DESIGN OPTIMIZATION AND ANALYSIS ON FLEXIBLE MANUFACTURING SYSTEM

MOHD KHAIRUL FADZLY BIN ABU BAKAR

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Universiti Tun Hussein Onn Malaysia

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ABSTRAK

Sistem pembuatan fleksibel (FMS) adalah ditakrifkan sebagai kumpulan yang sangat automatik teknologi sel mesin, yang terdiri daripada sekumpulan stesen pemprosesan saling oleh pengendalian bahan automatik dan sistem penyimpanan, dan dikawal oleh sistem komputer bersepadu. FMS boleh menghasilkan bahagian atau produk pada pertengahan kelantangan, pertengahan pelbagai pelbagai pengeluaran. Sistem susun atur di FMS adalah satu kriteria penting untuk mereka bentuk sistem FMS untuk menghasilkan bahagian atau produk. Ini susun atur kemudahan daripada FMS melibatkan kedudukan sel-sel dalam sempadan yang diberikan, untuk mengurangkan masa perjalanan keseluruhan diunjurkan antara sel-sel. Penentuan susun atur termasuklah penetapan koordinat spatial setiap sel, orientasi sama ada secara melintang atau menegak, dan lokasi muatannya atau titik dipunggah. Terdapat banyak jenis susun atur FMS seperti In-line, tangga gelung dan robot susun atur sel berpusat. Kajian ini memberi tumpuan kepada reka bentuk dan pengoptimuman FMS susun atur. Kesimpulan akhir boleh dirumuskan bahawa objektif untuk mereka bentuk dan mengoptimumkan susun atur FMS untuk kajian ini adalah berjaya kerana FMS susun atur dalam talian adalah susun atur yang terbaik berdasarkan masa yang berkesan dan kos menggunakan perisian simulasi ARENA.

ABSTRACT

Flexible manufacturing system (FMS) was defined as highly automated group technology machine cell, consisting of a group of processing stations interconnected by an automated material handling and storage system, and controlled by an integrated computer system. FMS can produce parts or products are in the mid-volume, mid-variety production range. The layout system in FMS is an importance criterion to design the FMS system to produce a part or product. This facility layout of a FMS involves the positioning of cells within given boundaries, so as to minimize the total projected travel time between cells. Defining the layout includes specifying the spatial coordinates of each cell, its orientation in either a horizontal or vertical position, and the location of its load or unloads point. There are many type of FMS layout such as In-line, loop ladder and robot centered cell layout. The research is concentrate on design and optimization FMS layout. The final conclusion can be summarized that the objective to design and optimize of FMS layout for this study is successful because FMS In-line layout is the best layout based on effective time and cost using ARENA simulation software.

CHAPTER 1

INTRODUCTION

A flexible manufacturing system (FMS) is an arrangement of machines interconnected by a transport system. The transporter carries work to the machines on pallets or other interface units so that work-machine registration is accurate, rapid and automatic. A central computer controls both machines and transport system. FMS technology can be apply when the plant presently either produces parts in batches or uses manned group technology cells and management wants to automate the cells. It must be possible to group a portion of the parts made in the plant into part families and the part similarities allow them to be processed on the FMS workstations. FMS can produce parts or products are in the mid-volume, mid-variety production range.

For this project FMS for educational propose is to be study. Flexible Manufacturing System (FMS) typically possesses multiple automated stations and is capable of variable routings among stations. Human resource development, equipment operator skills, manufacture of processing tools, products, processes & machinery, research and development are some of the issues resulting from higher level of technology implementation. Industry needs universities to respond with increase emphasis on design and manufacturing skills. With FMS teaching and training in the university laboratories, the increasing capability of engineers provides a distinct advantage for future industries.

The FMS is technologically more sophisticated for the industries and the human resources who must make it work. Flexible Manufacturing Systems (FMS), as they were called, became a great focus of attention in industry and in academic research for a number of years. The advantages of a well-run FMS were clear; short lead-times, low inventory and a step towards the factory of the future.

Human resource development, equipment operator skills, manufacture of processing tools, products, processes & machinery, research and development are some of the issues resulting from higher level of technology implementation. In this situation, a contingency strategy for training engineers and other specialists with FMS should be considered in university learning with engineering education. These evolving trends in industry must be applied back into the engineering curriculum. Industry needs universities to respond with increase emphasis on design and manufacturing skills.

The Educational Flexible manufacturing system (FMS) is a actual-size of automatic manufacturing system, which consist of a actual-size automatic storage and retrieval system, a actual-size product line, robotic arm and some CNC machines such as CNC milling machine and CNC lathe machine. The FMS is an open architecture platform, suitable for teaching and training in the fields of automatic control, CNC, manufacturing and mechatronics, robot system, material handling technology, sensors and many more. The FMS is based on Industrial grade components, design according to real industrial production and using most common parts in industrial facilities. Manufacturing management needs to be equipped with new and effective tools due to the rapidly changing and highly competitive nature of today's global markets. New generation hardware and software, tailored into specific applications are being developed each and everyday, however a success in reducing costs, increasing efficiency and improving quality is not easy until an application based integration of these components is attained. As mentioned by (Yücel, 2004) "Modern Flexible Manufacturing System (FMS) with a concrete system model design and the use of information technologies answers these requirements".

