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COMPUTER MODELLING AND SIMULATION OF AUTOMATED MANUFACTURING SYSTEMS

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ABSTRACT: Computer simulation of a computer model represents use of special computer software run on a single computer or a network of computers that attempts to simulate an abstract model of a particular system. Computer simulations have become a useful part of mathematical modelling of many natural systems in physics (computational physics), chemistry and biology, human systems in economics and engineering. Simulation of a system is represented as the running of the system's model. It can be used to explore and gain new insights into new technology and to estimate the performance of systems too complex for analytical solutions.
KEYWORDS: computer modelling, computer simulation, manufacturing systems

INTRODUCTION

Computer technology equipped with suitable software is advantageously used in various branches of practice at present time. It is difficult to imagine the development and production of new products in modern enterprise without exploitation of appropriate computer aided systems. Most of present CA systems are mainly determined and used in the area of computer design and constructing of new products, but only complete application of these modern computer technologies to all periods of product design and manufacturing, can bring the maximum profit for the enterprise.

Computer simulations vary from computer programs that run a few minutes, to network-based groups of computers running for hours to ongoing simulations that run for days. The scale of events being simulated by computer simulations has far exceeded anything possible (or perhaps even imaginable) using traditional paper-and-pencil mathematical modelling. A computer model refers to the algorithms and equations used to capture the behaviour of the system being modelled. However, a computer simulation refers to the actual running of the program which contains these equations or algorithms. Simulation, therefore, refers to an instance where you ran a model. In other words, you wouldn't "build a simulation" you would "build a model", but you could either "run a model" or "run a simulation". Model and simulation are often used interchangeably and the difference between them is trivial [1].

CREATION OF COMPUTER MODELS FOR COMPUTER SIMULATION

Computer simulation developed hand-in-hand with the rapid growth of the computer following its first large-scale deployment during the Manhattan Project in World War II to model the process of nuclear detonation. Computer simulation is often used as an adjunct to or substitute for modelling systems for which simple closed form analytic solutions are not possible. There are many types of computer simulations; the common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states of the model would be prohibitive or impossible [1]. Computer models can be classified according to several independent pairs of attributes, including:

- stochastic or deterministic (and as a special case of deterministic - chaotic),
- state or dynamic,
- continuous or discrete (and as an important special case of discrete - discrete event),
- local or distributed.

Another way of categorizing models is to look at the underlying data structures. For time-stepped simulations there are two main classes:

- Simulations which store their data in regular grids and require only next-neighbour access are called stencil. Many CFD applications belong to this category.
- If the underlying graph is not a regular grid, the model may belong to the mesh free method class.

Equations define the relationships between elements of the modelled system and attempt to find a state in which the system is in equilibrium. Such models are often used in simulating physical systems, as a simpler modelling case before dynamic simulation is attempted [1, 2].

- *Dynamic simulations model changes in a system in response to (usually changing) input signals.*
- *Stochastic models use random number generators to model chance or random events.*
- *A discrete event simulation (DES) manages events in time. Most computer, logic-test and fault-tree simulations are of this type. In this type of simulation, the simulator maintains a queue of events sorted by the simulated time they should occur. The simulator reads the queue and triggers new events as each event is processed. It is not important to execute the simulation in real time. It's often more important to be able to access the data produced by the simulation, to discover logic defects in the design, or the sequence of events.*
- *A continuous dynamic simulation performs numerical solution of differential-algebraic equations or differential equations (either partial or ordinary). Periodically, the simulation program solves all the equations, and uses the numbers to change the state and output of the simulation. Applications include flight simulators, construction and management simulation, chemical process modelling, and simulations of electrical circuits. Originally, these kinds of simulations were actually implemented on analog computers. By the late 1980s, however, most "analog" simulations were run on conventional digital computers that emulate the behaviour of an analog computer.*
- *A special type of discrete simulation that does not rely on a model with an underlying equation, but can nonetheless be represented formally, is agent-based simulation. In agent-based simulation, the individual entities (such as molecules, cells, trees or consumers) in the model are represented directly (rather than by their density or concentration) and possess an internal state and set of behaviours or rules that determine how the agent's state is updated from one time-step to the next.*
- *Distributed models run on a network of interconnected computers, possibly through the Internet. Simulations dispersed across multiple host computers like this are often referred to as "distributed simulations".*

SIMULATION OF MANUFACTURING SYSTEMS

Important element in chain of manufacturing planning and material flow is simulation. It is the very easiest option to verify network of material flow and production model of flexible manufacturing systems. Operation conditions at these systems are exactly set and bounded by character of operation as well as with time entry. Intervention of human factor is minimal, because these are fully automatic lines. Simulation used till now shows only fundamental view on material flow running [3].

