FMS AT WORK

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Foreword

THE advantages of the flexible manufacturing system to the small batch manufacturer have been the subject of many articles and conference papers. These, along with organised visits to actual users, particularly in Japan, have helped establish the importance of the flexibility of manufacture offered by this development. The ability to manufacture in 'batches of one' by using flexible manufacturing systems has such an effect in competitiveness, not only of individual companies but of those countries whose manufactured exports play a significant part in their economy, and will depend upon the innovative application of these computer based and associated technologies.

In *FMS at Work*, John Hartley reminds us that FMS, like automation, means different things to different people. It may not be the appropriate solution in every case, but through an understanding of the building blocks essential to the planning, implementation and operation of a flexible manufacturing system, there are advantages that can be extracted and tailored to suit the business needs and technical skills of a particular company. This message is relevant irrespective of size.

Starting with the CNC machine tool as the base from which to build a flexible manufacturing system, John Hartley goes on to cover the critical importance of tooling, material handling systems, in-process gauging, machine monitoring, computing and the relationship with CAD/CAM. These sections of the book not only provide a perspective of the technologies that need to be encompassed in the design and selection of equipment, whether it be for a full FMS or some part of the projected system, but also identify some of the pitfalls which, without standardisation of method, tooling and pallet systems and software interfaces, one can so easily stray. It is invaluable as a check list to anyone venturing into this field for the first time, as well as a reminder to those with some experience.

While most of today's FMS are designed to perform machining operations, the potential application of these principles to welding and press work, are already being actively pursued. These developments and future programmes using laser technology within an FMS give an indication of what the future holds.

At the beginning of the book, John Hartley writes "that FMS, not robotics, is the beginning of a new industrial revolution", a view fully shared. His book is a valuable contribution to an understanding of a subject so essential for success. It is a book to be read by all who have an interest in the future of manufacturing and the national economies of those countries whose exports depend largely on batch manufactured goods.

Frank Turner
Director, Manufacturing Engineering
Rolls-Royce Limited

Preface

FMS is perhaps the most important manufacturing process since the assembly line came into use at the beginning of the century. It will revolutionise manufacture in that the cost of small volume production will fall dramatically. At the same time, as a result of the introduction of FMS, the manufacturing industry will need far fewer employees than at present possibly 60 to 80% less over the next ten years.

Therefore, it poses social as well as technical problems, but is nevertheless an inevitable route ahead for competitive and ambitious manufacturers. My aim with this book has been to explain why FMS is advantageous, to describe the essential elements, and how some companies are already putting the principles to good use. In addition, I have looked at the potential for improved systems in the future, and what might happen in employment. My hope is that it may be helpful to anyone becoming involved in this area of manufacture.

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CHAPTER ONE

Who needs FMS?

A UNIQUE opportunity of increasing profits and return on capital is waiting for companies ready to involve themselves comprehensively in FMS (flexible manufacturing systems). Conversely, it is no exaggeration to say that failure to exploit the concept can lead to an almost irreversible trend to uncompetitiveness and dwindling market share.

FMS, not robotics, is the beginning of a new industrial revolution which will at last lead to manufacturing industry approaching the levels of automation taken for granted in process industries.

FMS is not the answer for everyone, but in the many industries where it is appropriate, its advantages should be grasped with both hands. The reason is simple; we are not talking of a new manufacturing process that will just give a boost to productivity, but of a concept that will drastically change the way in which companies operate, from the procedures involved in purchasing and ordering through to distribution and marketing.

With FMS it is practical to combine high productivity with small batch sizes and short lead times. Thus, manufacturing strategy enters a completely new era, and the timing could not be better. For example, the world is beset by protectionism, so that it is often necessary to produce assemblies in uneconomic volumes in countries such as Australia, Taiwan and most of South America.

With FMS, it is possible to machine two or three different engine cylinder blocks, say, or valve and pump bodies, in low volume at relatively low cost. Therefore, more companies will be able to set up small local manufacturing plants. But whatever and wherever they sell, they will have the opportunity of responding to market changes much more quickly than at present.

