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Integration Methods and Processes of Product Design and Flexible Production for Direct Production within the iCIM 3000 System

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***Abstract*—**Currently is characterized production engineering together with the integration of industrial automation and robotics such very quick view of to manufacture the products. The production range is continuously changing, expanding and producers have to be flexible in this regard. It means that need to offer production possibilities, which can respond to the quick change. Engineering product development is focused on supporting CAD software, such systems are mainly used for product design. Those manufacturers are competitive; it should be kept procured machines made available capable of responding to output flexibility. In response to that problem is the development of flexible manufacturing systems, consisting of various automated systems. The integration of flexible manufacturing systems and subunits together with product design and of engineering is a possible solution for this issue. Integration is possible through the implementation of CIM systems. Such a solution and finding a hyphen between CAD and procurement system ICIM 3000 from Festo Co. is engaged in the research project and this contribution. This can be designed the products in CAD systems and watch the manufacturing process from order to shipping by the development of methods and processes of integration, This can be modeled in CAD systems products and watch the manufacturing process from order to shipping to develop methods and processes of integration, which will improve support for product design parameters by monitoring of the production process, by creating of programs for production using the CAD and therefore accelerates the a total of process from design to implementation.

***Keywords*—**CAD- Computer Aided Design, CAM- Computer Aided Manufacturing, CIM- Computer integrated manufacturing, iCIM 3000, integration, direct production from CAD.

I. Introduction

WITH the development of industrial automation, our industrial manufacturing facilities and environment have been fully changed. Decision-making automation and integration of all activities in a product life-cycle are the development direction of future manufacturing systems. Currently, computer-integrated manufacturing systems (CIMS) have been widely accepted by researchers and engineers in discrete manufacturing industries. However, very few papers begin to discuss how to implement the CIMS strategy for continuous manufacturing industries [1]. On the market competition of manufacturing industry the production is higher and higher, the upgrade rate of the products is faster and faster, the quality, cost, designing and making cycle of the products have already become key factors that decide the success or failure of competition of manufacturing companies. In recent years, with the fast development of technologies of the computer, network communication and Computer Integrated Manufacturing System (CIMS) is important tool for producers.

In the first time is important to define and specify the technicality CIM-Computer integrated manufacturing. Computer Integrated Manufacturing (CIM) is a management philosophy in which the functions of design and manufacturing are rationalized and coordinated using computer, communication, and information technologies" according to Bedworth et al. [2]. CIM has the capability to largely or entirely automate flexible manufacturing by coordinating work cells, robots, automatic storage and retrieval facilities and material handling systems [3]. There are very many definitions about the Computer integrated manufacturing systems. With this problematic deals also [4]; the author defines CIM - Computer Integrated Manufacturing - as a concept for the structuring of industrial enterprises. Manufacturing technologies demand a CIM concept which can be realized through the capabilities of information processing available today. The idea of integrating different areas of CIM, such as production planning and control (PPC), computer aided design (CAD) and computer aided manufacturing (CAM), is explained through operating chains and put into a CIM architecture based on a hierarchy of EDP systems. Simply, CIM is the use of computer systems to integrate a manufacturing enterprise.

II. Proposals Needed for the Implementation of Integration

On the one side there is existed a system that can process data via computer, and thus realizes the specifics which are necessary for monitoring the process. However, on the other hand, it is necessary to implement that production system that can be controlled by the CIM and should be prepared for the fact that the production system is installed with system CIM, because as the author mentions [5] that Computer Integrated Manufacturing (CIM) will be vital to the profitable production of future sub-micron memory, logic and analog IC products. Computer technology now makes it possible to monitor and control very complex IC production operations. Without this

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technology it will not be possible to achieve the cycle times and yields that justify the tremendous investment in new fabrication facilities. The system, which will integrate and manage via CIM system, is to be fully automated. It is necessary to create an automated manufacturing system that is an interconnected system of material processing stations capable of automatically processing a wide variety of part types simultaneously under computer control. The system is not only interconnected by a material transport system, but also by a communication network for integrating all aspects of manufacturing. Such a system exhibits flexibility in parts routing, part processing, part handling, and tool changing. Additionally an automated manufacturing system exhibits the following characteristics: high degree of automation, high degree of integration, and high degree of flexibility [6]. On the Fig. 1 is described an example of AMS (Automated manufacturing system) [7].

