Comparison of automated material handling system with human labour in FMS environment: Identification of core attributes

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ABSTRACT

Flexible manufacturing is a process which permits production systems to perform under high customized production needs. The goals of manufacturing system like minimum inventories, improved quality, enhanced technical performance and reduction of cost can be achieved by implementing the FMS. Material handling system plays a very important role in flexible manufacturing system. Material handling system consumes a significant amount of cost and time in any manufacturing process. Selection of best material handling system is very important task. The basic requirement in the design of any material handling system is to identify the factors which affect the material handling. So, here the researchers have identified the core attributes of material handling system through exhaustive literature survey. Further, these attributes are sub grouped into different categories and their importance in the context of material handling system design is discussed.

Keywords: FMS, Material handling system, Attributes.

1. INTRODUCTION

In this age of globalization, manufacturing industries are changing rapidly to counter the vital threats of inflation in market needs and corporate lifestyle. Hence, in current circumstances, industries which are responding quickly to market fluctuations with more competitiveness will have good capabilities in producing products with high quality and low cost to satisfy the consumer needs. Now the factors which are important to the manufacturer are flexibility, quality, efficient delivery and customer satisfaction rather than the cost. Hence, to attain these factors manufacturing industries are adopting latest techniques like automation, robotics and other innovative concepts such as just-in-time (JIT), Production planning and control (PPC), enterprise resource planning (ERP). Flexible manufacturing system is also one of the techniques which are predominantly used by these industries to achieve their goals.

Flexible manufacturing is a technique which permits production systems to perform under high customized production needs. The problems such as minimum inventories and market-response time to strike into customer needs, response and satisfaction to adjust as per the trends in the market. In order to compete in market by reducing the cost and improving the quality of products and services will be compulsory to various companies to move over to flexible manufacturing systems. FMS is used as a feasible way to overcome the market issues while making reliable and good quality and cost effective products to fulfill the customer needs.

Flexible manufacturing system includes the concepts and skills in an automated production system like flexible automation, group technology, computer numerical control machine tools and automated material handling and storage. Flexible manufacturing system is collection of different tools and techniques. The components of flexible manufacturing system are discussed in the following paragraphs.

1.1 Basic Components of FMS

There are following basic components of flexible manufacturing system:

1. Workstations Automated
2. Material Handling and Storage System
3. Computer Control System
4. Inspection Equipments
5. Other Component

Workstations- Typically computer numerical control (CNC) machine tools that perform machining operation on families of parts are the workstations in FMS. The commonly used workstations in flexible manufacturing system are machining centers, load and unload stations, assembly work stations, inspection stations and Forging stations.

Computer Control System is required to coordinate the activities like control of each and every work station, sharing of control instruction to work station, Production control and Traffic control, System performance monitoring and reporting

Inspection Equipments includes the equipments to measure dimensions, concentricity, perpendicularity, and flatness of surfaces. The efficient central coolant, well-organized chip separation system and pallets and fixtures are the others components incorporated in flexible manufacturing system.

Since the material handling is a very crucial tasks in flexible manufacturing system and it consumes a good contribution of money and resources in any manufacturing system. So, our prime focus is only on material handling system.

1.2 Material Handling System

Material handling is as an integrated approach which involves activities like moving, handling, storing and controlling of materials by means of gravity, manual effort or power activated machinery. Moving materials consume time and space. Any movement of materials requires that the size, shape, weight and condition of the material, as well as the path and frequency of the move be analyzed. Material handling is an essential area of concern in flexible manufacturing systems because about 80 % of time that material spends on a shop floor is spent either in waiting or in transportation, even though both these activities are non-value added activities. Efficient material handling ensures for less blocking, timely delivery and reduced idle time of machines due to non-availability or gathering of materials at workstations. Safe handling of materials in a plant reduces wastage, breakage, losses and scrapes etc. The varieties of functions performed by material handling and storage system are:

i. Random and independent movement of work parts between workstations
ii. Handling of a variety of work part configurations
iii. Temporary storage of parts and subassemblies
iv. Suitable access for loading and unloading of work parts
v. Well-suited with computer control

1.2.1 Material Handling Methods in FMS

Material handling can be successfully performed by two ways:

1) By Material handling equipments
2) By Human labour

1. Material Handling Equipments

- Industrial trucks comprise hand trucks such as two-wheeled, four-wheeled, hand lift, and forklift and powered trucks such as forklift, tractor-trailer trains, industrial crane trucks, and side loaders.
- Conveyors such as belt, chute, roller, wheel, slat, chain, bucket, trolley, tow, screw, vibrating and pneumatic.