What are the advantages of FMS? Quite simply it is an unprecedented opportunity to slash drastically the hidden high costs of manufacture – work-in-progress and overheads such as indirect labour. These days materials and overheads account for 50–90% of total manufacturing costs, so any gains here are impressive. FMS also leads to unmanned operation, but in most cases, it gives a greater gain in reduced overheads than it does in reduced labour costs.

The results of early machining systems are impressive. In one case, the profit over a five-year period was put at £15 million, whereas a conventional machine shop, based on CNC (computer numerical control) machines would have produced a profit of just over £1 million in the same period. Then, the cost of work-in-progress was claimed to have been reduced from £3 million to about £150,000. In another case, output/h was increased six-fold, while tool changing times came down from 80 to 4h.

Other companies talk of reducing lead time by 50–60%, and of payback periods of two or three years for big investments. One company claims scrap has been reduced from 25 to 5% of output, and another talks of cutting its huge inventory costs in half. In all cases, substantial benefits have been made, in financial and operating terms. With new systems, the target should be to triple productivity or output/man. (Fig. 1.1)

But what is FMS? When Theo Williamson, then Director of R&D at Molins, Deptford, London, invented the concept, he was thinking in terms of a flexible machining system, and it was in machine shops that the first FMS was installed. His concept was called 'System 24' because it was intended to operate for 24h a day, under the control of a computer, but otherwise unmanned, on the 16-h night shift. That was the beginning of the path to FMS.

Williamson planned to use NC (numerically controlled) machines to carry out a series of machining operations on a wide range of workpieces. Workpieces would be loaded manually on pallets which would then be moved to the machines and loaded automatically as needed. Each machine would be equipped with a magazine from which tools would be selected automatically to perform different operations. Included were systems for clearing swarf and washing workpieces. This was a system combining the flexibility inherent in computer-controlled machines with very low manning levels. And that, basically, is what we mean by FMS. With the advent of robots and other computer-controlled equipment, the concept of FMS can be applied to other processes, from metal forming to assembly. (Fig. 1.2) It could be ideal for the manufacture of low-volume high-variety spares, too.

When the first FMS were installed, they followed Williamson's concept, with the addition of refinements to detect and compensate for tool wear and to detect for tool breakage. Thus, it became possible to machine a wide variety of workpieces on few machines with low manning levels – and that flexibility and high productivity are what FMS is all about. In almost any manufacturing industry FMS will pay dividends, so long as the term is used in its wider sense – flexible automation might be better – not just to define a machining system.