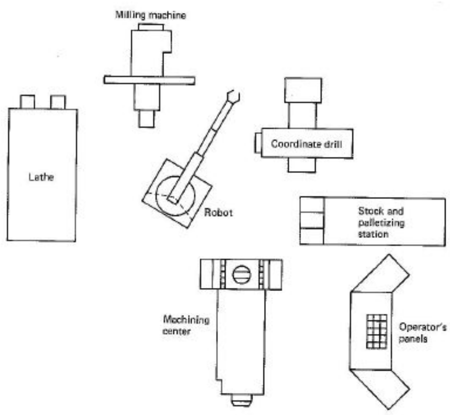


Fig. 1 An illustrative concept of automated manufacturing cell

One important thing is how can be increased to a different level automated manufacturing system. It is involved many technological areas in automated manufacturing systems: mechanical engineering, computing, communications, control, robotics, vision systems, Computer Aided Design (CAD), Computer Aided Manufacturing (CAM) and others. The article deals with the integration of CAD and CIM. Therefore, it is necessary to define, what CAD is and can do. CAD frameworks fall naturally into use in a CIM system because of their ability to integrate the work of design and production engineering teams. CAD framework forms the backbone for supporting design and planning activities in the facility level of a CIM implementation. The data management capability of the CAD framework serves in a limited way as a product data manager for the enterprise and it plays a major role in linking the facility level to the shop floor level. CAD application is the system used by engineers to design their product. As the use of computerized application became important tool in engineering field, the production field is also affected. This raises the issue of integrating CAD with manufacture systems. For that reason, most researchers try to create a system that can extract meaningful information from the CAD drawing and create a connection between CAD and manufacture system. For example in manufacturing field, manufacture system is a machine system where it is also known as CAM systems. However, there is no direct connection from CAD system to CAM system [8]. Thus it is very significant to product design, production and management of NC machine tools, it solves not only the problems of CAD modeling, NC programming and DNC communication, but also workshop's production monitoring and information exchange.

It can be defined the reference model of CIM from many views. Different approaches are possible. From the point of view of material flow and information flow is showed on Fig. 2 [7].

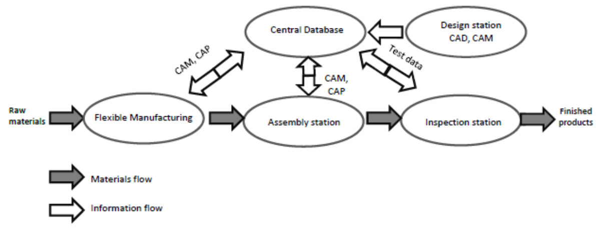


Fig. 2 Reference model of CIM from view of materials and information flow

We can define the reference model of Computer Integrated Manufacturing (CIM) from other view. On the Fig. 3 is showed the reference model CIM from point of view of the databases.

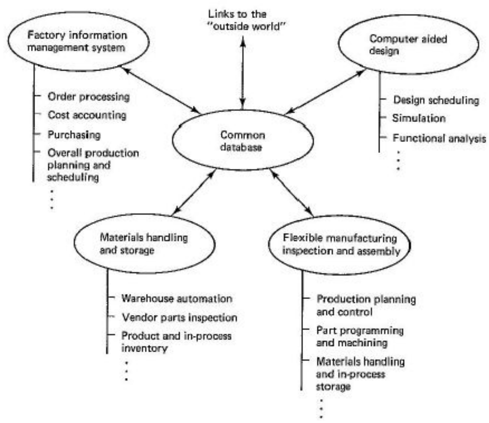


Fig. 3 Reference model of CIM from view of the databases

CAD systems have very important role in the manufacturing systems controlled by system CIM. CAD application system is used by engineers to design their products. As the use of computerized application became important tool in engineering field, the production field is also affected. This raises the issue of integrating CAD with manufacture systems. For that reason, most researchers try to create a system that can extract meaningful information from the CAD drawing and create a connection between CAD and manufacture system. For example in manufacturing field, manufacture system is a machine system where it is also known as CAM systems. However, there is no direct connection from CAD system to CAM system. Therefore, many approaches have been proposed by the previous researchers to solve the issues [8].

