Justification and Planning Process of Flexible Manufacturing System (FMS)
- 유동제조시스템 활용을 위한 기본요소 : 정당성 및 진행방법 -

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요 지

국제적으로 증가되어지고 있는 제조업분야의 경쟁으로 인하여 사업체들 간에는 경쟁적으로 이상적인 방법의 공장자동화 (Factory Automation)를 품질향상 및 생산성증가를 위한 한 방법으로 채택하고 있다. 치열해지는 경쟁력으로부터 시장을 고수하기 위해 공장자동화가 기업들 간에는 근본대책으로 설정되고 있는데, 이러한 경향은 사업체들이 보다 나은 품질의 제품을 저렴한 가격으로 소비자에게 제공하고 생산력향상을 경제적으로 달성하기 위하여 많은 액수의 비용을 투자하게끔 하고 있다.

현재 여러 종류의 공장자동화 방법이 개발되고 있고, 채택되어지고 있다. 그 중에서도 현재 많은 각광을 받고있는 분야가 유동제조시스템(Flexible Manufacturing System : FMS)이다. 본 연구에서는 유동제조시스템을 공장자동화의 한 방법으로 채택하기 위해 필요한 기본적인 두 가지 요소, 정당화 및 계획과정, 에 관하여 논하였다. 우선적으로 정당화되어야 할 문제점들 중에는: 1) 유동성에 대한 이해와 경제성에 대한 연구, 그리고 2) 노사관계에 관한 문제점들을 고찰하여 각 기업의 특성에 맞게 조절을 해야한다. 이러한 점들에 대한 이해, 연구, 고찰이 이루어지고 정당성이 성립이된 후에는 유동제조시스템을 점차적으로 정착시킨다. 이 진행과정에서 성립되어야 할 점들은 다음과 같다. 첫째, 시스템 채택방법을 택하고, 둘째, 분임조를 결성시켜 설정되어진 과제들을 분담하여 해결해 나아가면서 유동제조시스템이 하나의 고유적인 방법으로 회사의 특색 및 실정에 맞게 정착되도록 한다.

I. INTRODUCTION

A flexible manufacturing system (FMS) has been defined in several contexts through different terminologies. Managers, engineers, researchers, and writers, all with some experience in the automated manufacturing field, have classified FMS based on their experience, and have come close to each other in identfying the characteistics common to most of these systems.

In 1983, Philips [6] has defined FMS as follows:

"FMS are engineered, computer controlled, manufacturing processes that can adapt automatically to random changes in product design configurations, models, or styles."

Groover [5] has also attempted to define FMS in the following manner:

"A flexible manufacturing system consists of a group of processing stations (usually NC machines) connected together by an automated workpart handling system. It operates as an integrated system under computer control... capable of processing a variety of different part types tasks."

Based on these two and other similar definitions, we can conclude that computer control, automatic material handling, NC/CNC machine, and medium-sized production volumes are the main aspects of a given FMS. One other major aspect of FMS lies in flexibility.

There are three principle areas of FMS. These are; 1) the justification, 2) the application, and 3) the planning process. In this paper, because of its complexity, only the principles of justificaion and planning procedures of FMS are discussed. First, for the justification principle, justification criterion is developed. Secondly, the traditional approaches from an economic standpoint are discussed. Thirdly, the factors that make FMS a special kind of investment are identified, and an enhanced justification approach is developed. For the second principle area, the planning process, all of the necessary steps, initiating, adopting, team approach, and implementation, of this process are discussed.

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Ⅱ. FMS JUSTIFICATION

The wide acceptance of FMS around industries today may be attributed solely to the flexibility that they carry. This flexibility has been examined through different methods which led to several connotations that created some confusion about what makes a system flexble.

Ⅱ.1 Flexibility

A study that involved defining flexibility has developed a set of eight types of flexibilities covering all aspects of a manufacturing system [2].