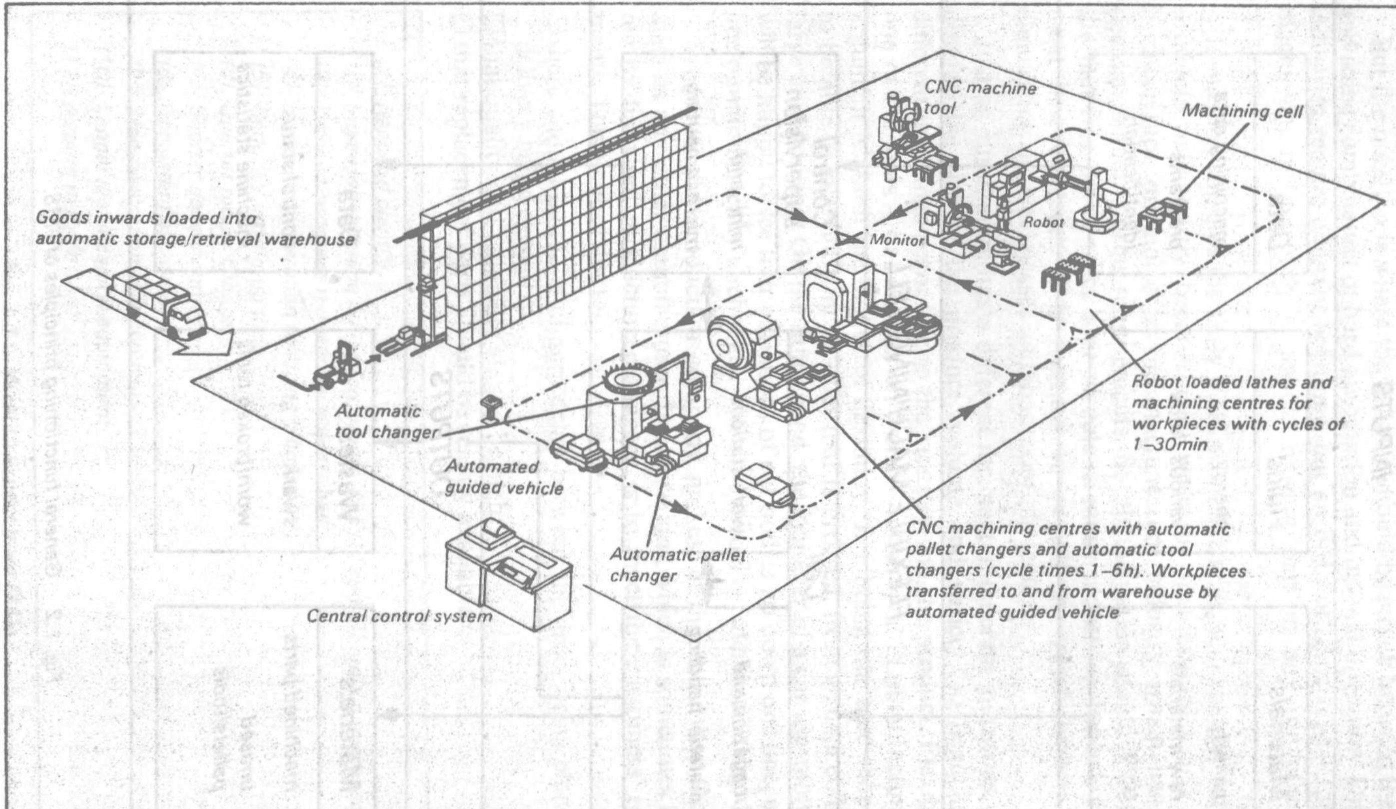

Fig. 1.1 *The principle of FMS: machines that can work on a variety of components unmanned, with automated tool and workpiece changing. Delivery of workpieces is by unmanned trolley*