- Monorails, hoists, and cranes such as bridge, gantry, tower and stacker.
- Automated guided vehicle systems such as unit load carriers, towing vehicles, pallet trucks, fork trucks and assembly line.
- Automated storage and retrieval systems (AS/RS) such as unit and multi load carriers, person-on-board, deep lane, and storage carousel systems.

Automated guided vehicle systems

An AGVS is a driverless vehicle, powered by battery with programming capabilities for destination, path selection and positioning. The AGVS is highly flexible, intelligent, and versatile material handling systems used to transport materials from different loading locations to different unloading locations all over the facility.

The components of an AGVS

1. The vehicle- It is used to move the material within the system without a human operator.
2. The guide path- It guides the vehicle to move along the path.
3. The control unit- It monitors and directs system operations including feedback on moves, inventory, and vehicle status.
4. The computer interface- It interfaces with other computers and systems such as the mainframe host computer, the automated storage and retrieval system and the flexible manufacturing system.

2. Human Labour: Human labour is mainly used to transport and handle the materials from one place to another. It is very suitable in developing countries like India where human workforce is easily and cheaply available.

2. LITERATURE REVIEW

There has been lot of work done on selection of material handling equipments in flexible manufacturing system.

Basnet (1994) reviewed the literature concerning the operations of FMS. Flexible manufacturing systems (FMS) are distinguished by the use of computer control in place of the hard automation usually found in transfer lines. The high investment required for a FMS and the potential of FMS as a strategic competitive tool make it attractive to engage in research in this area.

Chan et al. (1999) developed MHESA (material handling equipment selection advisor) which is an intelligent system to select the material handling system. This designed system can automate the material handling selection process and artificial intelligence can also be used.

Raj et al. (2007) proposed a new concept called humanized flexible manufacturing system (HFMS). In this system human labour is utilized in place of automated material handling system in FMS.

Kumar and Raj (2016) stated that material handling equipment plays an important role in the design and development of flexible manufacturing systems. In this paper an attempt has been made to select the most appropriate material handling equipment for the design and development of FMS. They proposed model on the basis of material handling attributes and sub attributes which are critical for material handling equipment selection.

Kant et al. (2017) presented a method for selection of material handling equipment (MHE) for flexible manufacturing system. In the first phase, the system considers major issues, rate of transfer, average time to transfer, flexibility etc., which is essential for the system. In second phase, the system selects the most feasible MHE types for every MH operation in a given application depends upon these major issues using fuzzy logic controller.

2.1 Gaps in Literature Review

Although a lot of work has been performed on material handling system in flexible manufacturing system but there is very little literature available which provides the details about the core attributes of material handling system so that automated material handling system with human labour in FMS

environment can be compared based on them. So, in this research paper various attributes material handling systems are identified and divided into different categories.

3. IDENTIFICATION OF ATTRIBUTES OF MATERIAL HANDLING SYSTEM IN FMS

A number of different attributes have been used in the design and analysis of material handling systems. They affect either the entire manufacturing system or the material handling system independently. From literature survey following attributes are identified which affects the material handling in flexible manufacturing system. These attributes are further divided into the sub attributes.

