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MANUFACTURING TRENDS IN LOADING AND UNLOADING OF MACHINES IN FLEXIBLE MANUFACTURING SYSTEMS

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ABSTRACT

Flexible Manufacturing System (FMS) is the most adopted and utilized for manufacturing among several manufacturing strategies in batch production of mid volume and mid variety of product requirements. FMS Installation is still a costlier issue. FMS is a great focus of attention in manufacturing environment on shop floor for batch production requirements in industries and in academic research since a number of decades. The need of small scale FMS is prevailing in the research field in present manufacturing scenario. This paper presents the manufacturing trends in loading and unloading of machines in FMS and the scope of research in the field.

Keywords: Manufacturing Strategies, Flexible Manufacturing Systems (FMS), Loading and Unloading of Machines.

1. Introduction

In rapidly changing market environment, to gain competitive advantage, the manufacturing firms are required to respond quickly and with high flexibility which is attracting the attention of researchers in today's manufacturing scenario. Because of its highly automated nature, a typical FMS has a high investment cost. A FMS has several configurations, types & classifications, composed of various components, and have different types of approaches, layouts and levels. In other words FMS has several parameters to depend upon. Mathematical formulations are required which could be helpful in selecting the best among several possible configurations of FMS's. This paper aims to outline and authenticate the stern need of carrying out the work in the field of loading and unloading of machines in FMS.

2. Background of Manufacturing System

Major parts of a production system are: Marketing, Product Design, Planning, Purchase, Manufacturing Engineering/ System, Factory Automation Hardware, Warehousing, Logistics and Supply Chain Management, Finance, Information Management. The Manufacturing Engineering/ Systems are investigated in the present study. Figure 1 shows a typical manufacturing system. The modified form of the same is shown in figure 2. Manufacturing system design involves a number challenging factors such as the need to boost system performance due to global competition and the growing complexity of both the manufacturing systems and products to be manufactured. Manufacturers are experiencing fluctuating market demand for their products, with ever shorter lead times and smaller but more frequent order quantities, accompanied by increasingly frequent changes in product specifications – even during manufacturing. Juhani Heilala, et. al. (2010) states that product life cycle are becoming shorter and it is difficult to forecast demands. All this requires agility and flexibility on the part of the factory, which runs counter to the built-in inertia and the gravitational force to 'conduct business as usual', combined with the limited ability of management to reconsider decisions almost 'in real time.

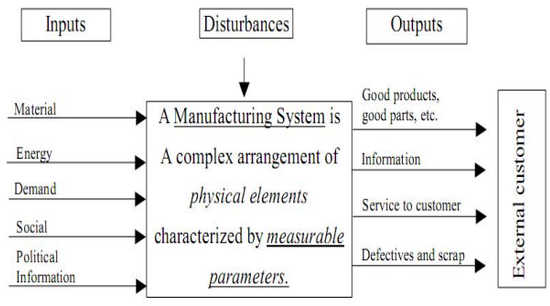

Fig. 1 Typical Manufacturing System

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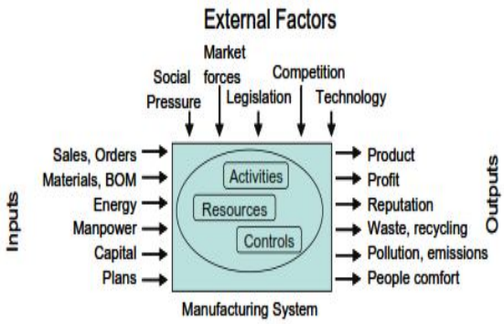

Fig. 2 Modified Manufacturing System

Manufacturing strategies impacts deeply the world economy. Manufacturers are facing an increasing business pressures that directly impact manufacturing operations. To remain competitive, manufacturers has to reduce manufacturing cost. Development can be brought into the product in different forms such as new features/functions, new looks/feel or new technologies, contributing to the main sources for keeping customers excited which affects the results in maintaining or increasing market share. This leads to an emphasis on enhancing the design and development capability and decreasing the design and development time and cost within organizations. This brings the need of an excellent fool proof manufacturing strategy.