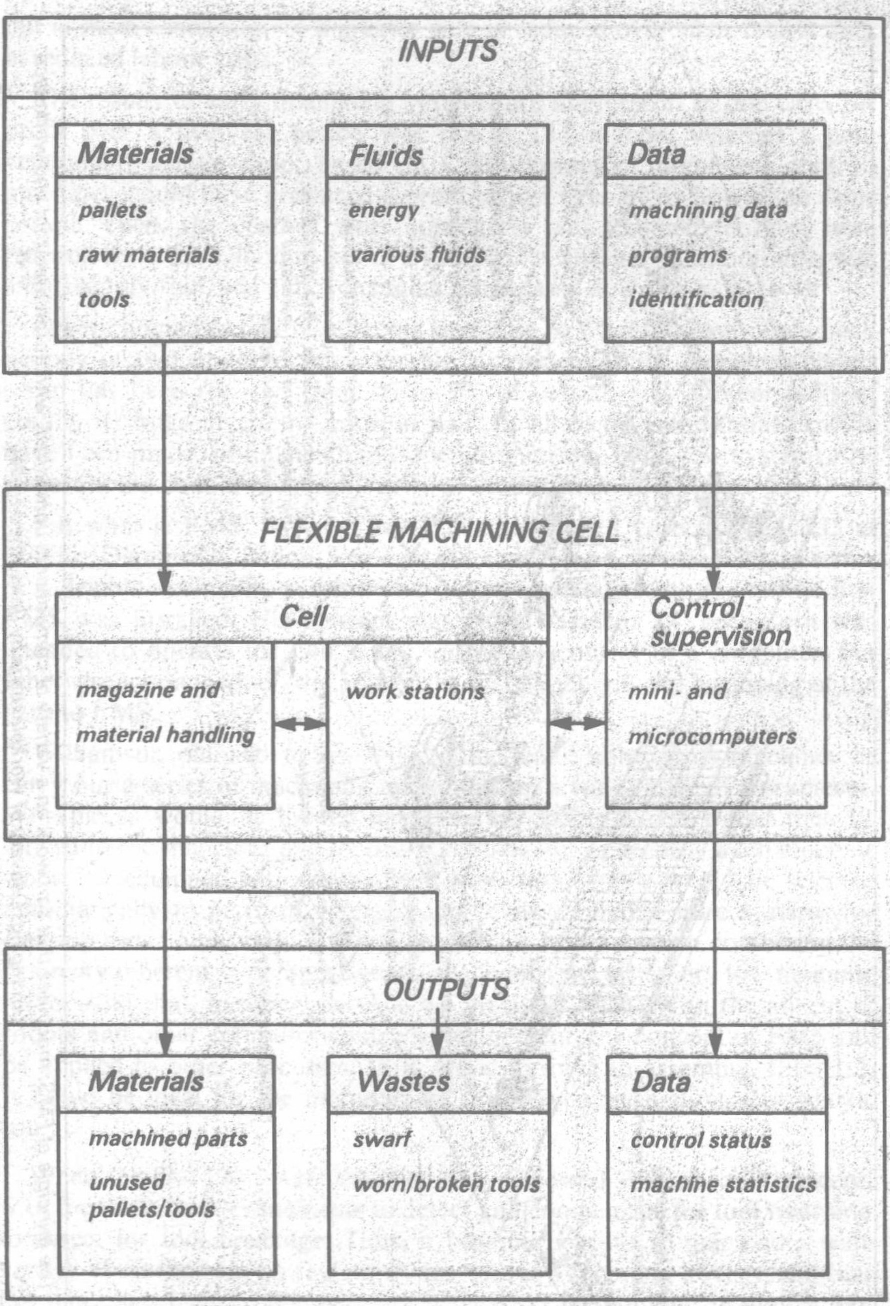

Fig. 1.2 General functioning principles of FMS

But the question is where the balance should be struck between the FMS and some combination of hard automation and manual operation. Different industries require different solutions, but an FMS of some type – forming, machining, or assembly – should have a part in any manufacturing strategy.

Ironically, some of the early FMS seem inflexible, and suitable for a few products only, partly because they were the first examples and partly because they originated in the machine tool industry which has some peculiar manufacturing requirements. But that situation should not obscure the fact that the concept is applicable to many industries. Indeed, as with most new concepts, it is essential to exploit the good features while eliminating the weaknesses and inappropriate features.

Just as automation has a different meaning in different industries, according to the size of the product, volume and variety, so flexibility has different meanings according to the industry and the product. Flexibility is one of the keys – but not the only one – to survival in manufacture. The argument is about the degree of flexibility. A jobbing machine shop needs to be able to machine any product that is ordered, from a small collar to a large cast housing. On the other hand, the manager of a car assembly plant will be happy to see four variations of car bodies go down one line, and the line remain basically unchanged when the model is redesigned. (Fig. 1.3)

Whatever the products a company makes, in the end it has the same aims as any other manufacturer. Its prime aim, which is sometimes forgotten by harassed production managers, is to meet the customers' requirements. This implies that:

- ☐ there should be the minimum delay between the order being placed and delivery being executed;
- ☐ that quality and reliability should be high;
- ☐ that replacement parts should be readily available.

(1) Reduced plant size
(2) Increased machine utilisation, which with (1) and (3) reduce overheads
(3) Work-in-progress reduced by at least half
(4) Unmanned operation reducing labour costs
(5) Reduced setting-up time
(6) Quicker model change
(7) Shorter delivery times
(8) Consistent accuracy
(9) Standardisation of techniques
(10) Longer life of capital equipment
(11) A route to CAD/CAM

Fig. 1.3 What to expect from FMS

On the other hand, to keep the company profitable, a high return on capital investment is needed, and this implies:

- □ stocks of finished parts and of work-in-progress should be kept to the minimum;
- □ manning levels should be low, and automation equipment should be kept running as much of the time as possible.

