MALACCA TECHNICAL UNIVERSITY *of* MALAYSIA

Development of Human Machine Interface (HMI) for Flexible Manufacturing System (FMS)

Thesis submitted in accordance with the requirements of the Malacca Technical University of Malaysia for the Bachelor Degree of Manufacturing Engineering in Robotic Automation

By

AMEEN BIN MAHADI

Faculty *of* Manufacturing Engineering

April 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: DEVELOPMENT OF HUMAN MACHINE INTERFACE (HMI) FOR FLEXIBLE MANUFACTURING SYSTEM (FMS)

SESI PENGAJIAN : 2004-2008

Saya AMEEN BIN MAHADI

(HURUF BESAR)

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka .
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
NO 2, Kampung Chepor Tambahan,
31200, Chemor, Perak.

Cop Rasmi:
AZRUL AZWAN BIN ABDUL RAHMAN
Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka
Locked Bag 1200, Ayer Keroh
75450 Melaka

Tarikh: 7/5/2008

Tarikh: 7/5/08

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this thesis entitled "Development of Human Machine Interface (HMI) for Flexible Manufacturing System (FMS)" is the results of my own research except as cited in references.

Signature	:	....
Author's Name	:	AMEEN B. MAHADI
Date	:	6 MAY 2008

APPROVAL

This thesis paper submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation). The members of the supervisory committee are as follow:

....

EN. AZRUL AZWAN BIN ABD. RAHMAN

Main Supervisor

Faculty of Manufacturing Engineering

ABSTRACT

The application of Human-Machine Interface (HMI) has widely been used due to rapidly evolution of advanced computer technology. In a factory environment, this is typically a user interface (UI) at the machine level that gives machine operator information about a process and allows them to control or make changes to the process. For years, HMI has reduced the number of operator and worker at certain manufacturing plant that also cause the hazard level on the workstation to be slightly reduced. Thus, this project will be focused on how far an HMI application can be developed to achieve this kind of objective. The project will be applied to existing FMS plant for LCD screen assembly line. The plant is a combination of several type of automation equipments such as transfer devices, sensors and actuators which is controlled by single PLC. Therefore, new type of communication needs to be established to access and manipulate the input or output data from the PLC using programming approach. A number of solutions have been researched to find an effective method in developing a reliable control and supervisory application for industry. This project will exposed the conceptual approach on applying HMI to the available production plant including the design, software selection until the development of actual HMI application.

ABSTRAK

Kegunaan Antaramuka Mesin-Manusia (HMI) telah meluas sejak evolusi mendadak yang berlaku terhadap kecanggihan teknologi komputer. Di dalam persekitaran kilang, ia adalah contoh Antaramuka Pengguna di peringkat mesin yang memberi maklumat kepada operator tentang proses serta membenarkan kawalan dan perubahan kepada proses dilakukan. Dalam masa beberapa tahun, HMI telah mengurangkan bilangan pekerja dalam satu kawasan yang juga dapat mengurangkan risiko kemalangan di kawasan mesin. Dengan itu, project ini akan memfokuskan sejauh mana aplikasi HMI ini dapat dibina untuk mencapai tujuan tersebut. Project ini akan dibina untuk disesuaikan dengan pelantar FMS untuk pemasangan skrin LCD yang sedia ada. Pelantar ini terdiri daripada gabungan beberapa jenis peralatan automasi seperti alat pemindah, sensor dan alat pendorong yang dikawal oleh satu PLC. Dengan itu, kaedah komunikasi terbaru perlu dihasilkan untuk membolehkan manipulasi dilakukan ke atas input dan output PLC tersebut melalui kaedah aturcara. Beberapa penyelesaian juga telah dikaji bagi menghasilkan satu aplikasi kawalan dan pemantauan yang diperlukan oleh industri. Projek ini akan mendedahkan konsep sebenar semasa mengaplikasikan HMI kepada pelantar FMS yang sedia ada, termasuklah rekabentuk, pemilihan perisian sehinggalah pembangunan aplikasi HMI yang sebenar.

DEDICATION

To my beloved late father, my lovely mother and all my family member whose support me into my success.