3. Manufacturing Strategy

A manufacturing strategy is the creation of consistent pattern of decision within the manufacturing function that supports the corporate strategy and helps to achieve the corporate goals. Manufacturing is a unique element within the overall enterprise. The key to gain a competitive manufacturing advantage which lies in the development of a manufacturing strategy that satisfies those business needs. M.R. Muhamad (1997) says that manufacturing systems can be designed to provide the corporation with different possible manufacturing capabilities such as cost, quality, performance, delivery time, reliability, flexibility and innovativeness. The manufacturing strategy will determine which of the possible manufacturing outputs will more closely match the goals and strategy determined at the corporate, or enterprise, level. There are various strategies that can be applied to the manufacturing operation. The existence of a manufacturing strategy guides the daily decisions and activities with clear understanding of how those daily decisions relate to the overall goals of the corporation. Manufacturing strategies are always required to achieve the reduction in inventory; lower the cost of the product; reduce waste; improve quality; increase flexibility in manufacturing to achieve immediate and rapid response to product changes, production change, process change and equipment change. The firms having manufacturing strategies for achieving corporate goals survive for long run.

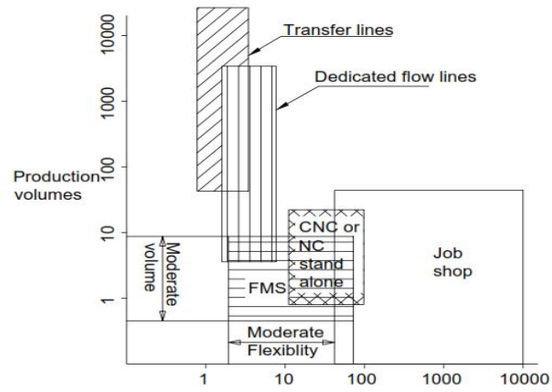

Fig. 3 Comparison of Different Types of Manufacturing Systems

A manufacturing strategy provides a vision for the manufacturing organization to keep itself aligned with the overall business strategy of the corporation. It consists of long term objectives, programs, and initiatives which helps for business gain and maintain a competitive advantage. A manufacturing system designed strategically and integrated properly with the rest of the enterprise functions play an important role in helping the enterprise to achieve its goals. A strategy is also a strong communication tool between different levels of management to bring all operations in line with corporate objectives. The literature reveals the following manufacturing strategies namely custom manufacturing; continuous manufacturing; intermittent manufacturing; flexible manufacturing; just-in-time manufacturing; lean manufacturing; agile manufacturing. Figure 3 presents the comparison of different types of manufacturing systems. The selection of the type of the manufacturing system depends on the effort and energy requirements, systems benefits, ease of implementation of the strategy, system cost to the enterprise and after all the benefits. Many manufacturing organizations are looking for FMS technologies for improvements in process flexibility. Need to produce more customized products of highest quality with lowest possible cost in minimum possible time; process flexibility is a growing concern of most of the manufacturing organizations.

4. Flexible Manufacturing System

Cost and quality are the primary priorities of manufacturing industries. The competitiveness of market brings the customer and delivery time into picture. This led the formation of customizability. The companies have to adapt flexible environment in their operations to satisfy different segments. The innovation of FMS is related to the effort of gaining competitive advantage. FMS is a manufacturing technology, a philosophy. Philosophically, FMS incorporates a system view of manufacturing. The system views of typical FMS given by eminent researchers are tabulated in Table-1. International competition, advancement in technology, customer demands, product variety and dynamic market changes are forcing the global industries to adopt such type of production technology in which changes can be made at minimum possible time and lower cost. For their survival, the manufacturing companies need to be flexible, adaptive and responsive to changes and be able to produce a variety of products in a short time at a lower cost. The products are needed to be produced with more variants. Fast changes in the design of products have compelled the manufacturing companies to seek such type of production technology, which can provide both flexibility and speed in the manufacturing system. Manufacturing needs to be cost effective and customized. The process flexibility is hence the main requirement in modern manufacturing systems. Such type of flexibility can be attained with the adaptation and implementation of FMS. Such production system should have the efficiency of transfer lines and the flexibility of a job shop. FMS has evolved as the ultimate weapon in boosting productivity and competitiveness with vast range of part variety that means to meet requirements of customized production which prevails in process plant layout having moderate runs. Loading in FMS's is affected by the FMS characteristics under analysis, type of plant and the production planning hierarchy of plant under consideration. The FMS loading problems are concerned with the allocation of operations and required tools to machines or workstations subject to resource and technological constraints of the system.

