point of view.

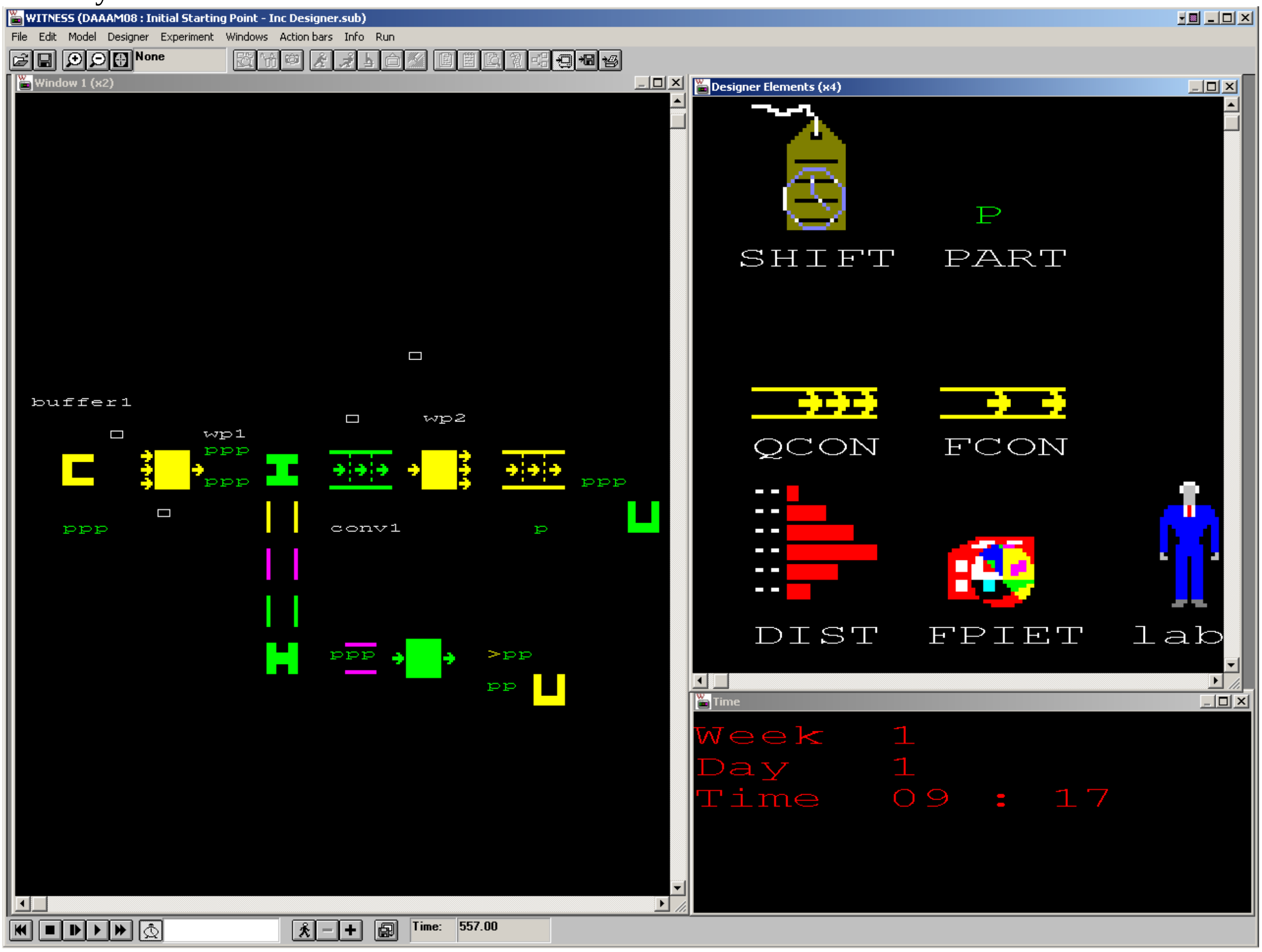

Figure 1. Witness integrated simulation model

3. MATERIAL FLOW SIMULATION

We use Witness software to realize the preliminary parametric model of the manufacturing system and to simulate the material flow in the system in order to identify the flow concentrator. Different algorithms are used for the diffused and concentrate manufacturing systems, for terminating or non terminating simulations according with the specific constraints characteristic for each case. For a designed manufacturing architecture it is always useful to simulate the material flow conduct before applying our design into practice in order to avoid potential flow concentrators generating low productivity or even blockage. The leading actor able to manage this area will be the flow simulator.

We define diffused manufacturing systems as architectures with more than two work points connected by transport & transfer systems and using deposits at local or system level [1].

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 nonterminating in nature, with specific algorithms for each category. We consider a material flow and process synchronous simulation the simulation of a model where at the level at the work point the process simulation is concomitant with the material flow simulation.

We consider that due to the complexity of the mean time between failure (MTBF) and mean time to repair (MTTR) modeling for various machines and manufacturing systems one can provide the best solutions for such productivity improvement based on stochastic distribution laws and not on fixed values, even if fixed values for these parameters would be used for some particular finite short simulations.

A running Witness diffused manufacturing model for terminating simulations is presented in figure 1. Each work point parameters were established based on process simulation results as described before.

Using the Witness reports one can identify the flow concentrators and according with manufacturing planning constraints can propose technological solutions or modifying manufacturing architecture based solutions to eliminate those concentrators.