Current level of technique development gives possibility of three dimensional projections and real-time work. Visualization using means of virtual reality, as for example Head Mounted Display immerse user directly factory, where he can observe exact location of horizontal and vertical arrangement of flexible manufacturing system features, control possible collisions, modify arrangement in order of optimization and reengineering of logistic models. For simulation reference model of production system creating in 3D it is necessary to integrate following steps [4, 5]:

- *preliminary machines location in considered manufacturing system,*
- *regular tool for effective usage of reference model,*
- *regular tool for effective model visualization,*
- *tools for risk factors monitoring.*

Integrating features are mainly software features from different companies. One option is logistics system outputs implementation into CAD systems, which support objects kinematics. A main task is model of objects, which participate in process creating and their following align according to optimization results in logistic software.

Operation away in technical preparation of manufacturing predetermine elaborate of current methods of projecting of integrated manufacturing systems, which includes automatic systems of scientific design, preparation of production, single production, managing and assembly. Purpose of such complex is realization of automated cycle of new manufacturing system build from pre-production phase of component preparation till establishing of serial production. By this process is necessary to secure possibility of performing activities in every stage using general informative base, as well as possibility of paperless data transmission between subsystems in this cycle in local computer networks.

EXAMPLE OF COMPUTER SIMULATION OF MANUFACTURING SYSTEMS

RMT (Rostocker Maschinenbau und Technologie GmbH & Co.KG) is a middle size company located in north Germany. It was established in 1995 by separating from division of Dieselmotorwerk Rostock. Company provides advisory-consultant services, planning and modern computer system aided design. One of company services is order manufacturing of components. This involves activities from material ensuring till conservation and storing of finished parts. Similar like in other successful companies in RMT is effort permanently innovate products and technologies. In process of production system proposing in many cases mainly in conditions of serial production with automatic control is used automated production systems [6].

In newly proposed flexible production system will be realized manufacturing of following parts:

- *Elastic Screw on Fuel Pump: length: 685 mm, drawing: 3 – 107.192.982, annual output: 720 pieces per year.*
- *Elastic Stud-Lower Half: length: 360 mm, drawing: 3 – 107.203.711, annual output: 450 pieces per year.*
- *Guide Bush for Exhaust Valve: length: 362 mm, drawing: 2 – 107.236.467, annual output: 400 pieces per year.*

In introduction of manufacturing system proposing it is necessary to realize capacity calculations of production machines, which can be of two types: informative or detailed. For capital plan elaborating, proposing of possible production grouping it is enough to use informative capacity calculation [12].

Based on realized capacity calculation was determined, that for set manufacturing program it is necessary to use 2 CNC machine tools and because of low operoseness of further operations was decided at other machines to set their number at one. Transport system was proposed based on machinery in RMT, portal manipulator with upgrades. Dispositional solution of flexible production system proposal is on Fig. 1.

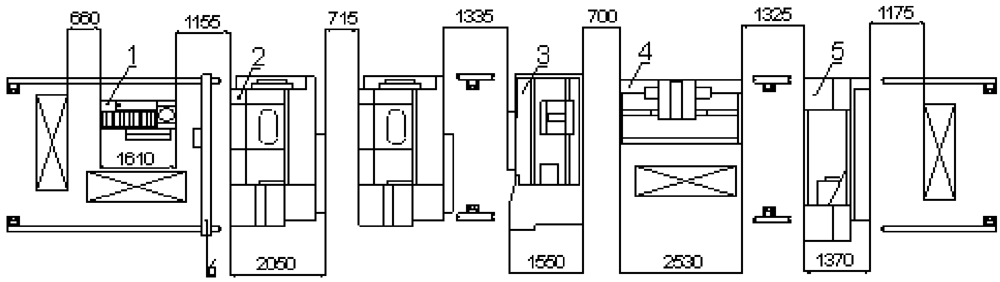

Figure 1. Dispositional solution of flexible manufacturing system proposal

A typical task is to design a complete manufacturing process of a production engineer by Factors, which influence selection of suitable logistic-simulation system, is necessary to analyze in view of requirements put on by simulating model. In generally it is necessary from system to make able:

- *the most detailed and transparent defining of system and its environment, defining input and output system variables,*
- *detailed component system identification and their mutual connections,*
- *possibility of each component detailed behaviour defining,*
- *possibility of parameters defining, which are important for system behaviour examining and their values will be defined in time of concrete simulation experiment,*
- *possibility data obtaining directly from company informative system.*

Selection was based on availability of systems a choice was made on simulator FACTOR/AIM 8.0 considering its specialization and support of all function which are needed by problem solving [7].