The first type is "flexibility of machine." It refers to the ease of replacing worn-out cutting tools, the ease of changing tools in a tool magazine to produce a different set of parts, and the ease of assembling or mounting the new flxtures. Moreover, a short time for change in NC program is covered by this flexibility.

The second type, "process flexibility," is dealt with the ability to produce a set of part types, using different materials, in several ways. This flexibility increases as decrease in machine set-up times and costs. It is measured in terms of the number of part types that can simultaneously be processed, but not necessarily in batches.

The third type is called "product flexibility." This type involves the ease of switching plans to produce a new (set of) product(s). This flexibility strengthens a company's competitiveness and heightens its potential responsiveness to market changes. It is measured by the change over time required between one part mix and another, not necessarily of the same part types.

The fourth type flexibilities is "routing flexibility." It enables a system to quickly recover from breakdowns and to continue producing the set of part types in process, a flexibility as such can be achieved when parts can be processed via several routes, or when each operation can be performed on more than one machine.

"Volume flexibility" is the fifth type. It simply provides for operating a system profitably at different production volumes. The higher the level of automation, the lower the machine set-up costs and the lower the variable costs and, thereby, the more volume flexible a system would be.

The sixth type is "expansion flexibility" which enables a system to expand as needed, easily and proportionally. The seventh type is "operation flexibility." It pertains to the ease of interchanging the scheduling of several operations for different types of part. It is known that, in several FMS, the ordering of operations is fixed, however, keeping the routing options open adds to the flexibility of making schedule decisions in real-time.

The last type is called "production flexibility." It refers to all the part types that a system can produce. This flexibility is measured in terms of machine tool versatility and the overall level of technology. The capabilities of all previously metioned flexibility types are required.

The study that yielded this classification has developed a relationship diagram (see Figure 2.1) among all eight types of flexibilities. The diagram is a result of the natural interdependence that exists among these flexibilities.

The ideal FMS is one that can possess all of these flexibilities. However, a planner must be careful about the effects of acquiring one flexibility on the others. For instance, volume flexibility can be achieved through the most advanced machine tools which may imply specialization. This would affect process, product, and production flexibilities in a negative way.

Ⅱ.2 Economic Justification

Having determined all areas of flexibility in FMS, the economic impact of this feature can be analyzed and justified.

Ⅱ.2.1 Cost Reduction

The first direct cost reduction emerges from the elimination of most of the direct labor that would be needed in a conventional system. It has determined that FMS technology reduces direct labor by at least 35% [7]. This reduction in turn diminishes errors caused by manual operation and eliminates scrap. Eliminating scrap implies potential direct material savings.

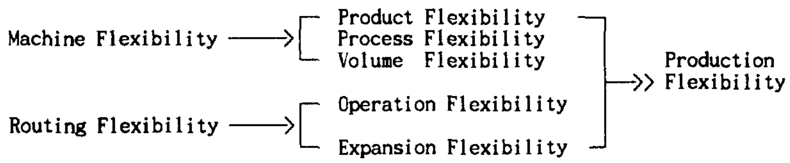

Figure 2.1 Relationship of Eight Types of Flexibilities

An empirical analysis at the University of Central Florida[7] showed that direct cost reductions can vary widely between 3% and 66% based on variables such as proportions of direct costs that are contributed by labor and by materials, scrap levels, and percentage increase of unit labor costs attributed to higher degrees of worker specialization.

Other costs that are reduced by implementing FMS concepts are associated with reduced manufacturing lead time, increased machine utilization, and reduced in-process inventory. Manufacturing lead time is reduced due to the possible elimination of its "non-productive" time components such as workpart handling time, tool handling time, machine set-up time, and etc. This reduction leads to better machine utilization since workparts would then spend more time on the machines than in between. Eventually, workparts are processed at a faster rate, and only few remain unfinished. Thus, in process inventory is minimized. The same empirical analysis mentioned earlier shows a reduction of about 81% in inventory carrying costs and equates that to the manufacturing lead time reduction.

