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Integration of Information for Manufacturing Shop Control

Zdravko Tešić* - Vojin Mitrović - Ilija Ćosić - Danijela Lalić
University of Novi Sad, Faculty of Technical Sciences,
Department of Industrial Engineering and Management, Novi Sad, Serbia

The concept of manufacturing execution system (MES) has acquired a huge importance in modern manufacturing enterprises, especially in low volume and high variety manufacturing industries. The integration between enterprise resources planning (ERP), manufacturing execution systems and shop-floor control (SFC) systems can take a major role in an enterprise control system. Manufacturing execution system is located in the middle, where an enterprise resource planning is located above and shop floor control system is located below. In this paper is presented the part of the automated shop floor control system with possibilities of connecting to the control system on the machine level. Also, possibilities and limitations in communication between existing automatic machine control systems as well as other devices into integral information system of manufacturing enterprise are described.

Keywords: enterprise integration, planning, scheduling, shop-floor control

0 INTRODUCTION

In the global market, one of the most basic characteristics is increasing of changes in organization-environment relationship, market, technological and production structures, complexity of the output, communication and information and relationships between workers. It is well-known that producing high quality, low cost products in short delays is the real challenge because these conflicting requirements rely on a high degree of automation, in many cases high manufacturing precision, add in most case excellence in manufacturing [1]. Thus, there is a need for better process management and for more integration within decentralized and modular individual parts of enterprise. The integration concept, whish aims at providing the right information at the right time at the right place, concerns: business process integration, teamwork or computer work for concurrent design and engineering activities, increasing flexibility and interoperability of information, systems and people to force environment variability in the cost effective way.

Today, industrial companies are using information technology to coordinate the activities of the many functions involved in running the enterprise. Traditional categories of functions have included planning functions, shop floor execution functions, and machine and process control functions [2]. These functions are hierarchically linked because the upper level planning functions typically constrain the activities that are allowed at the lower levels. In firms with advanced enterprise integration, these levels are coupled through the network architecture and a set of common databases that hold the most current information and make it available to all functions requiring it. Additionally, better results are achived by exploiting existing Web technology [3].

The integration and automation of product design, process design and planning, scheduling and control (which are major activities in production stage) is becoming increasingly significant approaches that can lead towards that automation are of immediate need, where such approaches must be able to emulate human information processing capabilities and to work under conditions of uncertainties [4]. SFC plays a major role in integrating and automating manufacturing facilities by performing the decision/making and execution activities required to fill production orders received from the factory level control system [5]. Associated with these orders are information objects such as process plans, due-date, quantity and priority. SFC uses this information to schedule work pieces on those resources, download the processing instruction and monitor progress of activities, which is exactly what we want to diseuss in this paper.

1 RELATED LITERATURE

The manufacturing enterprises operate more efficiently and better manage their resources when activities are clearly coordinated among the

*Corr. Author's Address: University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia, ztesic@uns.ac.rs

subsystems of the organization. If the information flows are unavailable for the decision-making processes, poor coordination develops. This results in lagging responses to changing conditions on the factory floor and lost productivity. One response to this need in organizations has been the implementation of computer technology in the form of information systems, databases, local and wide area networks, and middleware. In the information technology arena, this is known as enterprise integration (EI) [2].

Enterprise integration occurs when there is a need in improving interactions among people, systems, departments, services, and companies (in terms of material flows, information flows or control flows) [6]. From an organizational standpoint, EI is concerned with facilitating information, control and material flows across organization boundaries by connecting all the necessary functions and heterogeneous functional entities in order to improve communication, cooperation and coordination within the enterprise.

Enterprise integration is the coordination of all elements including business, processes, people and technology of the enterprise working together in order to achieve the optimal fulfillment of business mission of that enterprise as defined by the management [1], [6] and [8].