1.1 Problem statement

The design and use of flexible manufacturing systems layouts involve some intricate operations research problems. FMS design problems include, for example, determining the appropriate number of machine tools of each type, the capacity of the material handling system, and the size of buffers. FMS planning problems include the determination of which parts should be simultaneously machined, the optimal partition of machine tools into groups, allocations of pallets and fixtures to part types, and the assignment of operations and associated cutting tools among the limited-capacity tool magazines of the machine tools. FMS scheduling problems include determining the optimal input sequence of parts and an optimal sequence at each machine tool given the current part mix. FMS control problems are those concerned is monitoring the system to be sure that requirements for storage and retrival system for FMS.

1.2 Project introduction

The studies are concentrating on design layout of FMS and focus on monitoring and control system for educational flexible manufacturing system (FMS). There are many type of FMS layout such as In-line, loop ladder, open field and robot centered cell layout. The research is based on design and optimization FMS layout. Every layouts will be analyze using modeling software (Arena Simulation Software) to determine the most practical layout for the FMS.

1.3 Project objective

- Optimization of Flexible Manufacturing System (FMS) layouts for educational purpose.
- To simulate several FMS layouts using modeling software
- To propose the most practical layout to be used.

1.4 Project scope

- Study about Flexible Manufacturing System for educational purpose and focused on FMS's layout.
- Simulate the FMS layout using modeling software.
- To analyze the FMS based on layout using modeling software and determine the efficiency.

1.5 Significiance of the research

It is importance to study about Flexible Manufacturing System Layout using modeling software to determine the practical layout to be use as a real system. Through modeling software the setup cost for the real system can be reduced because the most practical layout can be simply setup without wasting the time. From this researce is shown that FMS In-Line layout is the best layout and practically be used for FMS educational proposes at Universiti Malaysia Perlis

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Flexible manufacturing systems (FMSs), being somewhat similar and yet different from conventional manufacturing systems, provide new and different problems and FMS have promised many benefits but there is evidence that the implementation of FMS is often fraught with difficulty. One result is that the implementation rate of FMS is much lower than has been expected. The aim of this research is to review the approaches that can be used to design an FMS and monitoring system. A review is given of the work done to date on the design of FMS in the areas of facilities design, material handling system design, control system design, and scheduling. Through examining the tools and approaches that are used to design these four phases it is apparent that no integrated design methodology exists for FMS. The tools available are not specifically tailored for FMS and their unique integrated form. Because of the lack of integration, an FMS must be designed by examining the four phases independently even though the design decisions from each area affect the efficiency of the other areas.

The design process for FMS can be broken down into the following phases such as facilities design - including the choice of machines and the layout of the FMS, material handling system design, which includes the choice of the material handling equipment and control system design - including the choice of the control scheme and methodologies to be used.

2.2 Simulation

As defined by Robert E. Shannon (1975) "The process of designing a model of a real or imaginary system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system." The first sentence of the definition mentions the types of systems that simulation studies can be conducted on. The systems can be "real" or "imaginary", which means that there can exist a physical facility or a process to be modeled, or the model can be a modification of the existing system or it can be totally imaginary. The imaginary systems refer to the ones that are planned as alternatives to existing systems and entirely original systems.

2.1.1 Simulation process

As Shannon states simulation is a continuous "process" rather than a one time create-and-use application. Especially computer simulation is an iterative method that includes several stages as Kelton et al (2004) identifies. A simulation study starts with efforts on understanding the system in addition with the identification of the goals of the study. The next step is creating the formulation of the model representation usually in terms of mathematical models or flowcharts. Subsequently, the created formulation needs to be transferred into modeling software using programming languages or with specific software tailored into the needs of a simulation study. Once a program is created, it is necessary to verify the program, in the sense that right things occur with expected inputs. The following stage is to validate the program with someone familiar to the represented system so that the program works in accordance with the conceptual model faithfully, supporting the validation work with statistical tests can be of critical importance at this stage. Experimentation on the developed model is the following phase, which includes designing experiments to identify the critical performance measures to be used with adequate confidence and running these designed experiments by using the computers effectively. The last stages take account of analyzing the results, getting insight of the results to evaluate the outcomes of the results and to assess the potential benefits. Finally, documentation is necessary for the inheritance of the work done for other simulation staff and also to clearly transfer the findings and recommendations to related management levels with precision and confidence.

The life cycle of a simulation study has also been identified in detail by Balci (1990). This life cycle has been divided into 10 processes, 10 phases and 13 credibility assessment stages. Figure 9 provides the details of those identifications and the precedence and succession relations between them. All those stages mentioned seem troublesome and time consuming, however success in simulation is difficult to attain without following these steps. It is necessary to identify what success is at this stage. According to (Sadowski 1999) a successful simulation project is the one that delivers useful information at the appropriate time to support a meaningful decision, which implies that there are three key elements of success in simulation; decision, timing and information.