ACKNOWLEDGEMENT

First of all, I would like to express my gratitude and deepest thankful to Allah S.W.T who gave me strength and capability of life to carried out my PSM. Thanks to Mr. Azrul who has given me his guidance and useful advice during PSM 1 and PSM 2 until the successful result finally obtain. Mr. Najib who has introduced me with very useful software to build my HMI project also provide me with instructions and guide to developed a reliable HMI application without involving any cost. Without him, my final result would be too simple and merely nothing compared to the real HMI. To Mr Shariman who has given me a brilliant idea and suggestion about programming approach.

Last but not least, I would like to thank all my friends in BMFA for supporting me with good spirit and information which help me during the whole process of my PSM. And finally I would like to thank all personnel who have involved direct or indirectly with me throughout my years in UTEM. All the experienced will be always in memory.

Ameen B. Mahadi

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

HMI	-	Human-Machine Interface
SCADA	-	Supervisory Control and Data Acquisition
MMI	-	Man-Machine Interface
FMS	-	Flexible Manufacturing System
FMC	-	Flexible Manufacturing Cell
FMM	-	Flexible Manufacturing Module
CIM	-	Computer Integrated Manufacturing
SSMS	-	Single-Stage Multimachine System
UI	-	User Interface
PPI	-	Point-to-Point Interface
MPI	-	Multi-Point Interface
COM	-	Component Object Model
TCP	-	Transmission Control Protocol
IP	-	Internet Protocol
RTU	-	Remote Terminal Unit

CHAPTER 1

INTRODUCTION

Today, advanced technology has led into the variation of hardware solutions that often need in manufacturing technology. This reality has forced many companies to make massive investment into flexible manufacturing system or FMS. FMS draws many good advantages such as short lead time, low inventory and high adaptability to changing production requirements due to unexpected customer need. However there is still a disillusion about economic advantages because the design and operation of FMS cannot properly accomplish with intuition or try-and error approaches that often found in industrial practice. Thus, design and operation of FMS required lots of planning knowledge that covers knowledge in industrial engineering, computer science, business administration, operations management and management science.

There are many definitions of FMS proposed by different kind of professionalist in different organizations. Generally, FMS described as a manufacturing system that where there is an amount of flexibility that allows the system to react in case of changes, whether predicted or unpredicted. However, the reality is, there is no actual statement had been recognize to be the definition of FMS. A manufacturing system said to be flexible if it is capable of processing a number of different workpieces simultaneously and automatically with the machines in the system being able to accept and carry out the operations on the workpieces in any sequence.

HMI is one of the FMS components which also known as the best solution to achieve FMS. FMS is one of the other well-known engineering systems that currently applied in many industries such as cellular manufacturing, just-in-time production (JIT) etc. The history of FMS starts in the middle of the 1960s where the market competition became more intense. At the same time the computer controlled machine was invented and became widely used to the present industry. During 1970s, cost became the primary concern. As a result, quality became top priority and speed of delivery became something customer also needed. Thus a new strategy called *Customizability* was formulated where the companies have to adapt to the environment in which they operate to be more flexible in their operations and to satisfy. At first, FMS was developed for metal-cutting applications, however the principles of FMS is more widely applicable to other categories nowadays.

HMI or also known as Man machine-interface (MMI) is one of the engineering tools that developed for the purpose to achieve the objective of FMS. HMI technology is defined as the application of software or hardware that allows a user to interact with their plant equipment. Today, the application of HMI has been widely used in many section of engineering. To make it simple, HMI has met people with technology. With the technology of HMI, a user will have the ability to control their plant equipment functions from a single personal computer platform. All the equipments operations and functions for manufacturing a product are easily controlled by a click of the mouse. In the past 10-years, HMI has become very graphical and today, HMI technology in many instances animates the manufacturing process on computer displays. The users or plant operators are alerted to manufacturing problems from visual and audio alarms that prevent potential problems from occurring.

1.0 Problem Statement

The need to use an HMI on manufacturing plants has become popular since the evolving of computer technology very rapidly. In manufacturing plants, control responsibility must be assigned to machine or human. Some tasks will be carried out automatically, while others will require operator intervention. This assignment must be clearly defined and understood by system users. In order to make a reliable control system, the HMI must display the information necessary and sufficient for competent decision making. The information must be easy to locate and organized in a consistent manner. The control provided must also be relevant to operational tasks so it will meets the operator's job which is to control the plants. Thus, the functions internal to the control system should be transparent so the users can have full access to the system. The other challenge is to make sure that the HMI is adequately responsiveness so the users always receive prompt feedback when they initiate an action. Finally, the system must be easy to maintain, adapt and develop. All of these challenges are required in order to produce full capability of HMI as the best solution of machine control and interfacing for this project.

