# PRESCREENIG AND EVALUATION OF A
# FLEXIBLE MANUFACTURING SYSTEM

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**Key words**: FMS, criteria analysis, analytic hierarchy process*.*

**Abstract:** The paper describes an interactive decision support framework designed to aid decision makers in selecting the most appropriate machines for a flexible manufacturing system (FMS). The framework can be used in the prescreening stage of the planning process, after a decision has been made, in principle, to build an FMS. The framework mainly consists of two parts. The first part (this paper) is called the prescreening stage, which narrows down all possible configurations by using the analytic hierarchy process..

## 1. INTRODUCTION

The flexibility is defined as the capability of one system to incorporate and adapt to changes from internal as well as external sources. The study of this ability is a quite new subject within the science of the operational systems but it is an old concept in the praxis.

The current status of the technology is considered to have two major dezadvantages: the first, due to its dependancy of the automatic technologies which are associated with high costs, is considered to be applicable only within big companies and the potential benefits of the FMS are too small. The second studied and researched case showed that FMS are simply used as automatic production lines in many cases.

These lead to the fact that FMS is indeed the only group of CNC maschines having automatic tools change and the load side in the same time.

Within different types of flexibility (the maschine, the itinerary, the pocess, production and flexibility volume) only the flexibility of machine tool are treated in this article.
The flexibility of a maschine: it refferes to the different operation types which one maschine can do wihtout beeing necessary for making a big effort from one operator to another.

## 2. MODEL DEVELOPMENT

The shortening of product life cycles and the fierce competition in the market have made manufacturers increasingly wary of the types of manufacturing system technologies and thus they must establish so as to maintain a competitive edge for long-term survival. In recent years, the flexible manufacturing system (FMS) has been widely considered as an effective instrument toward this end. However, implementing an FMS is very costly, and this investment tends to be irreversible, thus necessarily requiring careful consideration before a decision can be made. Decision-making concerning the implementation of an FMS is not only strategic but also involves issues at the tactical and operational levels.

The decision situation is characterized by the presence of both qualitative and quantitative criteria involving social and economic factors. In view of the multiplicity of criteria inherent in such decision-making situations, the methodology of multiple-criteria decision making (MCDM) is used as the framework of analysis [2].

The decision framework as proposed in this paper, is made up of two phases, namely the prescreening phase-strategic phase-and the evaluation stage-tactical approach. The overall methodology is depicted in Figure 1 and data flow diagram in Figure 2. The figures consider both quantitative and qualitative criteria.

As shown in Figure 2, the model has two main parts: the prescreening phase and the
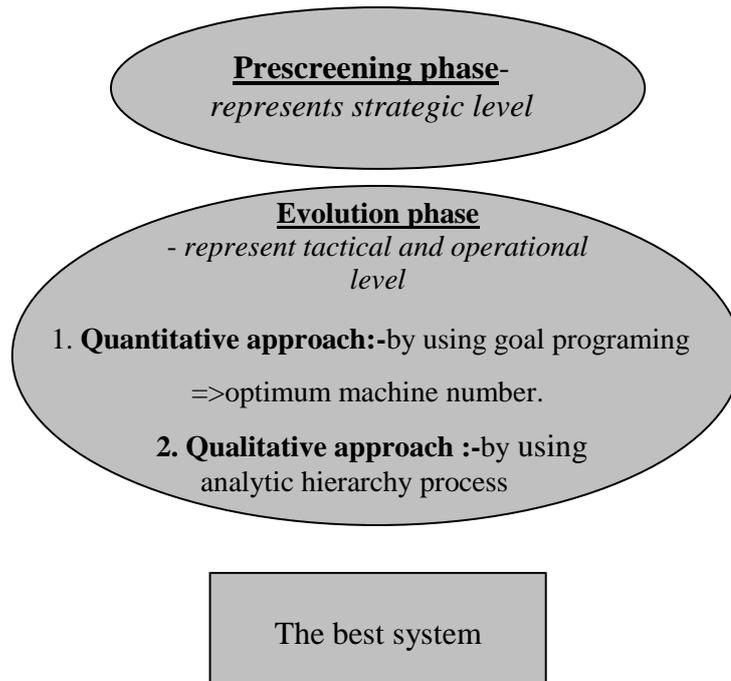
evaluation phase.