2.1.2 Simulation benefits

Simulation has many benefits for the users as outlined by J. Banks (2000). First of all, it lets users choose correctly among the possible alternatives, provides time compression and expansion according to the type of the simulated event, equips the managers with the tools to understand "why?" certain phenomena occur in a real system, allows the user to explore possibilities of new policies, operating procedures or methods. With simulation, one can diagnose problems of complex systems that are almost impossible to deal within the real environment, identify constraints that act as a bottleneck for operations, visualize the plan using the animation capabilities of the software used that results in a more presentable design. Simulation is also beneficial to build consensus among the members of the decision makers and to prepare for changes by considering the possible "what if" scenarios. Virtual Reality (VR) support creates training environments for production team, it can also be used to specify requirements for capabilities of equipment and carry out wise investments using all those properties.

2.1.3 Disadvantages of Simulation

There are things one should consider carefully on carrying out simulation studies. It is a probability that simulation may not be the perfect tool for all types of system analysis. Banks (2000) underlines four main disadvantages of simulation. The first disadvantage is that model building requires special training and it is highly unlikely that models generated by different modelers about the same system will be the same. The second disadvantage is about the simulation results' being difficult to interpret. As most simulation outputs are essentially random variables based on random inputs, it may be hard to determine whether an observation is a result of system interrelationships or randomness. The third disadvantage is that simulation modeling and analysis can be time consuming and expensive especially when enough resource is not allocated for modeling and analysis, resulting in a simulation model and/or analysis that are not sufficient to the task. A final disadvantage is that simulation may be used inappropriately, especially in some cases when an analytical solution is possible or even preferable.

2.1.4 Future of Simulation

The future of simulation is believed to be different from the past. According to J. Carson and D. Brunner (2000) there will be an increase in simulation becoming embedded in other larger software applications and simulation will be more widely used for real-time decision making rather than the traditional off-line methods. The general literature suggests that the interoperability of simulation software with other software is crucial. The data formats of the simulation software used to model and predict the behavior of manufacturing systems and the applications about design, manufacturing engineering, and production management need to be the same. Neutral interface specifications that would permit quick and easy integration of commercial off-the-shelf software should be developed.

One other important prediction about the future of the simulation is about the development of new simulation interface standards that would help the deployment of simulation technology. Currently, the simulation model development process is labor intensive, perhaps more of an art than science, an approach that leaves considerable work and creative responsibility to the simulation analyst.

One of the promising ideas for expanding simulation to a broader set of users is the concept of having pre-built models or model components that can be plugged together to form a model of the system to be modeled. The idea is to select the components from a library and use them directly. The goal is to build each model component once, verify its operation, and the make it available in a library to be used in many different applications.

2.1.5 Application Areas

Simulation has found a great deal of application areas both in the academic and industrial fields of work. The field of application of simulation includes but is not limited to manufacturing facilities, bank or similar other personal-service operations, transportation, logistics and distribution operation, hospital facilities, computer network, freeway system, business process, criminal justice system, chemical plants, fast-food restaurants, supermarkets, theme parks, emergency response systems, etc. The following sections give examples from the literature about several applications of simulation. The topic is studied under two main headings, dividing the applications as manufacturing and production and others. Although this study is in the field of manufacturing and production, other applications in different fields provide insight for different aspects of simulation.

2.1.5.1 Production and Manufacturing

One of the largest application areas for simulation modeling is that of manufacturing systems, with the first uses dating back to at least the early 1960's. Since then, it has been used effectively in the design and analysis of manufacturing systems. Law

(1999) has identified specific issues that simulation is used to address in manufacturing as follows:

The need for and the quantity of equipment and personnel

- Number, type, and layout of machines for a particular objective
- Requirements for transporters, conveyors, and other support equipment (e.g., pallets and fixtures)
- Location and size of inventory buffers
- Evaluation of a change in product volume or mix
- Evaluation of the effect of a new piece of equipment on an existing manufacturing system
- Evaluation of capital investments
- Labor-requirements planning
- Number of shifts

Performance evaluation

- Throughput analysis
- Time-in-system analysis
- Bottleneck analysis

Evaluation of operational procedures

- Production scheduling
- Inventory policies
- Control strategies [e.g., for an automated guided vehicle system (AGVS)]
- Reliability analysis (e.g., effect of preventive maintenance)
- Quality-control policies

As seen from the above discussion, manufacturing and production offers a huge number of issues to deal with. Some of the recent applications of simulation and modeling in this area are given below. It should be noted that there are thousands of studies in this field, but the following are important as they mostly make examples of using ARENA® in simulation.

The work of Williams (2002) is important as it presents the usefulness of simulation in studying the impacts of system failures and delays on the output and cycle time of finished parts. Also, the similarity of the robotic work cell used as the modeling medium to our environment is worth mentioning. The case study illustrates a modeling approach with system verification and validation revealing fundamental system design flaws.