The real problem that will be expected to be faced during the development of this project might be comes from the software selection and the development of communication interface between programming platform and PLC. Besides, to achieve the main objectives which are to develop a plant supervisory and control application is a next challenge that needs to be faced in order to produce a reliable HMI for FMS.

1.1 Project Objective

The purpose of HMI in this project is to develop an application that allows a user or operator to communicate and control the equipment. Basically, the information that is gathered by the system via PLC must be communicated to the human user of the system for analysis, interpretation, and decision-making. The user must also communicate to the CIM plant system in order to issue commands, change settings, and perform other operations. The need to communicate information necessitates an effective Human-Machine Interface (HMI). HMI design for FMS plant system takes human factors into account, but is often constrained by technological limitations that prevent optimal interfaces from being implemented. The important thing that we will discuss here will be on the machine-to-man communication path.

1.2 Project Scope

This project will focus on designing and developing a third type HMI which is PC based HMI that will be equipped with the existing LCD monitor assembly CIM plant as interfacing tool to accomplish FMS. The HMI that will be developed here will have two different function; i) plant control system and ii) plant monitoring system. That is mean, this HMI will have basic control such as start/stop button to control the assembly flow of LCD monitor; along with plant monitoring system that consist of some basic signal located at each station of the CIM plant to indicate the process flow. First the project will start with the development of plant system control. All the appropriate basic control of the assembly plant will be identified as well as its connection with every address on the PLC. This project will used Progea's MoviconX HMI software as a design and development software of HMI for this system. Several critical programming will required, such as to program serial communication protocol as a main network system between HMI and the plant. After the development, some tests will be carried out to identify any problem that may caused by certain errors committed during the implementation.

CHAPTER 2

LITERATURE REVIEW

At literature review section, all the related researches about the development of this project will be disclosed. All the literature has been taken from various kinds of sources, such as text book or articles from previous study by specialist in this field. Basically, the information that will be dug out from the sources will started with the implementation of FMS. The FMS will be the prior target for this project because HMI is part of FMS components. Next, it will be followed by the application of HMI at production plant for example FMS plant. Several case studies will be identified to help during developing this project. After that, the design theory of HMI will be discovered from several articles or journal to gather the ideas from different point of view.

2.0 FMS

Pires (2005) stated that, one of the very important characteristics of the manufacturing systems are flexibility and agility of the manufacturing process, since companies need to respond to a very dynamic market with products exhibiting very low life-cycles due to fashion tendencies and worldwide competition. Consequently, manufacturing companies need to respond to market needs efficiently, keeping their products competitive. This requires a very efficient and controlled manufacturing process, where focus is on automation, computers and software. The final objective is to achieve semi-autonomous systems, i.e., highly automated systems that work requiring only minor operator intervention. In many industries, production is closed tracked in any part of the manufacturing cycle, which is composed by several in-line manufacturing system that perform the necessary operations transforming the raw materials in a final product.

The need to transform from conventional to FMS has become a major requirement for today's manufacturing cell because FMS integrates manufacturing cells into large unit, all interfaced with a central computer. FMS have the highest level of efficiency, sophistication, and productivity among manufacturing system. Although high cost, they are capable of efficiently producing part in small runs and of changing manufacturing sequences on different part quickly that enables them to meet rapid changes in market demand for various types of products (Kalpakjian & Schmid, 2001).

Global competition, advancements in technology and ever changing customers' demand have made the manufacturing companies to realize the importance of FMS. These organizations are looking at FMS as a viable alternative to enhance their competitive edge. But, implementation of this universally accepted and challenging technology is not an easy task. A large number of articles have been reviewed and it is found that the existing literature lacks in providing a clear picture about the implementation of FMS (Suhaib *et al.* 2006).