In order to validate the increased productivity obtained on the optimized manufacturing system architecture, a new simulation is necessary. If one weighs the productivity for the preliminary and optimized architecture the increasing productivity due to the optimization can be quantified. A very important issue of this algorithm is to evaluate if the optimized architecture supplementary costs are or not covered by the productivity gain. This financial analysis is based on a NPV algorithm and validates the financial profitability of the optimization.

At the first level main parameters for the work points modeling in material flow simulation are provided form CAM simulations describing the manufacturing process [3]. This way the material flow simulator is integrating the process simulation results at the level at the work point in order to provide a complete model of the manufacturing system.

At the second level the non terminating simulation algorithm (mainly used in diffused related architectures) is applied for each manufacturing system of the enterprise.

At the third level the manufacturing architecture material flow is simulated. In this model the work points are the basic simulation model units describing the manufacturing system material flows. At this level the complexity of synchronizing process and material flow simulation is higher then in concentrate manufacturing systems with a single work point.

In the end at the level of the entire virtual manufacturing system the process simulation for each work point is synchronic with the material flow simulation describing the entire system activity.

This local synchronizing process of the material flow simulation using Witness software as well as the CAM simulation allowed us to change some of the manufacturing cycles introducing stochastic distribution laws values for MTBF, MTTR or failed parts adapted to each work point characteristics.

If we use the integrated model versus the asynchrony classic one the accuracy of the simulation results for the presented case study increase with 8-9 %.

Of course if we want to validate the increased productivity obtained by eliminating the flow concentrator we must proceed to the economic analysys mentioned before.