Patel et al (2002) have used discrete event simulation for analyzing the issues of first time success rate, repair and service routing logic, process layout, operator staffing, capacity of testing equipment and random equipment breakdown in automobile manufacturing processes. They offer concepts and methods for discrete manufacturing processes especially for the Final Process System for optimizing resources and identifying constraints.

The studies in literature include the auxiliary programs for simulation, as well. Rogers (2002) has used OptQuest for ARENA® for applying optimum-seeking simulation tools to manufacturing system design and control problems. The author describes the software as a tool that can be broadly applied to find optimal values of controllable parameters for systems being analyzed via simulation.

Altinkilic (2004) has presented a use of simulation to improve shop floor performance. The performance of the existing system is evaluated by using ARENA®. Due to the motivation for redesigning the shop flow, manufacturing cells are performed and the performance of the new system is evaluated and compared with that of the current system. As a result, based on a simulation analysis, several recommendations are made to the management of the mentioned job shop production system.

2.1.5.2 Other Areas

The example studies given below provide a reflection of the usage areas of simulation apart from manufacturing and production, and of typical results those can be attained. It is known for sure that both the number and range of the point at issue is almost unlimited, but these studies are important to provide a basic understanding of simulation applications.

Chen (2002) has used simulation to come up with an application to provide a critical decision support tool in a chemical plant for logistics activities. Using the simulation model, the authors have determined capital equipment requirements and assessed alternative strategies for logistics operations, such as the number and size of storage silos for the chemical plant. Although the authors do not propose a new concept, the object oriented approach they have used and their discrete event model to simulate continuous production flow is worth mentioning.

One of the mentioned application areas was policy. Simulation has been widely used to help public policy makers evaluate decisions on subjects such as traffic, emergency planning and health management. An application of simulation involves the discussion of traffic management for İstanbul district and advises on the future of the city taking marine traffic into consideration (Köse 2003). Land traffic and air traffic has also been subject to individual symposiums and editorials in several journals.

In their studies Hill (2001) and Standridge (1999) have studied the applications of simulation in the fields of military problems and health care applications, respectively. Both studies address wide ranging issues in their respective areas with sample applications to come up with invaluable comments and results about simulation studies in general. Graves and Higgins (2002) has combined logistics and military requirements in a single simulation study. With the applications described in the study, the potential impact that simulation can have on army logistical systems have been illustrated in the fields of supply, transportation and maintenance.

The work of Nsakanda and Turcotte (2004) illustrates the use of simulation for evaluating and analyzing air cargo operations at one of the new state-of-the-art cargo facilities at Toronto Pearson Airport. A brief description of the airline's cargo operations has been described as well as the simulation modeling approach. They have showed that the simulation-based tool they have proposed could be effectively used in its current level of development to quantitatively evaluate and compare different policies, business practices and procedures within a given set of operational and business constraints.

2.2 ARENA®

The ARENA® modeling system from Systems Modeling Corporation is a flexible and powerful tool that allows analysts to create animated simulation models that accurately represent virtually any system. First released in 1993, ARENA® employs an object-oriented design for entirely graphical model development. Simulation analysts place graphical objects, called modules, on a layout in order to define system components such as machines, operators, and material handling devices. ARENA® is built on the SIMAN simulation language. After creating a simulation model graphically, ARENA® automatically generates the underlying SIMAN model used to perform simulation runs (Takus, 1997). This brief description provided by a senior software developer of the program owning company, emphasizes the graphical interface, and ease of programming that arises as a result. The ARENA® product suite is designed for use throughout an enterprise, from strategic business decisions, such as locating capacity in a supply chain planning initiative, down to operational planning improvements, such as establishing production line operating rates (Bapat, 2000). To achieve enterprise wide top-down scalability and ease of use by all levels of an enterprise, ARENA® has many unique properties, which are described in brief below. ARENA® has a natural and consistent modeling methodology due to its flowchart style model building regardless of detail or complexity. Even the flowcharts of systems created by Microsoft Visio® can be imported and used directly. It is extendable and customizable, which results in a re-creatable, reusable and distributable templates tailored to specific applications. The scalable architecture of ARENA® provides a modeling medium that is easy enough to suit the needs of the beginner, and powerful enough to satisfy the demands of the most advanced users. This makes it a perfect tool for continuously improving modeling studies as the modeler's capability and experience increase as the study progresses. One other advantage of ARENA® is that it is open to interaction with many applications such as Microsoft Access and Excel with its built-in spreadsheet data interface. Furthermore, with Visual Basic for Applications (VBA®) support there is virtually no limit on creating interfaces and programs. With those mentioned advantages ARENA® has become the academic standard, which is thought in most Industrial Engineering schools worldwide, which also encouraged the Integrated Manufacturing Technologies Research Group to obtain an academic license of the program.