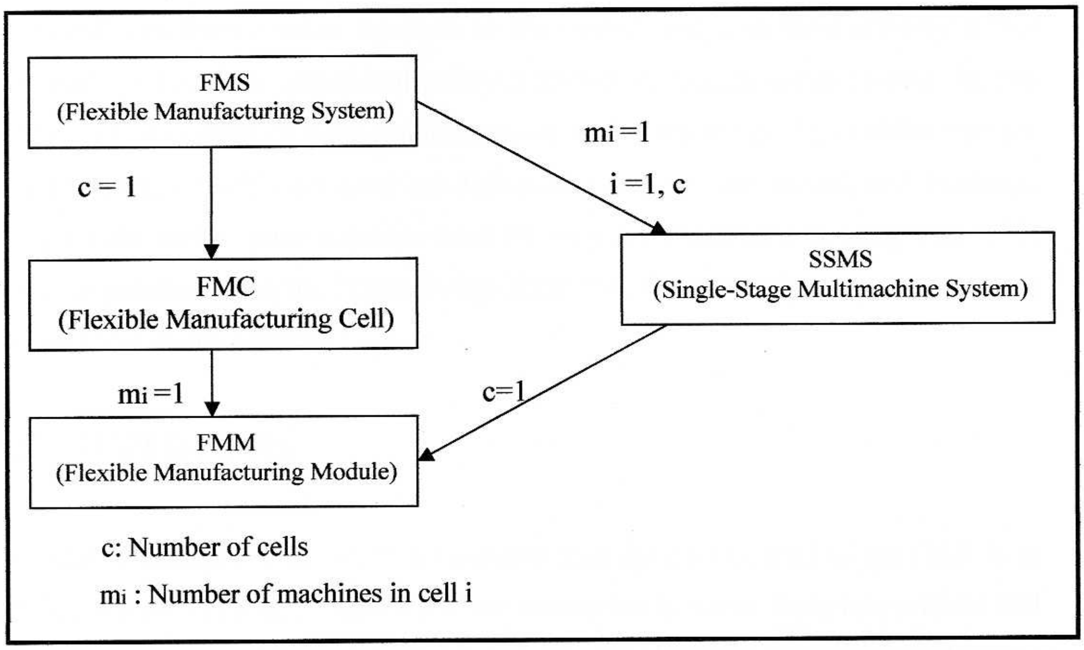

Figure 2.1: Relationship between FMS and SSMS

According to Kumar and Sridharan (2005), in most FMS, operations are allocated to machines and the corresponding tools are loaded into tool magazines of the machines.

In these systems, parts are transferred from one machine to another according to the routing determined by the operational allocation decisions. The operational policy for systems of this type is called the part movement policy. On the other hand, in some FMSs, each part visits only one of the machines for the entire processing. Such systems belong to the category of Single-Stage Multimachine System (SSMS). Figure below shows the relationship between FMS and SSMS, as presented by Koo and Tachoco.

The SSMS can be regarded as a special case of FMS, which consist of many cells with each cell containing one versatile machine. It can also be viewed as a group of independent flexible machining modules. A flexible machining module consisting of a single flexible machine is the basic building blocks various FMS configurations.

A distinct characteristic of SSMS involves no part routing between machines. In SSMS, since all the operations of a part are performed on a single machine, the parts do not move between machines but only travel between the load/unload station and the machines. In such systems, tools required for a part but unavailable at a machine are transferred from another machine or the central tool store (tool crib) by a tool transport system. This operational policy is known as tool movement policy. In this policy, the assignment of tools is not necessary at the beginning of a planning horizon or a production batch since tools are delivered when they are needed, and therefore, parts remain on the same machine until the required machining is completed. This policy is possible when the system is equipped with fast tool delivery devices and an efficient tool control model.

2.1 HMI for FMS

On 2002, Frangopol *et al.* made a statement that the overall goal of the HMI is to provide a platform that permits ab initio interaction between materials science and system engineering. This includes the following three key features: a) the HMI serves as a real time display of device performance and reliability assessment, b) the HMI gives information regarding the status of the devices, e.g. damage accumulation and remaining life, and c) the HMI serves as a platform for simulation of the devices for the purpose of life prediction, design and optimization.