Ⅱ2.2 Justification Approaches

Numerous traditional methods can, and are being used today for economic justification of different projects. Some of these methods that commonly employed are as follows:

a. Payback period.

b. Return on investment (ROI).

c. Discounted cash flow analysis.

d. Life cycle costing.

e. Sensitivity analysis.

Each method of the above treats only certain aspects of the project under consideration. Life cycle costing, however, treats most of the aspects, and attempts to include all of the relevant costs that tend to be omitted from projects economic justifications such as feasibility studies costs, research costs, design costs, maintenance costs, recruitment costs, training costs, and etc.

Hence, with respect to FMS projects, life cycle costing provides the most economical analysis. Nevertheless, additional factors must be considered to enhance the accuracy of this, or any other approach selected for the justification of such projects.

One of these additional factors worthy of consideration with FMS projects is the effect of the overall system integration which leads to indirect cost reductions in work tracking, inprocess inspection, transprotation, tool control, and production control. If this integration is omitted, and CNC machines are considered in separate, the recognizable cost reductions will only be limited to the direct environment of these machines.

Another closely related factor that should be considered is flexibility itself. This pertinent feature of FMS carries several hidden benefits which should be accounted for as explained earlier in this paper.

In addition to hidden benefits, FMS projects possess several hidden added costs. Areas where such costs are incurred involve:

a. Bringing in new skills.

b. Simulating.

c. Testing.

d. Getting the system operational.

e. Maintaining and enhancing.

A FMS is a sophisticated combination of many elements operating as a single unit. A sound economical analysis of such a system requires considerable efforts and should cover the planning, installing, and operating phases of the project. This extensive coverage is essential due to the great impact of each of these phases on the success of failure of any FMS.

Ⅱ.3 Labor Implications of FMS

It is a common notion that unions are opposed to the introduction or FMS, or to any new technology for that matter. However, this opposition can be treated, and FMS can be justified, even though large portions of labor are eliminated as a result of implementing such systems.

The support of unions and workers can be gained only if two conditions are met. One condition is "adequate pre-notification," and the other condition is "non-compulsory redundancy" [8]. Adequate pre-notification is the need for management to communicate, at all times, to all workers the essence of change and progress in the company. Most problems are encountered when management attempts to implement new technology before the workers have had any chance to recognize what this technology entails. Early notification and consultation help prevent such problems. Open consultation must accompany early notification to achieve maximun acceptance. Competitiveness must be proven to be the main reason of change, not profits. All the expected improvements with this change must also be explained and discussed throughout the process. Non-compulsory redundancy is new technology's promises of eliminating monotonous jobs. Job satisfaction is expected and therefore should be achieved.

The FMS concept has evolved to enhance companies's competitiveness through flexibility to market changes, and to eliminate redundant jobs through automation; what is left, then, is to share this concept with the entire workforce in the early planning stages.

Ⅲ. FMS PLANNING PROCESS

Engineers are usually the first to be inspired by the idea of FMS in a given industry. Mechanical, electrical, industrial, production, and computer engineers are typically the most interested in such an idea. The evolution of a FMS project, therefore, is depends on the extent in which one of these engineers convinced with its application in his or her industry.

Ⅲ.1 Initiating and Developing the FMS idea.

Several criteria can prompt the initial consideration that FMS is worth examining. Group technology is one of these criteria. However, for the FMS idea to develop and become a reality, the initiator must find some important allies whom will be able to help achieving the desired goals. These allies should represents, and be respected by major department in the company. Hence, the benefits of a FMS must be proven to positively influence these departments.

The FMS proposal should pertain to each department separately. With respect to the marketing department, for instance, the FMS proposal should cite the improvenments that can be attained by reducing product costs, reducing delivery lead times, improving product quality, and simplifying the introduction of new designs.