2.3 Overview of Flexible Manufacturing System at Automation and Robotic laboratory Universiti Malaysia Perlis

Definition according to the Computer and Automated Systems Association of the Society of Manufacturing Engineers: "CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency." Accordingly the CAD/CAM technology, related to the use of computer systems for design and production, was developed. CAD (computeraided design) was created to assist in the creation, modification, analysis, and optimization of design. CAM (computer-aided manufacturing) was designed to help with the planning, control, and management of production operations. CAD/CAM technology, since the 1970s, has been applied in many industries, including machined components, electronics products, equipment design and fabrication for chemical processing. Total CIM systems can handle order entry, cost accounting, customer billing and employee time records and payroll. The scope of CIM technology includes all activities that are concerned with production. Therefore in many ways CIM represents the highest level of automation in manufacturing. UNIMAP CIM system consists of an computer integrated manufacturing system with the following major components such as an automatic material handling system as material transportation and tracking module, one unit of ABB Robot which handle the material storage and retrieval system, a unit of ABB Robot which handle the manufacturing module (integration with CNC milling and CNC lathe machine), a unit of MTS CNC lathe machine, a unit of MTS CNC milling machine A system integrated controller using Mitsubishi PLC, citect SCADA system as system User Interface and Integrated Web Based Ordering System. **Figure 1** shown Layout of FMS at Automation and Robotics Laboratory UNIMAP.

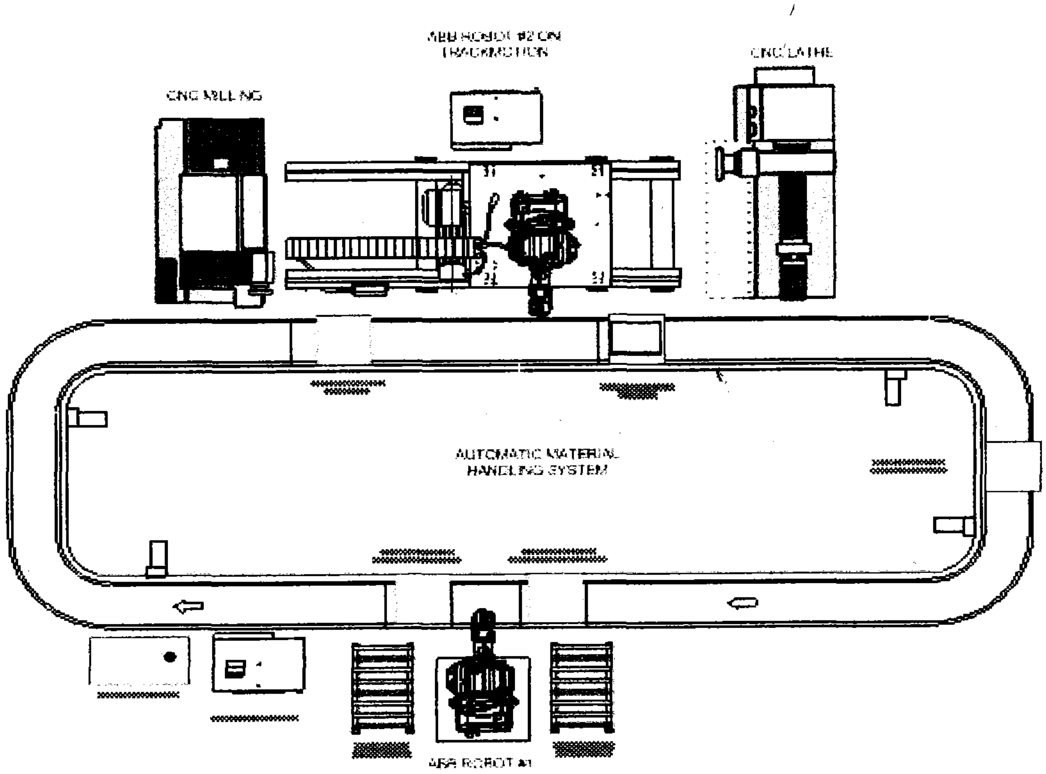


Figure 1 : Layout of FMS at Automation and Robotics Laboratory UNIMAP

2.3.1 Automatic Material Handling System

The Automatic Material Handling System consist of a closed loop roller type conveyor with dimension of 6000mm x 2000m track width 220 mm for use of 200 mm with pallet. The conveyor is divided into four section, namely two straight parallel stretch and two 180 curve section. Each section of the conveyor is driven section by an inverter motor, therefore protected against overload. In addition, the motor speed can be varies. Roller type conveyors enable the use of pallet position unit as the rollers are mounted on side of the conveyors, leaving the center space available for the pallet id detection. The conveyor comes complete with control panel, emergency button, pneumatic tubing and accessories. **Figure 2** shown four section of automatic material handling system for FMS.