Table 3.1: List of attributes and sub-attributes

S.N.	Attributes	References
1	**Productivity** • Material handling productivity • Labour productivity • Energy productivity	Tuzkaya et al. (2010), son and park (1987), Peters et al.(1998)
2	**Flexibility** • Routing flexibility • Expansion Flexibility • Process flexibility • Operation flexibility	Chan et al. (1999), Browne et al. (1984), Son and Park (1987), Peters et al.(1998), Bouh and Riopel (2015),
3	**Cost** • Initial cost • Operating cost • Other Cost (maintenance, salary etc)	Devise et al. (2000), Bou and Riopel (2015) Sinriech and Tanchoco (1995) Mahadevan and Narendran (1992)
4	**Responsiveness** • Setup New products • Speed in handling • Variety of products • Volumes of products	Chakraborty and Banik(2005), Beamon (1998)
5	**Others** • Safety • Accuracy • Repeatability • Reliability • Supervision	Kulak(2005), Beamon (1998)

3.1 Discussion Regarding the Identified Attributes

Productivity may be defined as the reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be spoken as human efforts to produce more and more with less and less inputs of resources (Dixit and Raj, 2016). Productivity denotes relationship between output and one or all

associated inputs. Productivity is further classified into three categories: material handling productivity, labour productivity and energy productivity. Material handling productivity refers to how well the material is transported in a particular material handling system. Utilization of labour efficiently in the material handling system is the measure of labour productivity. Energy productivity can be defined as the utilization of energy to the per unit material transported.

Material handling flexibility is the ability to transport different work pieces between various processing centers over multiple paths economically and effectively (Hutchinson, 1991; Sethi and Sethi, 1990; Coyle et al. 1992). Routing flexibility is defined as ability to process a given set of part types using multiple routes economically and effectively (Upton, 1995; Gerwin, 1993; Sethi and Sethi, 1990). Expansion Flexibility is the capability of building a system, and expanding it as needed, easily and modularly. This is not possible with all the material handling system. This flexibility can be measured according to how large the material handling system can expand in FMS. Process Flexibility may be defined as the ability to produce a given set of part types, each possibly using different material, in several ways. Buzacott (1982) calls this `job flexibility', which `relates to the mix of jobs which the system can process.' Gerwin (1982) calls this `mix flexibility'. Operation Flexibility is the ability to interchange the ordering of several operations for each part type.

Cost in material handling system is combination of variable and fixed costs. Variable costs are generally the operating costs of the material handling system. Variable costs include the cost of power, lubricants and maintenance. The variable costs may also include the routing or travel expenses, which are proportional to the distance travelled. Other Costs is associated with salary and other expanses provided to human labour and cost associated with sudden failures and breakages. Fixed costs include such costs as the construction and purchase of equipment and hardware.

The handling time per job is comprised of the time directly associated with material handling. This time includes: (1) the time the job spends in queues waiting for the material handling vehicle, (2) the total travel time, and (3) the total loading and unloading times, and (4) total vehicle blocking times. The total handling time per job includes the time from when a job enters the system until it leaves the system (Gaskins and Tanchoco 1987).

Material handling system set up should be flexible for the new products. So the system should be designed in such a way that variety of products can be handled through that system. Material handling system must be capable of transporting and handling a large volume of products with a good speed. Kim and Tanchhoco (1993) have defined the P/T ratio as the ratio of the average processing time per operation divided by the average transport time per transfer.

Safety is a measure concern in the industries. Material handling system should ensure the safety of human labour as well as machines. Accuracy is the quality or state of being precise. Repeatability is the measure of providing the similar output for same input over a long period. Reliability is defined as the probability that an item will perform a required function, under stated conditions, for a stated period of time (Smith 1993). A reliability measure, then, is a metric for quantifying this probability. Material handling system has the capabilities to supervise itself and quickly respond to errors.

4. CONCLUSION

This paper discussed about the flexible manufacturing system and its components. Material handling methods used in flexible manufacturing system is also explained. The core attributes for design of material handling system in flexible manufacturing system are identified in this paper. These material handling system attributes are sub grouped under a broad topic and discussed in the context of material handling system design in flexible manufacturing system. This research can be further extended to select and design the material handling system suitable for a particular industry by the applications of various MCDM techniques like AHP and ANP based on these attributes.

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