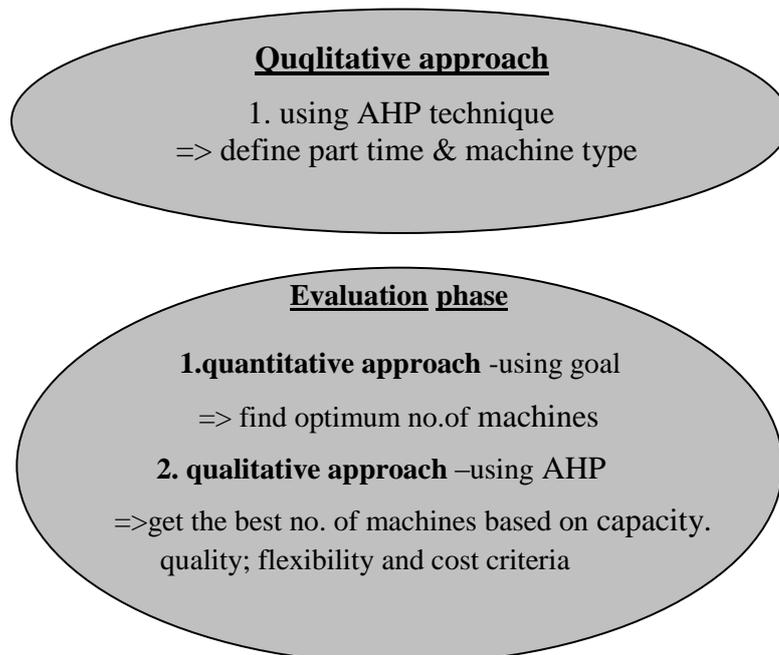**Fig. 1 Overall procedure of the model**



**Fig. 2 Data flow diagram of model**

### 3. PRESCREENING PHASE (Phase 1)

The prescreening phase mainly considers the strategic level. At this level, there is a set of plans and policies by which manufacturing seeks to consider- cost, performance, performance, quality, delivery, flexibility and innovativeness.

The strategic analysis targets two elements:
- the alternatives proposed to fit into the general production strategy;
- the organization (company) must be capable to successfully exploit the new system.

At the first level, the types of products are classified according to four different characteristics as follows [3]:

*1) Introductory demand situation* - the products are planned to be produced with the new system

*2) Increasing demand situation* - the products fave already been produced with the existing system, and introduced in the market;

*3) Constant demand situation* - the product have already been produced with the existing system and market demand is constant and stable;

*4) Declining demand situation* - the products have already been produced with the extinding system and demand is declining with stable condition but is still considered profitable.

The criteria taken into account are: investment cost, capability, flexibility, usage ratio, unit cost and economic risk. After determining the criteria, it is necessary to choose possible alternatives that depend on specific situations and on the type of products planned to be realized with the selected system. The main alternatives are combinations of various types of machine-tools, transfer systems and computers. Accordingly, the overall diagram of the first-phase model is shown in Figure 3.

## 3.1. Evaluation phase

The results obtained from the prescreening model are taken into the evaluation phase, which aims to evaluate the system using quantitative and qualitative criteria. The evaluation phase is mainly divided into two parts. The first part employs a quantitative approach to find the best number of units of each type of machines already selected from the prescreening phase. The other is to find out the sensitivity of the results using qualitative criteria by changing the types of machines obtained from the the quantitative criteria analysis.