III. Systems and Methods for Integration on System ICIM 3000 from Festo

Integration between software CAD and flexible manufacturing system will be created on the system iCIM 3000 that is produced by Festo Didactic Company. Flexible manufacturing system is primarily intended for educational purposes but is ideal for scientific purposes.

A. Description of iCIM 3000 System

Automatic warehouse, assembly station, testing station and CNC machines are combined into a flexible production system using a pallet transport system [11]. Each station removes its designated pallet from the conveyor, processes the materials upon it and then replaces it on the conveyor. The cell computer coordinates control of the pallets to the workstations and their start in accordance with the planned process. Each individual station has its own controller and can therefore also be used on its own for training purposes. In accordance with the latest technological trends, networking of the system is performed using Ethernet to ensure open interfaces and extendibility. The flexible manufacturing system equipment of the iCIM consists of various stations and they are configured individually into single stations and into complete processing system in connection with other stations. Every single station is used in the "stand alone" mode, the respective programs for the single stations to be created by the user themselves. It is possible to create a lot of operations integrated for "stand alone" mode.

B. Single Stations Description within the System iCIM 3000

The system iCIM 3000 generally consists of two CNC processing centers: CONCEPT TURN 105 (position 1) and CONCEPT MILL 105 (position 2), both include flexible robot feeders that carry out CNC-related loading/unloading operations, on Fig. 4. The main operational and communication device that supplies all equipment and stations is transport system. The CNC feeding Turn is responsible for the production of single rotary parts. The robot Mitsubishi takes the raw parts from the magazines to equip the turning machine. There the work pieces are processed corresponding to their other. Before the work pieces are coming on the conveyor system, the processed work pieces made available on pallets. The CNC feeding Mill is responsible for the production of single cuboid parts. The principle of supply the milling machine by robot is the same as turn machine. Both machines are controlled via CNC control system Sinumerik from Siemens co. It is possible to generate NC code and translate to CNC control system.

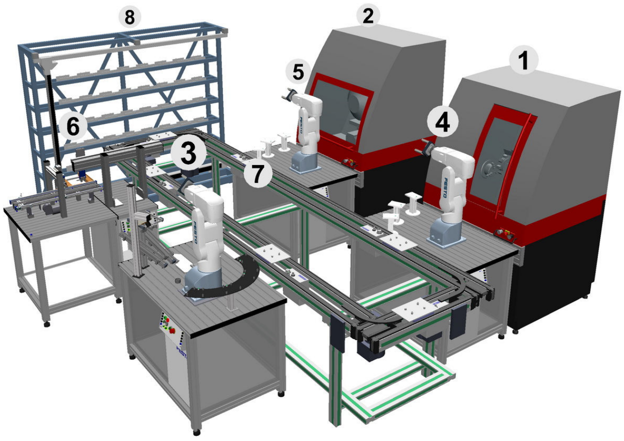


Fig. 4 3D layout configuration of the iCIM 3000

The transport system is responsible for the transport of the work pieces, which are placed upon special work piece carriers. Generally, the pallet conveyor transport system is the center of the iCIM system. The station is mounted at position 7 on Fig. 4. For this reason are used eight carries circle on the conveyor, ready to take over a pallet to bring it to the target, that is the station of iCIM. The carriers are coded by means of memory chips, which are read out at position as well as at all positions, where iCIM stations are placed. The codes of all carries in a system are different. When a carrier reaches a stop gate, the carrier's code is read out by the transport system controller Siemens S313C 2 DP and is send to the CIROS Production online system. The Stop Gate for the carriers have a pneumatic stopper cylinder, an inductive sensor for the pallet detection and an identification RFID chip with decoder of RFID to read out the carriers codes. These signals are transferred to the conveyor PLC by means of an industrial PROFIBUS.