Loading is one of the most critical decisions in FMS planning. The machine loading problem of a FMS is well known for its complexity. The approaches, implementation area and the findings obtained by various researchers for machine loading existing in the literature are tabulated in table 2.

Table 1: System Views of FMS

Year	Researcher	System views of FMS
1985	Buzacott & Mandelbaum	Flexibility is the ability of a manufacturing system to cope with changing circumstances.
1996	Jang et. al.	FMS is a computer-controlled configuration of semi-dependent workstations and material-handling systems designed to efficiently manufacture multiple types of products ranging from low to medium volume
2004	Chan et. al.	FMS is an integrated computer controlled system that consists of, but not restricted to, computer numerical controlled (CNC) machine tools, and automated material and tool handling devices
2005	Solimanpur et. al.	FMS is a production system in which a set of machines and a flexible material-handling system like robot automated guided vehicle (AGV), etc. are linked and controlled by a central computer

5. Research Review

The research review is tabulated below in table -2 and literature gap is discussed thereafter.

Table 2: Approaches, Implementation area and Findings of Researchers

Year	Researcher	Approach	Implementation area	Findings
1995	P. Brandimarte et. al.	FMS modelling	system development	minimization of the total evaluation time
1997	Roh H., & Kim Y	heuristics approach	part & tool loading and part sequencing	Improvement of system's performance
1997	Mohamed Z. & Bernardo J	interface analyzation	tool planning and loading and routing decisions	Tool policy effect on the flexibility.
1997	Tiwari et. al.	petri-net model	Machine loading	minimizing system unbalance
1998	Mukhopadhyay et. al.	simulated annealing	Machine loading	minimizing system unbalance
1999	Atlihan et al	generic modelling framework	tactical planning	Improvement of system's performance
2000	Tiwari and Vidyarthi	meta-heuristics like genetic algorithm	loading problem	optimal solution to the problem
2000	S. Rahimifard, S.T. Newman	series of computer based experiments	loading policies	meet the delivery dates of production orders, and at the same time reduce the manufacturing cost
2002	Buitenhek et. al.	defined algorithms	loading, unloading time	expensive components of FMS
2003	Swarnkar and Timari	hybrid algorithm based on tabu-search and simulated annealing	loading problem	maximization of system efficiency
2004	Abou-Ali et. al.	dispatching strategies	loading problem	maximization of system efficiency
2005	Chan et. al.	fuzzy goal programming & artificial immune systems	machine tool selection and operation allocation	job sequence determination
2006	Nagarjuna et. al.	heuristic model based on multi-stage programming approach	loading problem	minimize the system unbalance
2008	Yogeswaran et. al.	hybrid algorithm (GASA)	loading problem	efficient machine loading heuristics
2008	M.K. Tiwari	a heuristic approach based on reallocation paradigm	loading problem	minimum positive system unbalance
2009	M. Yogeswaran et. al.	genetic algorithm and simulated annealing algorithm (GASA)	loading problem	minimize the system's imbalance
2010	L.J. Zeballos et. al.	integrated CP model	Loading/ unloading problem	solution of various case studies of different sizes
2010	Santosh Kumar Mandal, et.al.	AI-based optimisation	loading problems	minimization of system unbalance
2011	Murat Arıkan & Serpil Erol	hybrid simulated annealing-tabu search algorithm	loading problems	minimization of system unbalance
2012	Vijay M Kumar et. al.	meta-hybrid heuristic technique based on genetic algorithm and particle swarm optimization	loading problem	minimization of system unbalance