Manufacturing execution systems solutions provide real time information about what is happening on the shop floor, for managers and direct operation workers. It is an information bridge between planning system used in strategic production management (such as ERP) and manufacturing floor control supervisory control and data acquisition [7]. Core functions of MES include planning system interface, data collection, exception management, work orders, work stations and material movement. However, there is an increasing need to provide support defining and implementing an interoperability relationship between these manufacturing software and business applications. Major problems remain with respect to the interface between the business planning level and the manufacturing shop floor level, so that management and operation decisions within a closed loop are facilitated to pace the production according to the life-cycle dynamics of the products, processes and humans inside the enterprise [8]. Several modeling frameworks are currently being proposed to integrate production planning and control with process automation.

In this paper the part of the automated shop floor control system with possibilities of connecting to the control system on the machine level is presented. Also, possibilities and limitations in communication between existing automatic machine control systems as well as other devices into the integral information systems of manufacturing enterprise are described.

2 MANUFACTURING ACTIVITY INTERACTIONS

The development of planning, scheduling and control system involves several production management activities with a series of individual tasks that are to be completed in order to manufacture a product of a required quality [9]. For example, in metalworking industry we have these core functions: design, process planning, manufacturing planning, scheduling and control [10] (Fig. 1).

Design is the function that defines a product (geometry, material, shape, tolerance, etc) based on customer requirements. Process planning is the function that defines how the product will be machined. The basic task of this function is to define machining processes (e.g., turning, milling, welding), to select tools and machines for these processes and to estimate manufacturing costs. Production planning defines which product to produce, when produce them, how to produce, and how many of each with the goal how to meet delivery and keep costs low. Planning means generating of production tasks together with forecasting of prices and market demands for a long period. Scheduling is the function that defines due dates for products and machine capacity, it defines start and end dates for individual part as well as the order in which they flow through shop floor [11]. Some efficient, contemporary approach applay evolutionary optimisation techniques in scheduling (e.g., genetic algorithms [12], ant colony systems, etc).