## 3.2. Quantitative criteria analysis- The goal programming model

The validity of the model is based on the following assuptions:
Each product type's set of operations is known and has a prespecified production goal.
- Operations are defined by the tools and machine characteristics. Thus, operational time is dependent on the type of machines.
- Each type of part requires one type of pallet and fixture.
The total number of pallets equals three times the number of machines in the system [5].
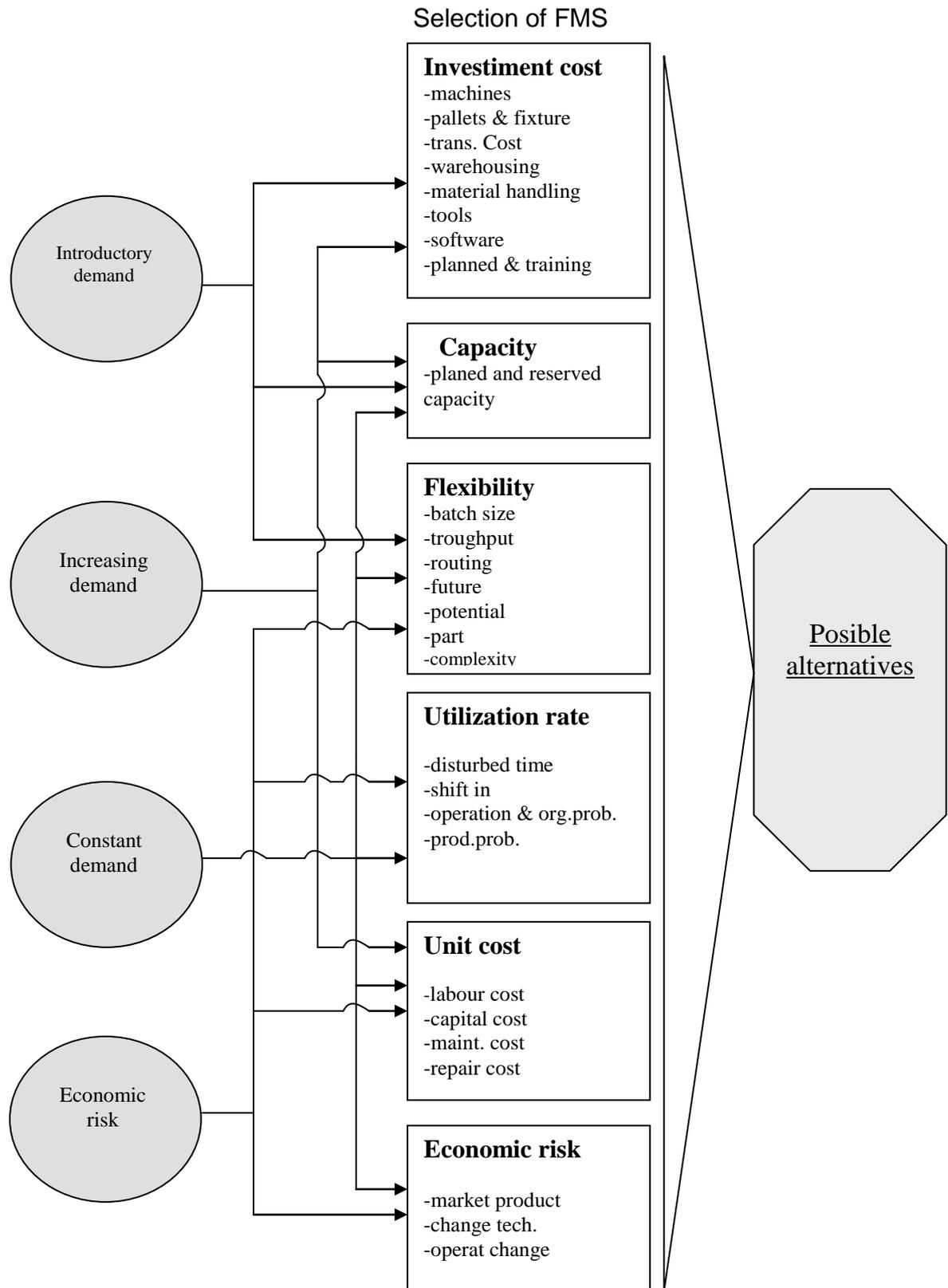
Selection of FMS