In many cases, if properly designed, those individual manufacturing systems require simple parameterization to execute the tasks they are designed to execute. If that parameterization can be commanded remotely by automatic means from where it is available, then the system becomes almost autonomous in the sense that operator intervention is reduced to the minimum and essentially related with error and maintenance situations. A system like this will improve efficiency and agility, since it is less dependent on human operators. Also, since those systems are built under distributed frameworks, based on client-server software architectures which require a collection of functions that implement the system functionality, it is easier to change production by adjusting parameterization (a software task now) which also contributes to agility. Furthermore, since all information about each item produced is available in the manufacturing tracking software, it is logical to use it to command some of the shop-floor manufacturing system, namely the ones that require simple parameterization to work properly. This procedure would take advantage of the available information and computing infrastructure, avoiding unnecessary operator interfaces to command the system (Pires, 2005).

In plant-wide control applications, the human communicates with the technical system via the HMI and, usually, also with other human users and/or categories of users either via the HMI or directly face-to-face. Thus, at least two different levels of human performance within the functional and conceptual domain should be distinguished in an analytical model of the human user (Johannsen, Averbukh, 1993):

- the control specific level, including controlling in the narrower sense, fault management and planning (Johannsen, 1992), and
- The communication specific level.

The global structure of the multi-level human user model is presented in figure 2.2. Here, problem solving is executed on both level, control and communication, through the formation and/or modification of the knowledge- and experience- based mental model as well as with knowledge utilization within the actions execution. Problem solving on the control level comprises fault management and planning Communication is accomplished in three different ways. The first one is the interaction with the application or technical system, e.g., during the usage of embedded support tools for procedural advice or explanation. The second way of communication is the one with other human users via the human-machine (computer) interface, e.g, in HMI supported group meetings or in video conferencing. The third way of communication indicated in figure 2.2 is the direct face-face communication.