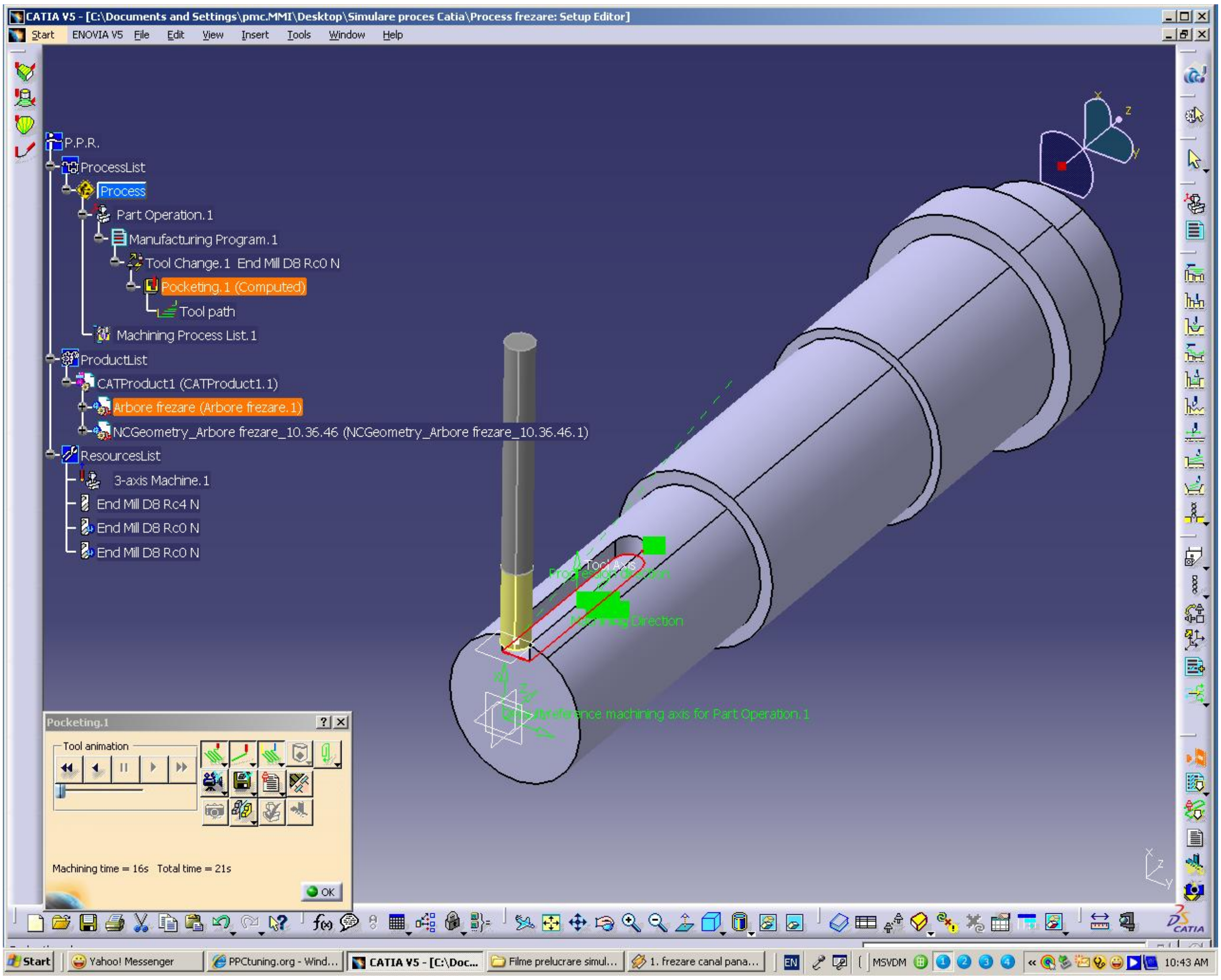

Figure 2. Process simulation model

4. CONCLUSIONS

In this paper starting from the conceptual model called the Butterfly Effect synchronized simulation techniques for increasing manufacturing systems performances are used to evaluate manufacturing systems preliminary architecture.

Material flow and cutting process simulation models based on specific software solutions are the main actors of this simulation project undertaken with the goals of demonstrating and confirming production rates of a manufacturing process based on a proposed design layout and operational data and of identifying ways of improving the design of the system in order to increase those production rates. According with this algorithm one can analyze the results of the material flow simulation and identify the flow concentrator for each one of the manufacturing systems integrated in the two virtual simulation models. If an architecture modification is proposed as a solution for this problem a second simulation to validate the optimized architecture and the obtained increase of productivity is necessary.

Last but not least a NPV financial analysis must confirm the profitability of the manufacturing optimized architecture.

5. REFERENCES

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