**Investiment cost**
-machines
-pallets & fixture
-trans. Cost
-warehousing
-material handling
-tools
-software
-planned & training

Introductory demand

**Capacity**
-planed and reserved capacity

**Flexibility**
-batch size
-troughput
-routing
-future
-potential
-part
-complexity

Increasing demand

Posible alternatives

**Utilization rate**

-disturbed time
-shift in
-operation & org.prob.
-prod.prob.

Constant demand

**Unit cost**

-labour cost
-capital cost
-maint. cost
-repair cost

Economic risk

**Economic risk**

-market product
-change tech.
-operat change

*Fig. 3. Hierarhical structure of the decision problem*

5.4

The requirement is to find the number of each type of machines and pallets according to the corresponding demand characteristic of products to obtain maximum profit.

The goals considered are follows [2]:

- maximize profit to cover the cost of automation
- to minimize the cost of investment, it is needed to minimize the total number of pallets, fixtures and AGV.
- to fulfil the demand of products
- balancing loading in machines.

After defining the goals of the sistem, the goal constraints can be formulated as follows:

➢ -a-Profit

$$\sum_{i=1}^{I} B_i N_i - \sum_{j=1}^{J} (N_j M C C_j + TTC_j) - AC \cdot AGV - CC - CL \sum_{j=1}^{J} + d^- - d^+ = T$$

$$i = 1,2,...I,\qquad (1)$$

where Bi is the expected profit from product i, T the target profit, TTCj the tool cost at type j machine, AC the AGV cost, MCCj the type j machine cost, CC the computer cost and CL the belt cost.

➢ -b-Total number of fixtures: to minimize the cost of production, the total number of fixtures should be minimized:

$$\sum_{k=1}^{K} F_k + dc^- - dc^+ = NPP,\qquad (2)$$

where NPP is total number of available pallets.

-c-Demand:

$$\sum_{k=1}^{K} N_i N_{ki} + d_1^- - d_1^+ = D_i$$

$$i = 1,2,...,I,\qquad (3)$$

where Di is the demend of product type i.

➢ -d-Machine loading : minimize the overloading and underloading of machine capacity in each type of machine:

$$\sum_{k=1}^{K}\sum_{i=1}^{I} N_{ki} t_{ij} + d_j^- - d_j^+ = MC_j$$

$$j = 1,...,J,\qquad (4)$$

where MCj is the type j machine capacity

The goal objectives are proposed in the fowing order of priority:

- maximize profit
- minimize the number of fixtures and pallets in the system
- maximize production to satisfy demend
- minimize overloading and underloading of machine capacity.

Then the overall obiective goal can be presented as:

$$\min \left[ P_1 d^+, P_2 dc^+, P_3 \sum_{i=1}^{I} d_i^-, P_4 \sum_{j=1}^{J} (d_j^- + d_j^+) \right]\qquad (5)$$

### 4. CONCLUSIONS.

Before developing new technology in a company, it is necessary to perform, the investment analysis. The high level of investment in machine-tools and in transfer systems for the blanks from a FMS requires the making of careful decisions for selecting the types and number of machine-tools and of blank transfer systems. It is necessary to make a detailed analysis on the decision-making model.

There are many approaches to this problem. In this paper are developed a two-phase model to cover quantitative and qualitative criteria and dynamic situation of system.

It is very interesting to link the flexibility index to demand patterns of products. The researcher is now developing a model based on the flexibility index for product design by using concurrent engineering concepts. Finally, defining the quality criterion as a quantitative parameter by using a quality deployment function or developing a new function to catch customer voice is very interesting in decision making.

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