Simulator FACTOR/AIM 8.0 from Pritsker Corporation Inc. (USA) with high level of statistic evaluation, demands from user knowledge from field of technical simulation. AIM 8.0 solves different types of tasks, however for this case is enough to execute Gantt Studies, where basic features are terms of product delivery.

Simulating model is mathematic and logic presentation of physical system dynamic characteristics. Simulation model has two main advantages. The first, values and conditions set up to simulation model can be changed without long-time study of whole system. The second, system is able with certain degree of explicitness replace the real physical system. Based on flexible manufacturing system disposition proposal an illustrative simulation model is presented on Fig. 2.

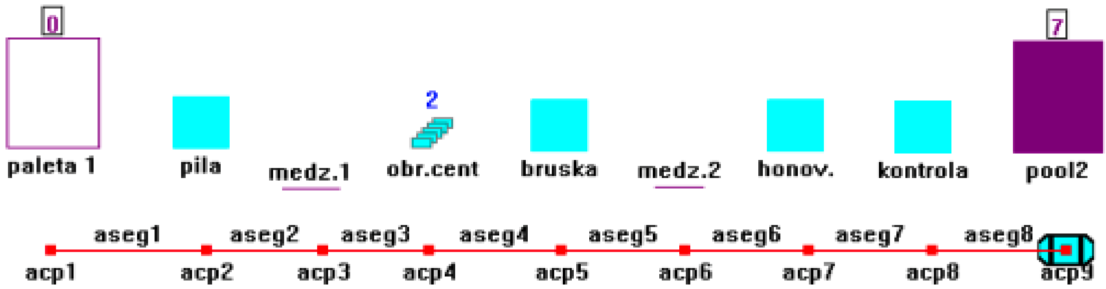

Figure 2. Simulation model of flexible manufacturing system

Using logistics software for production planning and managing was determined optimal operation (input and flow of components among machines according to orders) of production system. Time and capacity defining was because of reason of possibilities of FACTOR/AIM system selected exemplificative quantity of components in one order as well as simulation time [8].

Simulation results show, that machine centre is used the most (55%). Other machines in production process have very little usage, but this result was already predicted in capacity calculations. Input period and orders time setout are presented by Gantt diagrams. Resource Gantt Chart express detailed machines operation. By zooming of certain item more detailed values are shown, for example: time, when the machine was loaded, by which item, and how long, which process plan was executed and so on. Figure 3 presents Load Gantt Chart, which gives detailed description of selected item.

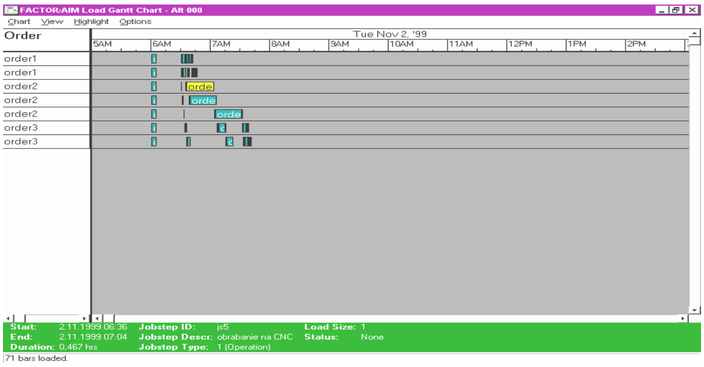

Figure 3. Load Gantt Chart

CONCLUSIONS

As it was presented, production logistic deals mainly with flow of material. Manufacturing system deals with parts transition from one machine to other. Software application for logistic flow optimization FACTOR/AIM, arranged each order according to criteria of the fastest manufacturing with the best usage of machines. This means that such components are to produced, which allocate machine lea off all and at the end are manufactured components with long manufacturing time. In company management the concept of logistics is used in wider extent and with stronger effect. Literature significantly points to growing need of system treatment and formation of logistic processes and functions in integration and strategic aspects, what can be seen in development and evolution of logistics in the sense of integrated management concept.

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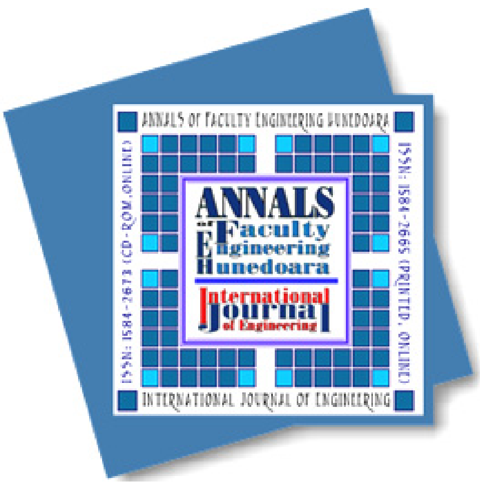

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