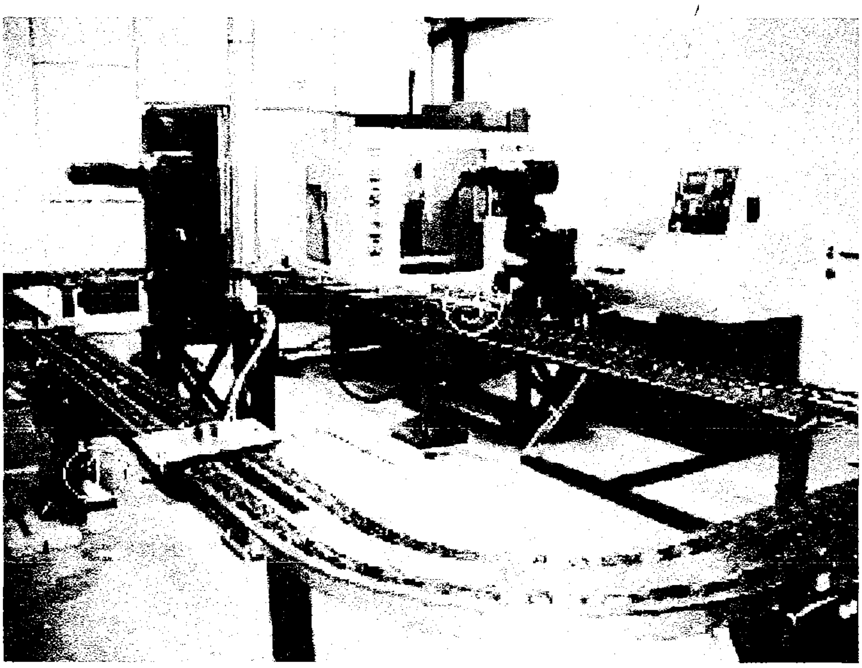


Figure 2: Four section of automatic material handling system for FMS.

2.3.2 Material Pallet

Each pallet is aluminium based, with general dimesion of width 200 mm x length 200. Pallets have guide roller bearing to enable it to guide and move smoothly on straight and cornering section of the conveyors. The pallets have locating guide holes for pallet positioning station usage. The pallet positioning station is located on the conveyor, designed to stop, position and locked the pallet at the four designated position. The positioning station also has an ID checker sensors to enable AHMS controller to identify clearly which pallet arrives in the station and then pass the correct information to robots and CNC controller to start operations. Each pallet has a binary ID which enables the ASRS to keep track of each material or process associate with each pallet. The pallet contains 4 pin which is used to identify the pallet id. The first pin is used as pallet present detection. The second, third and fourth pin is used to code the binary bit of the pallet. If pin 2,3,4 is present, the binary bit represented would be eight. **Figure 3** has shown material handling system for pallet and figure **4 shown** pallet ID identification for FMS.

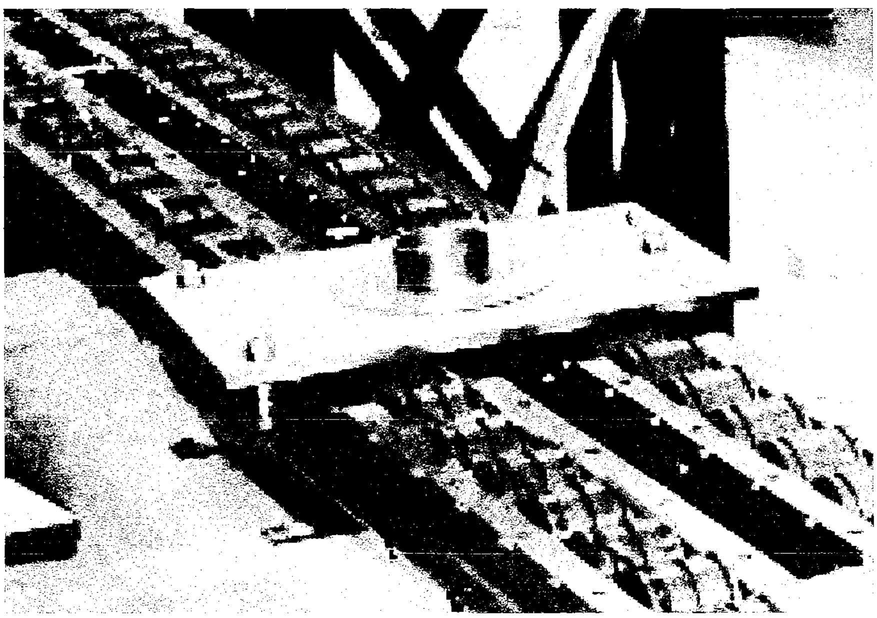
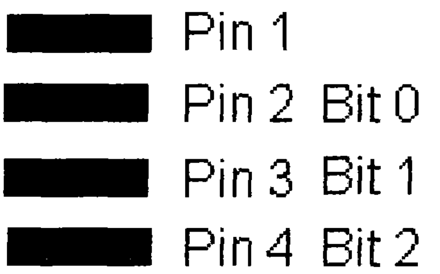


Figure 3: Material handling system for pallet



Bit 2	Bit 1	Bit 0	Pallet ID
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

Figure 4: Pallet ID identification for FMS.

2.3.3 Material Storage Rack (ASRS)

There are two material storage stations (Storage Rack). The former storage stations are meant for raw/unprocessed parts whereas the latter storage stations are meant for finished goods. Each storage station consists of 16 storage location, which is equivalent to two full cycle run (8 pallets/product per full cycle). On every storage location, there is a limit switch which is used to detect presence / absent of object. During system initialization, the central controller will check whether object is present or absent from the system. The status of each cell is displayed in the system SCADA. **Figure 5** is shown material storage rack for FMS.