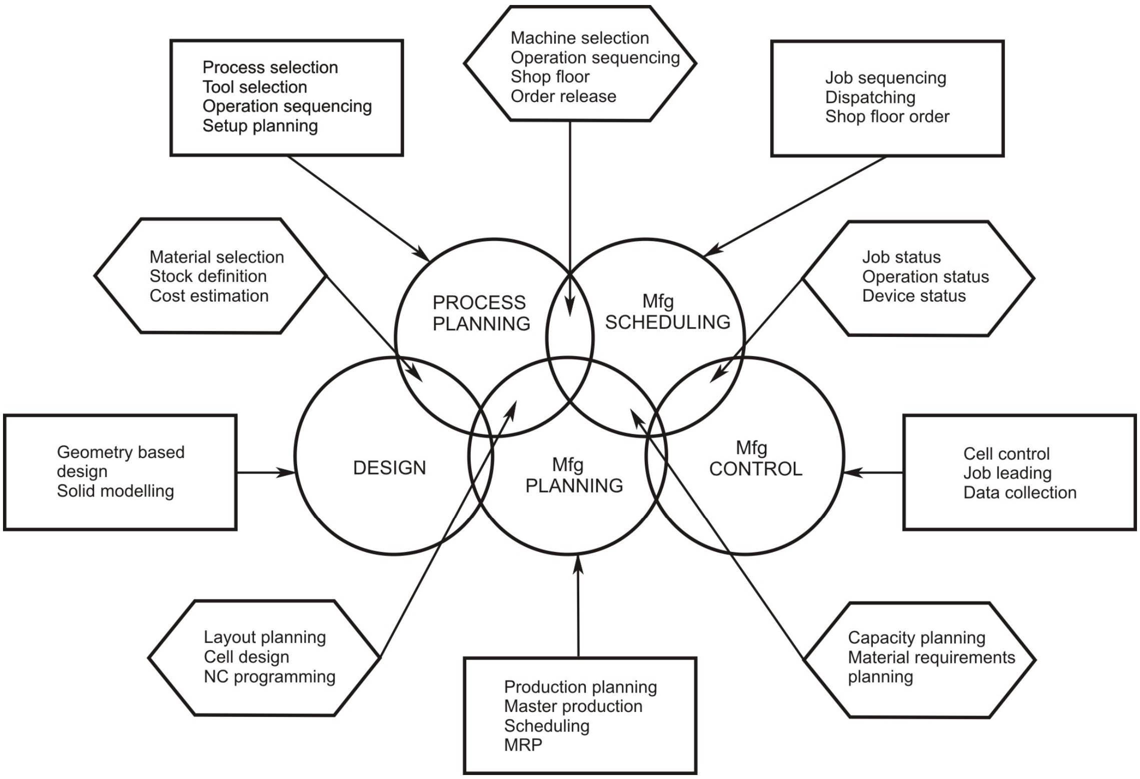

Fig. 1. *Manufacturing activities interactions*

The control function is responsible for detailed production operations on the factory floor, and also provides the machine controllers with the information concerning how to produce an individual parts by downloading controller programs to the machine as required. This function monitors real-time actual results, and data summaries are logged for storage in factory databases.

A model showing the interactions between various production activities. However, there are numerous tasks that require interaction between two or more activities. They are shown within overlapping circles of activities and represent integration links. For example, set up planning is part of process planning, but also needs information about scheduling for efficient setups.

Understanding of the interactions between activities is important in order to completely utilize engineering and management knowledge and expertise. Each of these activities needs specialists in its domain, while the intersecting areas need group work, and they are suitable for applying concurrent engineering principles.

3 CONCEPT OF THE AUTOMATION AND INTEGRATION

A possibility to connect computers within communication networks gives an additional impulse to the integration of planning, scheduling and control levels of the manufacturing system. With this linking and data exchange between different applications (e.g., direct processing of production data in software packages for business analyses) next advantages are foreseen [13]:

- managers can have a more direct access to shop floor operations,
- production planners can use the actual data in real-time,
- sales personnel can provide realistic estimation on delivery time for customer,
- customers who are interested in current state of their orders can be given real information about work completing level,
- quality control personnel are made aware of quality problems on current orders,
- cost accounting has access to the latest production costs,

- production managers have access to parts and products design documentation,
- cross functional communication and collaboration is enhanced.

Automated shop floor control system (MP-Integrator) include the following: dispatching and monitoring production - that is, controlling the release of work orders to the shop floor and tracking work-in-process inventory, and data collection from shop floor operation to provide a history of factory events.

Fig. 2 shows the structure and hierarchy of processes in planning, scheduling and control system and logical connections of a module for integration of operation procedures on technological systems (machine) and work orders (MP-Integrator) which is used to plan the realization of work operations.

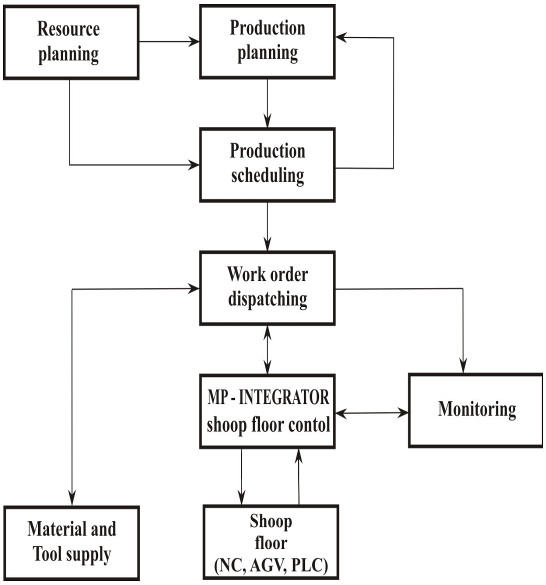

Fig. 2. *Planning, scheduling an control structure*

Analysis of the types and connectivity options of the control unit on technological systems, communication protocols, operating systems, programming languages and already made applications for production planning are inputs for design of the application module MP-integrator [14]. The application is designed to accept scheduled work order operations, checking the state of the technological systems, finds the corresponding NC program in the database and triggers its transfer to the control unit. Status of the technological system (work, defect, idle, queued operations, completed operations, the number of quality parts) in the defined time intervals read from the control unit of technological systems.