The FMS deficiencies experienced in past projects and standardized as corresponding risks must also be pointed out and made aware of. Such risks are encountered in objectives as maximun system utilization, equipment up-time, and flexibility level.

Constructing a FMS proposal becomes very critical, and a feasibility study is necessary in investigating the practicality of such a project. Thus, careful and thorough planning is essential in the early stages of any FMS-related design.

Ⅲ.2 Adopting the Idea

There are two different cases for a FMS project. First, it involves the design of a new plant in which a FMS is considered to be the main instrument of production. Second case evolves when a FMS is considered in an already existing plant where conventional methods of production are ready for replacement. Different approaches are needed for examining these cases.

In the first case, the regular procedure, and all the arguments discussed as early as possible. In the second case, new factors emerge, and their investigation becomes essential. One of these new emerging factors is concerned with the selection of parts for treatment in the FMS. This selection tends to cream off the major, complex or costly items; leaving a mass of other parts which are none the less vital for final assembly or spares and hence, to the business as a whole.

Also, the integration of the FMS with the rest of operations on the plant floor is a critical process that has to examined carefully. Another major area of analysis is the cost of the idle time wasted in renovating a specific area of the plant. Major expenses can be incurred in lost production during that time and therefore they should be accounted for.

The drastic reduction in the labor force which results from the introduction of any FMS has to be adjusted for and justified. This is another sensitive area of analysis that has to be consider carefully. Several problems may exists. The first obvious one is laying off people. Second, due to the long time needed for getting the system set up and running, manpower planning, retraining, and redeployment efforts may produce some unexpected problems. These problems and others should be encountered at an early stage.

Ⅲ.3 The FMS Team

One objective that must be incorporated in any FMS proposal is the use of a team approach in evaluating, designing, and implementing the system. It is discussed earlier that a project of this kind has considerable impact on every department in a company. It is only natural, then, that a team should be formed with representatives from every part of the organization to evaluate the project and ensure its success.

Ⅲ.4 Actual Implementation and Maintenance

When all the planning has been accomplished, implementing follows as the last phase of a FMS prject. This is where all the estimating, calculating, and modelling becomes a reality. However, the process of implementing requires planning by itself and several techniques are present for such a process.

The main feature that must be planned for is flexibility [2]. This flexibility that measured here is in terms of design and maintenance.

Design flexibility should provide for ease of incorporating changes in the layout of the system while implementing, and for future expansions or modifications [3]. In the case of a FMs, this flexibility is difficult to attain due to the fixed nature of FMS components (e.g. fixed material handling lines, fixed machining cells, and fixed warehousing system), and the high cost of remodelling. However, additional lines of material handling, more open areas around machining cells, and similar other stipulations can be employed to induce some flexibility to the design of the system.

Maintenance flexibility is needed when the system is ready and operating, but should be planned for during implementing. Options in this area include back-up machining centers/machine tools, back-up material handling instruments, and back-up computer systems. Simulation can be adopt to estimate necessary maintenance requirements.

It is in this phase that everything becomes final, hidden problems become visible, and any necessary change becomes costly. Moreover, number of researchers [7][1] found out that more work evolves at this phase but it leads to a good results. Therefore, each person involved in a FMS project should always be on cautious, and always test for alternatives.

Ⅳ. CONCLUSION

A flexible manufacturing system by itself does not solve all manufacturing problems. Throughout the planning and realization of any FMS, several options will always arise. These options will imply the analysis of the machining, the tooling, the material flow, the flexibility level, or any other aspect of the system, Thus, the integration of the system with all the other operations of a certain organization is necessary.

The decision-making process will be accompanied with uncertainties due to many "ifs" and "buts" that surround any FMS economic evaluation. These uncertainties are verified upon operating the system, unexpected problems, and benefits, are recognized. Careful planning becomes the key. Weakness in planning can cause problems during the implementation of process.

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