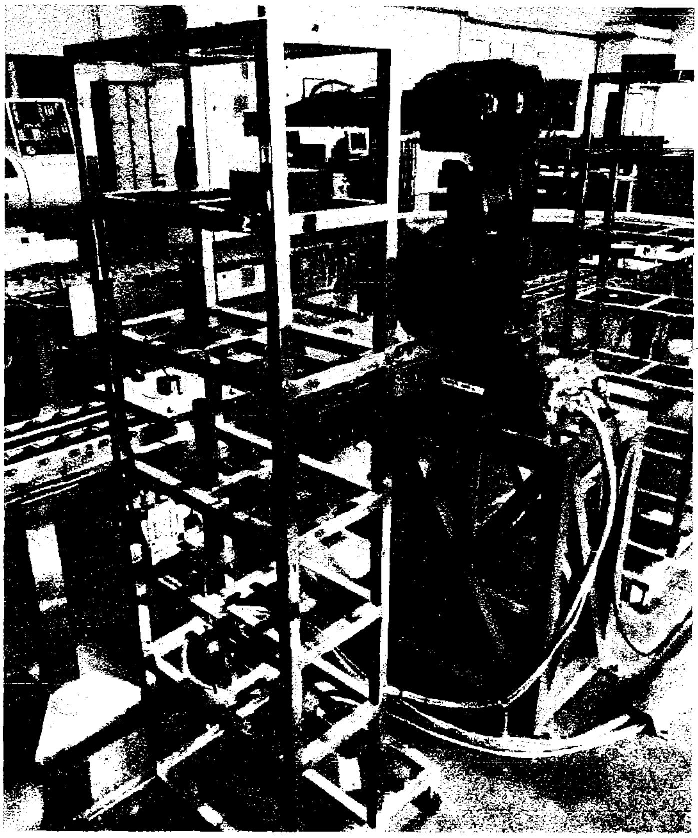


Figure 5: Material storage rack for FMS

2.3.4 ABB Robots

There are two units of ABB Robots, the first unit is installed for handling of supply of raw product and retrieval of finished product to storage rack. The second unit of ABB robot is utilized for handling of semi-finished product between CNC lathe and CNC milling machine. Each unit of ABB robot is equipped with a gripper designed to handle both raw and finished product. A unit of ABB robot which is handling the product for CNC machine cells is equipped with 2 position linear track motion in order to enable a bigger working envelope and extend robot reach to both CNC machines. **Figure 6** is shown ABB robot for FMS.

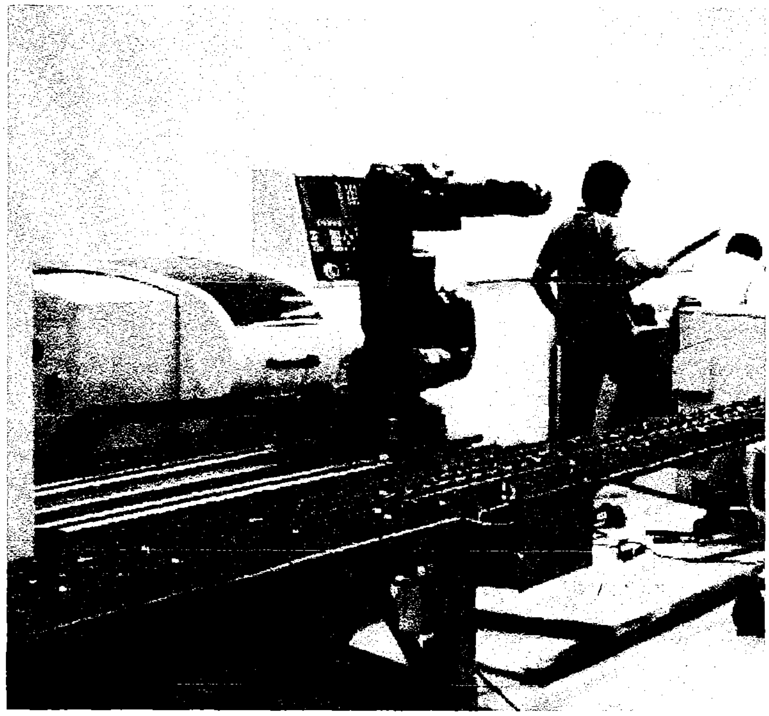


Figure 6: ABB robot for FMS

2.3.5 Citect Scada System

CitectSCADA is a fully integrated HMI/SCADA solution and one of the world's leading industrial automation software packages, is renowned for its reliability and flexibility. Used in a wide range of industries, CitectSCADA enables highly scalable, reliable control and monitoring systems to reduce operating costs, improve productivity and product quality. Easyto-use configuration tools and powerful features enable you to quickly develop and deploy solutions for any size application. SCADA or Supervisory Control And Data Acquisition, is a system with primary function of collecting information (data) and providing an interface to control specific equipment such as Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs) et cetera. CitectScada is being deployed to enable user to configure and monitor the runtime parameter and condition of the system. In this system, the Scada consist of several main screen with is used to show the current activities in the system. The main screen shows the general layout of the system, with status of Conveyor, robots, CNC machines and other runtime parameters. **Figure 7** is shown SCADA main screen for FMS.