Of course, these are conflicting requirements in many ways, but to meet orders promptly and keep costly stock to the minimum, a short lead time – the time taken to process a component from selection of the raw materials to finished product – is the key. Short lead times, which give a company a competitive edge, are a feature of FMS.

To maintain high standards of quality, a high level of automation is needed; thus corrections are made to the process in time to avoid rejects being produced. But traditionally, automation implied high capital investment and inflexibility. Now we need a high level of automation so that good quality can be guaranteed even if a batch of only five or six parts is being produced.

While striving to gain a high return on investment, managers must be able to cope with big variations in demand between products, and have to be able to switch to new ones – without high cost or long periods of downtime. For example, in some industries, such as toys and consumer products, there is very big seasonal demand before Christmas, while major events such as the Olympic games and the World Cup produce temporarily high demand for television and video sets. Air conditioners are bought mainly in the spring, and heaters in the autumn.

On top of that, there are big fluctuations in demand for different models. In television sets, for example, the trend is for sets with large screens to increase, but a substantial market for small portable sets has developed. But however much market research is carried out, no one can really be sure in what proportions the 18 or 20-in. sets will sell over a three year span. Nor can a car manufacturer be certain whether the hatchback or saloon will be more popular, and in any case, the proportion changes from year to year. Nor for that matter can it be sure how the market for diesel cars will compare with that for those with gasoline engines.

The market is continually changing, and it is certain that the rate of change will be faster in the future than in the past. The consumer electronics industry is a prime example of what is happening. First, there was monaural audio, then stereo, and now digital audio on a new type of disc and tape. But that may be replaced by video, as people want to see as well as hear. There is also confusion in the video scene. There are video cassette recorders (vcrs) and now video disc players (vdps), with an ultra-compact vcr at an advanced stage of development. On top of that there is the erasable disc which will change the whole scene.

In addition, there has been a trend to very small audio equipment, such as the tiny Sony Walkman. No sooner is one model introduced than another company introduces a smaller one, and so it goes on. One manufacturer has put the life of a product in that market as only four months. Clearly, the manufacturing plant has to be flexible enough to be used for many successive models.

Superimposed on these normal, but increasing, fluctuations in the market, are major events such as crises in the supply and demand and the cost of oil and other commodities, trade embargoes, protectionism, and changing values of various currencies. Clearly, companies need to adopt flexible policies to deal with such major events, and that includes flexible manufacture.

In meeting these eventualities, each company devises a strategy based on its forecasts of the various market strengths and weaknesses. In addition there is legislation that makes a product more popular, opens up new areas, or closes old ones. Flexibility is a part of that corporate strategy, and must extend to manufacture.

But alone, flexibility is not enough; to compete, a company also needs high productivity to give low unit costs. After all, a skilled machinist, a turret lathe and a pillar drill are an extremely flexible combination. Give him the material and the drawing, and the machinist can produce a wide variety of parts, in batches from one to any number you like. But he needs time to set up his machine, select the tools, and he may need to make some special fixtures for some operations.

So it is hardly surprising that although the machinist is flexible, his productivity is low, especially with small batches. In addition, the machines spend a lot of time idle.

Research by Cincinnati Milacron has shown that on average in jobbing machine shops, the workpiece spends about 30% of the working day actually on the machine. The rest of the time the machinist is either setting up the machine, going to obtain material for the next job, sorting out tooling, and so on. Even worse, the research showed that the workpiece is actually being cut for about 5% of the time it is in the shop.

It is true that the introduction of NC and, later, CNC machines had a dramatic effect on these figures, simply because one machine could carry out a large number of processes with only one setting-up process. Nevertheless, that man with his machine is a good example of flexibility with poor productivity and low machine utilisation.

A manual assembly line is also flexible. With training, the operators can assemble almost any product of reasonable size. In addition, they perform dexterous acts which we take for granted. They can detect if a thread is deformed before it does any damage, or if a part is too loose or too tight a