Application MP-integrator takes data about the status of technological systems and transmits them to the work orders, so they are available to all applications of an information system of the factory.

4 CASE STUDY

Based on the above concept the solution is developed in the factory that produces roller bearings (FKL), with one group of automated technological systems - lathes, type PF-120-2 with the HUNOR 721 control unit and two NC milling machines EMAG MSC12, with control units SINUMERIK-3T (Fig. 3). Server is a personal computer (COMPAQ) with data and where the data using software for database management (MS SQL Server 2000) ensures their integrity and consistency. Workstations are also personal computers connected to the server Ethernet 100 Mb/s network and TCP/IP protocol with the support of active components - switches. Application module MP-Integrator is installed on the PC and connected to Ethernet at the top level, and through the serial switch (RS-232) with the control unit of the technological systems (machines).

A special hardware device is made for connecting of machine tools called Two Way Serial Switch (TWSS) which scheme is given in Fig. 4. It is placed on PC located in the shop cell consisting of a group of NC machines. It is software controlled and can provide up to 12 serial outputs. With this device is possible to transfer one NC program on one machine tool in one particular period. Besides, acceptance and saving of manually corrected programs in G-code which are done by operators on machine tools, are also enabled.

Work order operation user interface is shown in Fig. 5. Acquisition of data from manual, assembly and other work places, which don't have their own control units is handled with the operational panel. In the case of already mentioned rolling bearing factory, the operation panel that has been used is the product of Festo Corporation, and it represents the series panels with Remote Access Panels. This panel type (Front End Display) offers a whole operator's interface which makes access much easier and also provides diagnostics during the operation of a machine besides which it is placed.

Project development is made with the Designer software package for Windows, which is installed on a PC. This software is designed to replace the programming in BASIC or C++ programming language.