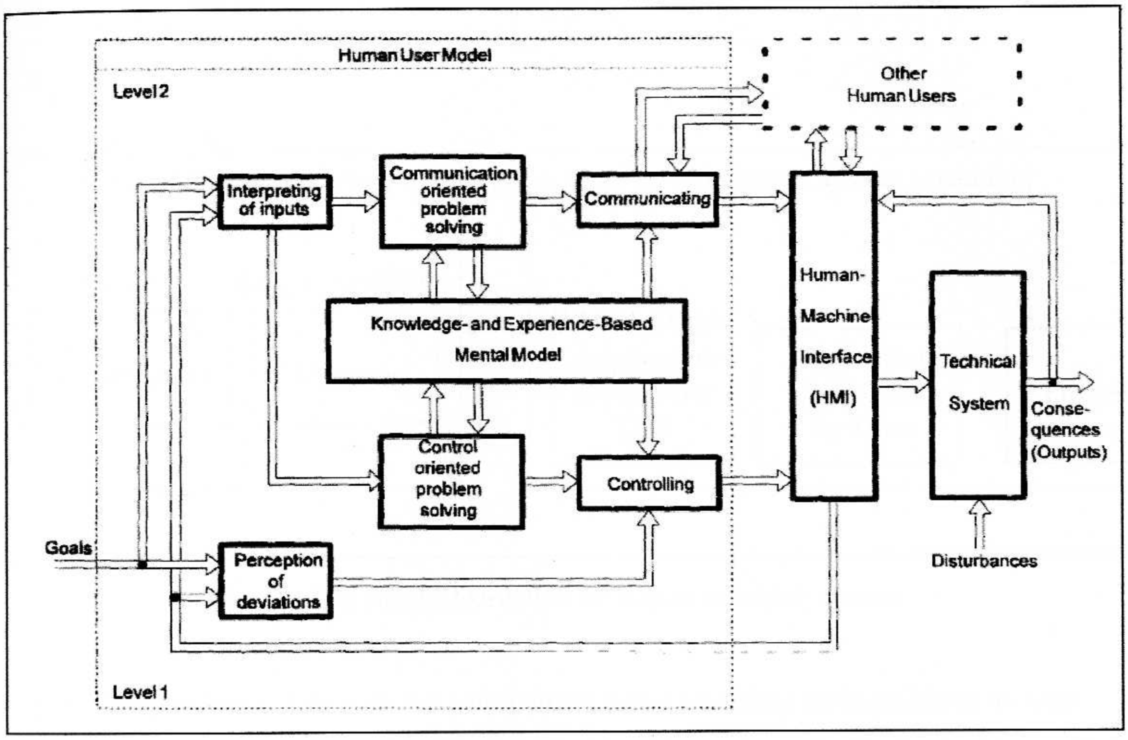

Figure 2.2: Global structure of multi-level human user model

2.2 HMI in Computer-Integrated Manufacturing (CIM)

The basic function of the interfaces in CIM systems is to facilitate information transfer between the 'integrating' computers and the participating humans (the latter being normally simple information sources and sinks, and not being the supervisors of the integrated system functions). Thus, quite evidently, human factors are in most cases almost entirely out of consideration during the traditional design process of interfaces. This is because, with the advent of computer integration of the complex system functions (first in sophisticated manufacturing and production systems), the belief in the overall 'miracle' stemming from introduction computer integration overshadowed the key role of the humans, and there was little care taken in human factors, apart from consideration of some comfort and ergonomic aspects (Balint, 1995).An appropriate structure of HMI for integrated automated systems distinguishes between the presentation level and the dialogue level, see figure 2.3 below.

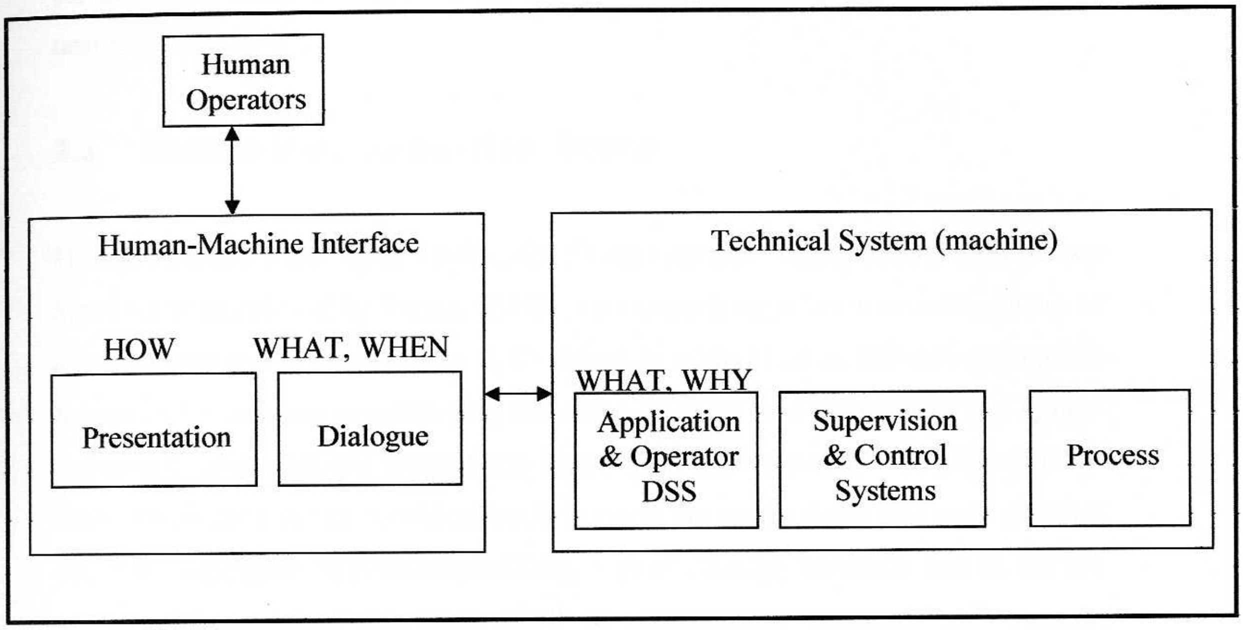

Figure 2.3: General structure of human-machine system

The dialogue level deals with the information flows regarding such problems as what information to handle when. The presentation level is concerned with the problems of how to present the information to the human operators, and how to transform their control inputs. Although a lot of research is currently being undertaken in the area of multimedia interfaces, the main mode of presentations stills the visualization (Johannsen, 1994).

2.3 User interface

User interface are now a much more important part of computer than they used to be. The revolution in personal computers and falling hardware prices are making computers available to ever broader groups of users, and these users are using