Other important station that provides supply of the work pieces, semi product, final products and assembled products from system iCIM is AS/RS station; position Nr. 8 on Fig. 4. That means automatic storage/retrieval system station. This station has the function to provide and store the work pieces and various palettes. The storage system consists of two general equipments. Main storage is specific for all material supply used in iCIM production, raw and semi-finished parts as well as end products. All work pieces are stored on standard pallets, equipped with fixtures for each specific work piece. Forty of these standard pallets can be stored in 5 rows with each 8 shelves in the rack. Second important equipment as industrial type is Cartesian 3 axis servo robot transports pallets from the shelves to the carriers on the transport system and vice versa. The servo robot is controlled by a PLC Siemens S7-315 2PN/DP. This robot is also equipped by Flex Pendant for manual use of the robot.

Other station of flexible manufacturing system is named as Flexible Robot Assembly Cell (FAC), position Nr. 3 on Fig. 4. The robot assembly station has the function to assemble products from semi products created by CNC machines or other products stocked in AS/RS station. In dependence of the order, the robot assembles the desk set. Once the desk set has been assembled it is moved to the AS/RS station. The flexible assembly station offer deals with all aspects of robotized assembly and handling processes. The assembly cell, however, be restructured for handling other work pieces within the kinematic range of the industrial robot. The robot cells are ideal both for integrated application as part of a production system and for use as an individual station.

Last station from the system iCIM is the Quality Handling station that is responsible for the work pieces testing and the manual feeding of the system with pallets, position Nr. 6 on Fig. 4. The pallet handling is done by a linear handling and the testing is executed with an analogue positional transducer. On the Fig. 5 is showed an installed system iCIM 3000 in the Laboratory of flexible manufacturing system with the robotized operation for environment of drawing-free production.

Fig. 5 Real system iCIM 3000 installed in laboratory

On the Fig. 5 is showed an installed system iCIM 3000 in the Laboratory of flexible manufacturing system with the robotized operation for environment of drawing-free production.

C. Methods for Control of iCIM 3000 System

The system iCIM is designed as the system with single operated and controlled automatic stations that are controlled via master operating control system. So, all stations are separately programmed and controlled via separate autonomous PLC and the communication between all stations is performed by TCP/IP protocol over the Ethernet and PROFIBUS. All operations in the flexible manufacturing systems are provided by CIROS Studio. CIROS as Computer Integrated Robot Simulation is the universal 3D simulation system, suitable for various application ranges, adaptable in composition, efficient and convenient for everyday work. CIROS Studio enables to create a detailed planning of industrial manufacturing work cells, to test the reachability of critical positions, the development of robot and PLC programs and the optimization of the cell layout. All movements and handling processes can be simulated to check collision problems and to optimize cycle times. The Modeling Extensions for CIROS support the composition of robot based work cells. Efficient modeling is provided by using component libraries containing machinery, robots, tools, conveyor belts, part feeders, etc. Free 3D modeling and import from CAD systems are also possible via the standard data format STEP [9]. That is very important for the transferring and also for integration between CAD system and system CIROS that is the control system for our CIM.

For the control of iCIM are available 2 programs to work with CIROS production; production simulation to work without a real system and production supervision to work with a real system. It is necessary to create a plant in CIROS production simulation to work with CIROS production supervision with that is possible to work with system online. On the Fig. 6 is showed offline CIROS production simulation for iCIM 3000 that is installed in the Laboratory.

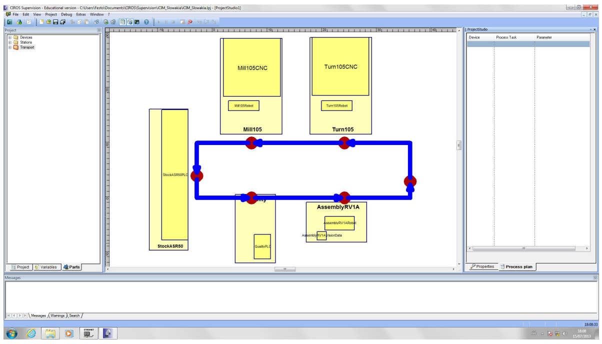


Fig. 6 Offline system iCIM 3000 in the CIROS production simulation

In this simulation we have to create a system with all stations, so a new production simulation program. All stations have to be inserting in this simulation with all operating programs. It is possible to modeling all stations with connections [10].