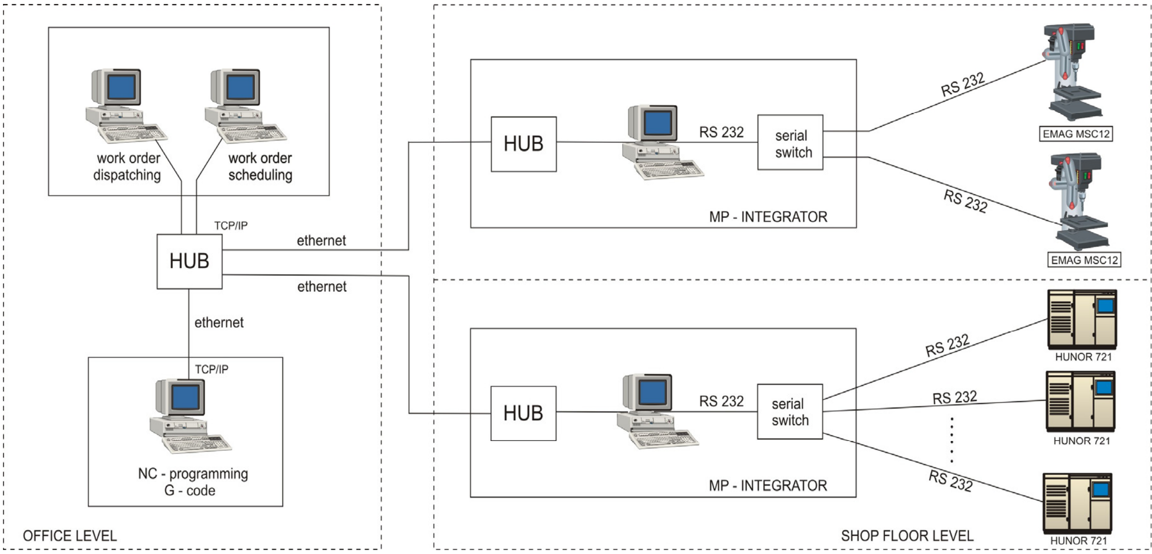

Fig. 3. *Structure of experimental network*

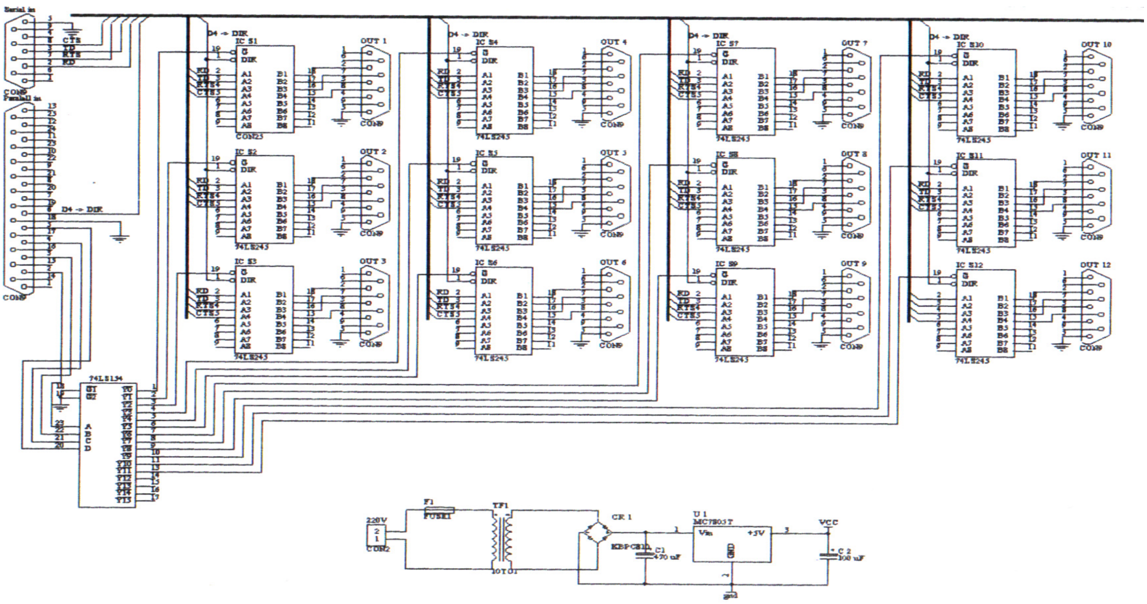

Fig. 4. *Configuration of the main board for TWSS*

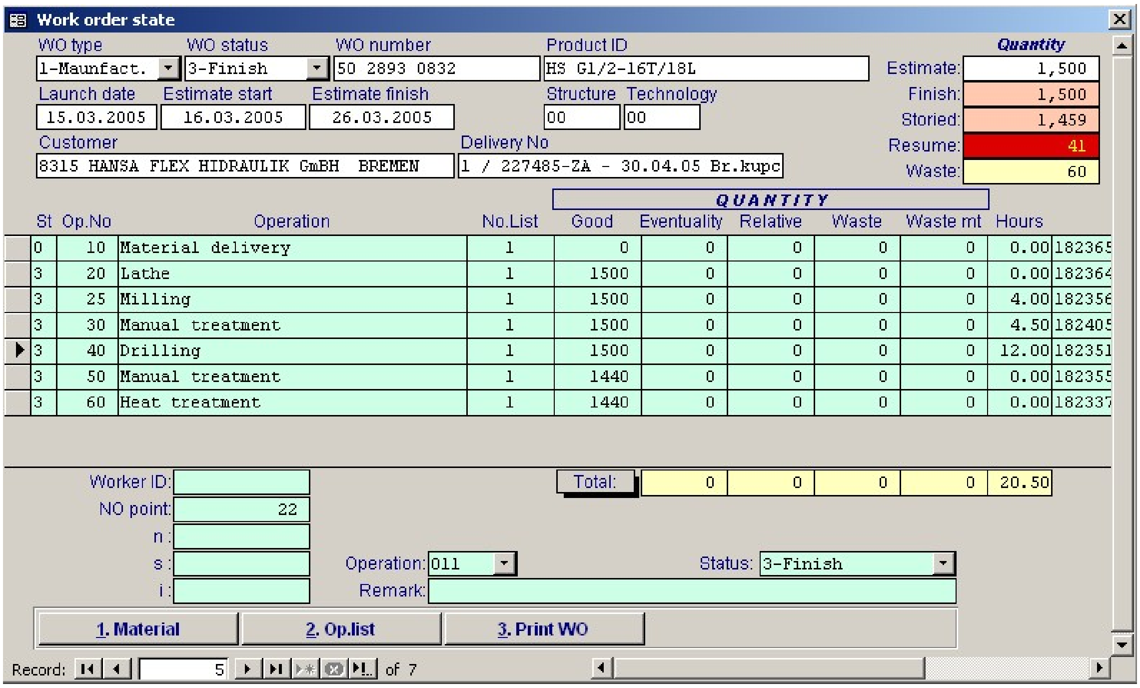

Fig. 5. *Work order user interface*

Model of communication between the planning and scheduling systems, with computer set SCADA system in the workplace and technological systems that communicate using the operation panel and programmable logic controller (PLC) is shown in Fig. 6.

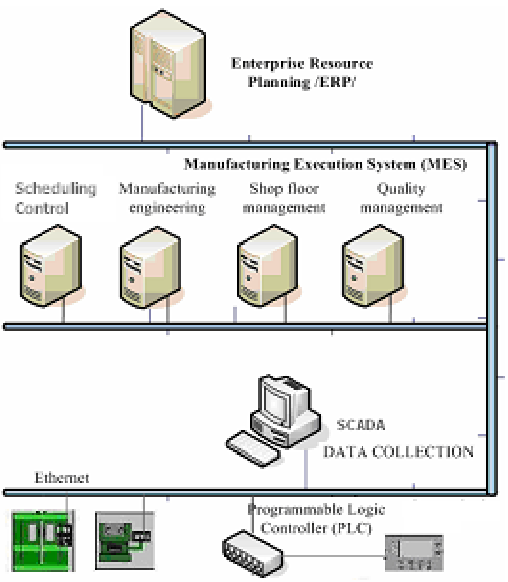

Fig. 6. *Structure of enterprise communication*

This model can be applied to the control of filling up of a work order list for the execution of any job on any operation regardless of whether it is an automatic device, mechanized or manual workplace. The problem of communication between different moduls of the system is solved by getting connected to the local industrial Ethernet. The system with PLC controller is compact, flexible, reliable and simple for monitoring and service. All advantages of networking are used such as greater speed of transferring data, simple expansion, the possibility for connection of various components, and independence of operations from the other components in the network. Expected benefits are: a greater degree of integration between the planning and control levels of the manufacturing system, reducing the possibility for losing data from work order, reducing the throughput time, and lowering the costs of production.

5 CONCLUSION

The subject of presented research is the development of models of integrated processes in the industrial company with a focus on controlling the processes of production. The development process requires analysis and research of different approaches in the field of the industrial system characteristics and process identification. The integral Information system that includes both business and part of production management is designed in modern programming environment.

The hardware device has been made to connect the existing, outdated management systems NC lathes, through the industrial network with a database of NC programs that allows the transfer of NC programs on the machine and return adjusted G-codes. Communication feedback from automated technological systems to control module via the operator panel and the network has been established.

The main contribution of the presented research is the integration of the highest with the lowest level of management, in the real industrial enterprises. Displaying solutions provides the necessary information for making quality decisions in the processes of planning, scheduling and control. Manufacturing is a very dynamic environment, and handling change and disturbances are high on its list of research challenges. To cope with these challenges, future manufacturing execution system designs must apply the most fundamental and recent insights in self-organizing systems [15], a topic that is being intensely investigated by the multiagent systems community today. Open research issues remain, however.

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