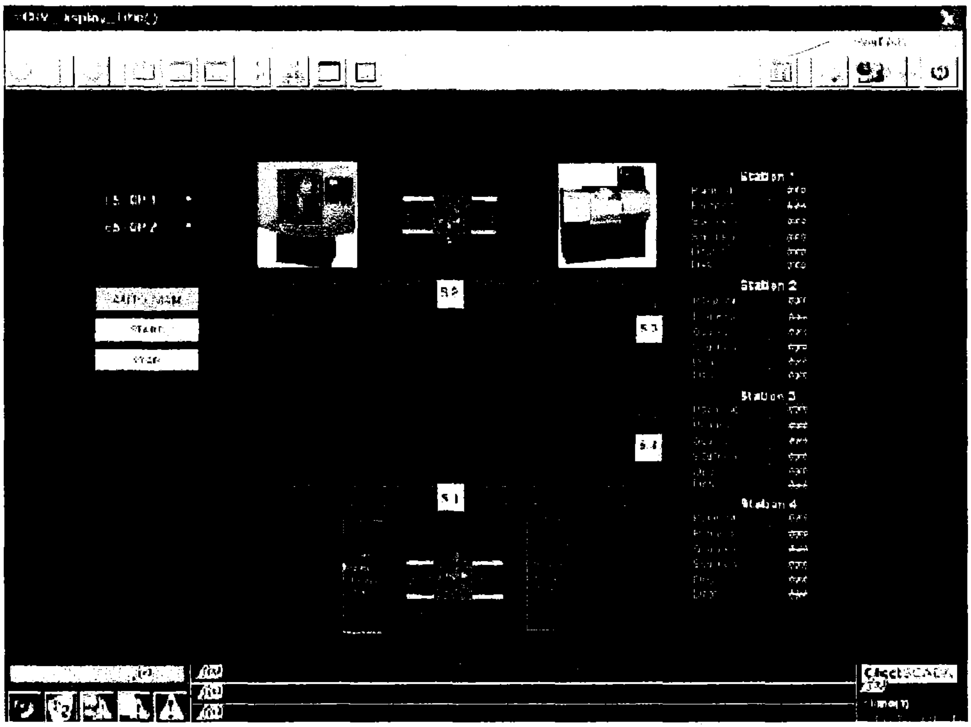


Figure 7: SCADA main screen for FMS.

2.3.6 Integrated System Controller Mitsubishi Programmable Logic Controller

The brain behind all the system activity is a unit of Mitsubishi Q-Series Programmable Logic Controller. This unit of PLC acts as the central controller for the activities in the whole system. Mitsubishi PLC in KUKUM's system consist of Q01CPU with 6 units of I/O cards (4 units QX41P and 2 units QY41). The PLC is mounted on a 8 slot base with a 240Vac power supply unit. The PLC controls the functions such as inverters which control the motors for AHMS conveyors, communication with ABB Robot for loading and unloading of products from Storage Racks, communication with ABB robot for picking and placing products to and from pallets and CNC machine, communication, start and stop control of for CNC Milling, communication, start and stop control of for CNC Lathe, position control for ABB robot linear track motion, tracking and data acquisition for Storage Racks, tracking of pallets and associated orders, overall system run coordination and communication and provide data for Implementation of CitectScada system. **Figure 8** is shown PLC unit for FMS.

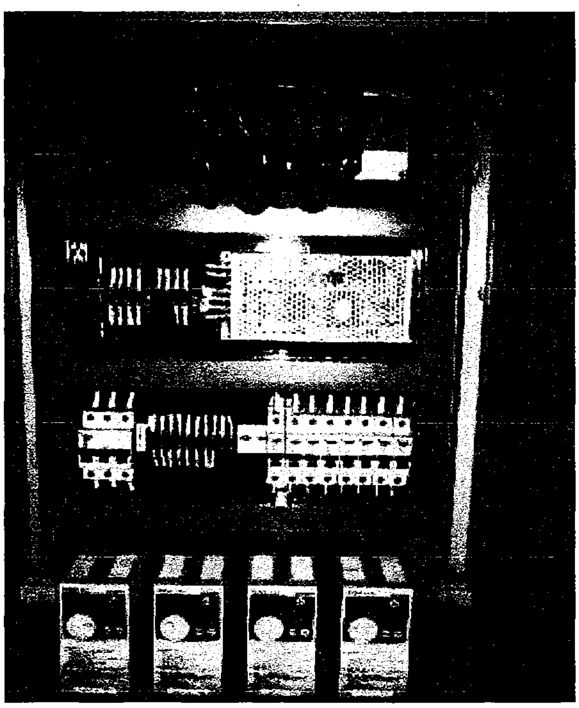


Figure 8: PLC unit for FMS.

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