6. Manufacturing Trends in Loading and Unloading of Machines in FMS

Various approaches adopted by researchers for loading and unloading of machines in FMS in subsequent years involves FMS modelling (1995), heuristics approach (1997), interface analyzation (1997), petri-net model (1997), simulated annealing (1998), generic modelling framework (1999), meta-heuristics like genetic algorithm (2000), series of computer based experiments (2000), defined algorithms (2002), hybrid algorithm based on tabu-search and simulated annealing (2003), dispatching strategies (2004), fuzzy goal programming & artificial immune systems (2005), heuristic model based on multi-stage programming approach (2006), hybrid algorithm (GASA) (2008), a heuristic approach based on reallocation paradigm (2008), genetic algorithm and simulated annealing algorithm (GASA) (2009), integrated CP model (2010), AI-based optimization (2010), hybrid simulated annealing-tabu search algorithm (2011), hybrid algorithm optimization (meta-hybrid heuristic technique based on genetic algorithm and particle swarm optimization) (2012). The findings of referred researchers involve the followings. P. Brandimarte et. al. (1995) reported to work for minimization of the total evaluation time. Swarnkar and Timari (2003) and Abou-Ali et. al. (2004) worked for maximization of system efficiency. Mohamed Z. & Bernardo J (1997) showed the effect of tool policy on the flexibility. Roh H., & Kim Y (1997) and Atlihan et. Al. (1999) observed improvement of system's performance. Tiwari et. Al. (1997), Mukhopadhyay et. al. (1998), Nagarjuna et. Al. (2006), M.K. Tiwari (2008), M. Yogeswaran et. al. (2009), Santosh Kumar Mandal, et.al. (2010), Murat Arıkan & Serpil Ero (2011) and Vijay M Kumar et. al. (2012) aimed for minimizing system unbalance. Tiwari & Vidyarthi (2000) provided the optimal solution to the problem of machine loading. Buitenhek et al. (2002) pointed out the expensive components of FMS. Chan et al (2005) determined the job sequence. Yogeswaran et. al. (2008) presented efficient machine loading heuristics. L.J. Zeballos et. al. (2010) reported to solve various case studies of different sizes by using integrated CP model.

7. Conclusion

The literature review reveals the existence of CNC machines loading & unloading problems. It is necessary to point out here that the mathematical formulations for establishing numerical relations is required to solve the loading/ unloading problems. Solution of loading/ unloading problems still needs to be solved by several other approaches for optimization of the solution to the problem. Solutions using Matlab, Arena, Plant Simulation, FLEXlm etc. are still required for optimized solution to the problem. Some universal law needs to be established regarding loading/ unloading problems regardless of the type of the plant/ company where the strategy is to be adopted. Also there is always a scope of optimization for any technology, and secondly the FMS strategy is still in growth stage. Hence there prevail a lot more scopes of research in solving loading/ unloading problems with different variants and the formulation of universal laws/ formulas. Lot of work is going on worldwide with physical simulation of FMS's. In this era of physical simulation mathematical formulation cannot be forgotten. The researchers have solved several problems such as minimization of the total evaluation time, maximization of system efficiency, effect of tool policy on the flexibility, improvement of system's performance, minimizing system unbalance, provision of optimal solution to the problem of machine loading, expensive components of FMS, determination of job sequence, efficient machine loading heuristics and solution of various case studies of different sizes. However, the problems such as effective layout for optimized solution to the problem for various types of operations of different sizes of jobs are still required. Similar to the principle of group technology the concepts have to be formulated for machine loading and unloading of machines in FMS. A coding and classification system is required for simplification and optimization of the solution to the problem while considering FMS characteristics under analysis, type of plant and the production planning hierarchy.

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