In the CIROS production supervision is possible to control all stations and CIM in generally. The first step for supervision is created production simulation, after that we can provide the supervision via import the simulation and generation the system. In CIROS production supervision it is possible to assign the drivers to the respective components, create new process plans, create handshake for process plans, working and use from macros, working and operating with real plants, use from task tool. After the generating the project and the plant is possible to adjust the connection between all stations, if they are online. On the Fig. 7 is showed opened visualization window. If the production works, the visualization window is available and the different modules with their functions appear in the visualization window.

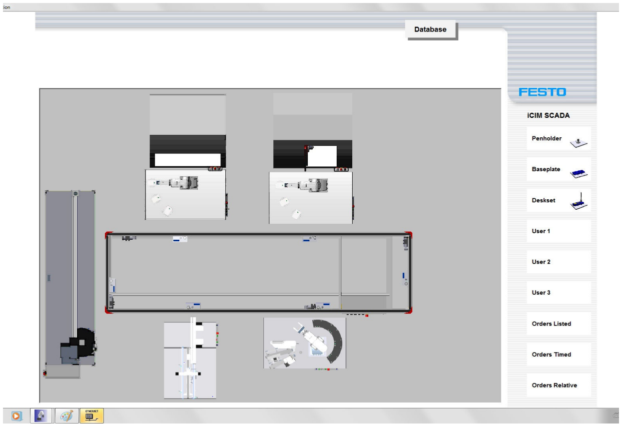
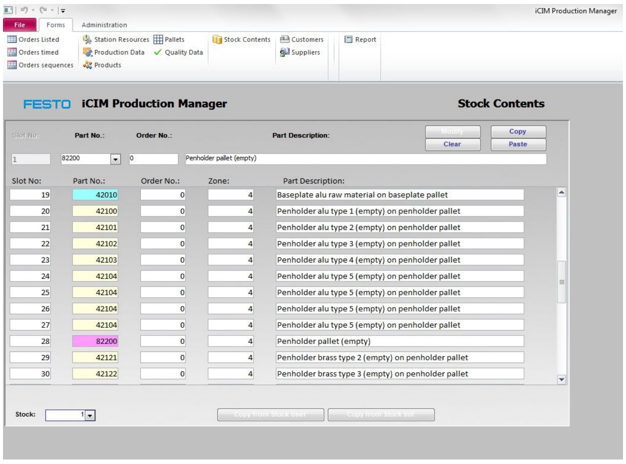


Fig. 7 System iCIM 3000 in the CIROS production visualization

D.Production in iCIM 3000 System

The system iCIM is designed as the system with stations and the control system CIROS. All tasks are provided from online SCADA system CIROS. The product specified resources of the system are intended for the manufacture and assembly of the product family. A family of desksets is the ideal product to show everything in a factory and that is why the iCIM 3000 system comes with is pre-programmed. The part list contains purchased parts as well as parts to be produced in the factory. The most important production steps like CNC processing, quality control, automated robotized assembly, buffering, storing and delivery can be shown for these parts. Many different variations of the product can be manufactured by variation of the materials and assembly positions. The product can be produced in different variations depending on the customer demand or order. On the Fig. 8 is showed the database in the stock contents, many variations of the products.



Slot No:	Part No.:	Order No.:	Zone:	Part Description:
19	42010	0	4	Baseplate alu raw material on baseplate pallet
20	42100	0	4	Penholder alu type 1 (empty) on penholder pallet
21	42101	0	4	Penholder alu type 2 (empty) on penholder pallet
22	42102	0	4	Penholder alu type 3 (empty) on penholder pallet
23	42103	0	4	Penholder alu type 4 (empty) on penholder pallet
24	42104	0	4	Penholder alu type 5 (empty) on penholder pallet
25	42104	0	4	Penholder alu type 5 (empty) on penholder pallet
26	42104	0	4	Penholder alu type 5 (empty) on penholder pallet
27	42104	0	4	Penholder alu type 5 (empty) on penholder pallet
28	82200	0	4	Penholder pallet (empty)
29	42121	0	4	Penholder brass type 2 (empty) on penholder pallet
30	42122	0	4	Penholder brass type 3 (empty) on penholder pallet

Fig. 8 Stock contents in system iCIM 3000 in the CIROS

Material and shape of the base plate and penholder can be changed to form a customized product and the position of the hygrometer and thermometer can be selected. The variations of production and assembly are several hundred and more to make experiments related to logistic, flexible assembly and manufacturing. On the Fig. 9 is showed deskset to be initially produced.

Fig. 9 Example of product family

The order is realized in CIROS production visualization. On demand of customer is produced deskset from database. The request is send to transport system and also all stations. The command is also send to AS/RS station to restore the part out of the specific shelf. All parts have to be stocked in the stock. The tasks are performed on the ground of the operations database. The product in database has all operations saved. So, after order is the pallet loaded with work pieces on the carrier in transport system. So after that can be perform the operation on CNC machines, assembly station or quality station.

IV. A Few Customization Issues for Integration between CAD and iCIM for Direct Production

As it has been described before, the system iCIM 3000 offers the chance of diversity in terms of the range of items to produce. It is possible to create direct production from CAD on the system iCIM. It has to be explained some methods and conclusions for integration between CAD system and flexible production system. It was used the CAD/CAM system Catia from Dassault Systems for the simulation. For testing is designed a product penholder that is designed in Catia, is showed on Fig. 10.

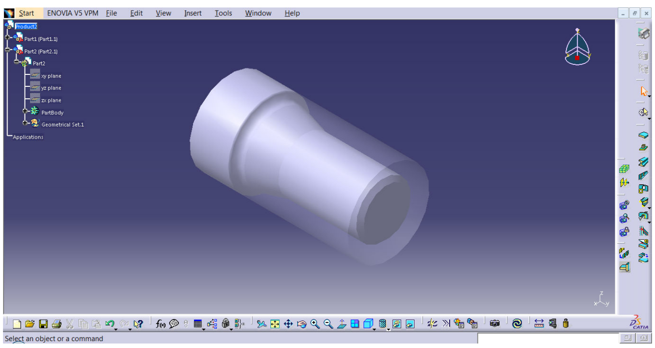


Fig. 10 The design of Penholder with raw and product in Catia

It was generated the model in Catia and transfer to STEP. On the Fig. 10 is showed the raw of material for production – semi product and also final product. Thus it is very significant to product design, production and management of NC machine tools, it solves not only the problems of CAD modeling, NC programming and DNC communication, but also workshop's production monitoring and information exchange. The CAD software EMCO is generated the NC program for production on EMCO CNC Turn controlled via Sinumerik. So we need post processor for generation the NC code for production. It can not only edit NC programs for the NC equipment, but also modify the programs which are in the DNC server or from CAM workstation. It is not possible to produce the Penholder on the system iCIM. It is possible only the production on single station. Now it has to be generated a new product in the stock contents database. The product has to be included order number, the position in the stock, the operation mode on which station can be produced, the program for production. It has to be generated the new program for production in CIROS simulation in the second step. On the Fig. 11 is showed the product after CAD design and new product creation in the CIROS iCIM system.

Fig. 11 Final product of Penholder in system iCIM 3000

V. CONCLUSION

The flexible manufacturing system as a project is located directly in the new laboratory at our Institute. The laboratory is created directly for the research of possibility of integration between CAD system Catia and iCIM 3000. In this paper are described some methods how is possible to reach direct production from CAD. Next research will be focused to design other types of product and develop directly connection between software Catia, generation of product and NC code and insertion of new product in CIROS iCIM database.

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