Continuous Improvement and Participative Factory Planning by Computer Systems

E. Westkämper (1), R. von Briel
IFF Institut für Industrielle Fertigung und Fabrikbetrieb (IFF), Stuttgart, Germany
Fraunhofer Institut für Produktionstechnik und Automatisierung (IPA), Stuttgart, Germany

Abstract
Turbulent influencing factors – based on market requirements and technological demands – lead to a permanent change and improvement in the factory processes, manufacturing systems and layouts. New investigations in manufacturing show that the application of new machining processes and tools require a systematic and stepwise change of the layout and the organisation in order to activate the economic potentials. It is evident that continuous improvement and optimisation with the perspective to medium-term objectives can be realised by means of new methods and new computerised systems for factory planning. Digital models and the technology of virtual reality allow the continuous planning of changes in factories. This paper includes results of the planning of future manufacturing systems and the systematics of continuous planning based on digital modelling and virtual manufacturing.

Keywords: Digital Factory, Simulation, Virtual Reality

1 INTRODUCTION

According to the American scientist H. Mintzberg [1], turbulent influencing factors have been a major challenge and cause for problems in manufacturing enterprises since the beginning of industrialisation. Even if these statements are true, and turbulence seems to be nothing new for manufacturing, the current high speed of innovation in manufacturing technologies forces enterprises once more to search for new principles, new mechanisms and new tools to enable a faster adaptation of the performance of today's manufacturing systems to the changed market needs.

Nearly all influencing factors of the factories' performance are dynamic factors. Therefore, the thesis may be that a factory never operates at its highest level of economy and performance. Consequently, the structure of the factories, their resources and processes have to be adapted and continuously improved. The factory development has to be oriented to strategic objectives taking into account a permanent change and optimisation in order to ensure at any time operation on the highest possible economic level.

This paper, inspired by several investigations in the German manufacturing industry and by developments of new tools and systems for factory planning, illustrates the increasing demand for continuos improvement and so-called participative planning methods using computerised technologies for digital and virtual manufacturing with a holistic approach.

2 TURBULENT INFLUENCING FACTORS AND THE DEMAND FOR CONTINUOUS ADAPTATION OF FACTORY STRUCTURES

Nearly all external and internal factors influencing the performance and the economic results of manufacturing are permanently changing. Manufacturing is – in the view of cybernetic science - a multi-scale (time and room) chaotic system.

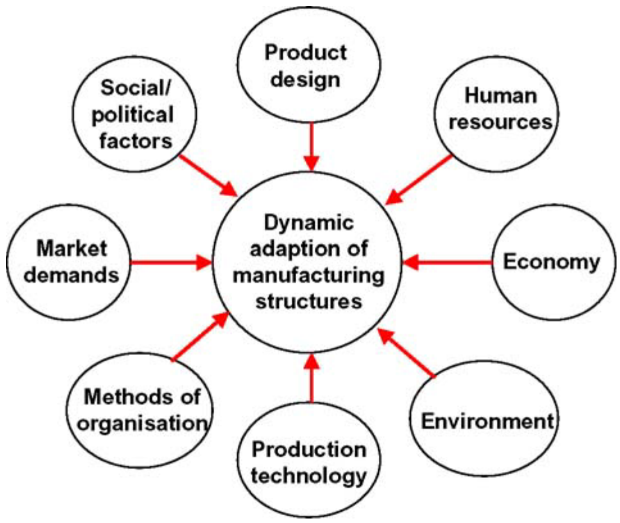

Figure 1: Influencing factors in manufacturing systems

Figure 1 shows the main factors. The factory as a multi-functional and complex system has to be managed in view of the fulfilment of customer orders and economic objectives. More and more factories have to be seen as nodes within production networks. Their reliability, productivity and flexibility are influencing the manufacturing quality and costs and thus the overall efficiency of these networks.

Years ago, flexible manufacturing systems, which were highly automated and flexible in view of changing orders, seemed to be the answer for an increased economic efficiency and adaptability to changing market requirements and reduced lot sizes. One main objective of flexible automation was the reduction of workers and influencing human factors like work time or direct operations. But we learnt that these concepts were not flexible enough to compensate fast changing product technologies or product design and market demands.

We also learnt that it takes a long and detailed planning procedure to optimise the processes and to change the layout of systems, equipment and peripherals. And, the partial reinvestment or reconfiguration of flexible manufacturing systems seems to be expensive because of interfacing problems and missing long-term standards.

Under today's conditions, a prediction of what will happen on the micro-scale (processes) or macro-scale (factories network structure) is nearly impossible. At that time when decisions to invest in manufacturing systems are made on defined products, manufacturing programs, number and qualification of workers, etc., it is known that all these factors will change again in the future more or less. The life time of manufacturing systems is much longer than the life time of products. The usual life time of manufacturing systems is higher than 10 years. The life time of products is much shorter and has a tendency to become even shorter. Electronic products, for example, change every year. Consequently, the layout and technical functionality of manufacturing systems have to be changed more quickly in view of product requirements, economic objectives and the state-of-the-art of technologies. The performance has to be measured permanently against best of class.

Technical investments in manufacturing systems and factories are "long-life products", which have to support companies strategies. This means, that the planning of factories and investments have to be part of the strategic and business planning and oriented to strategic objectives. On the other hand, they are the basis of economic operations. The planning of factories has to cover a full time scale from here and now to a long future perspective.

But there are some more main aspects which lead to the demand for permanent improvement and adaptation of manufacturing systems and the factory structures.

Figure 2 illustrates the dynamics of orders and delivery over longer planning periods. Following the philosophy of manufacturing on demand with low stocks, lowest lead times and shortest and just-in-time deliveries, companies have to solve the problems of changing capacities.

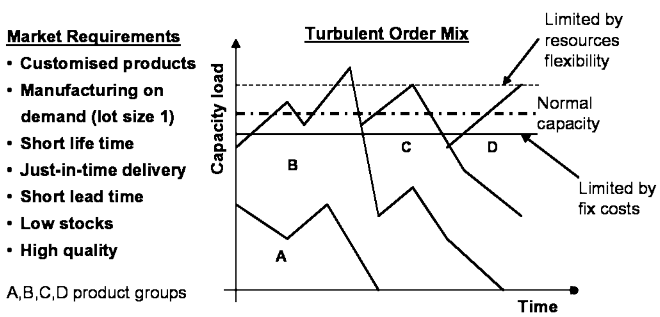

Figure 2: Dynamic order development and capacity load

In the automotive industries, so-called "10-day cars" are being discussed. Some manufacturers actually think that a customer-specifically configured car can be produced on time with such a short lead time including manufacturing of components within the corresponding supply chains. Investigations in German manufacturing industries have shown the dynamics of order structures and a total value of +/- 30 % to the normal capacity in short planning periods. Usually, companies equalise their capacity load by adapting their personnel resources and additional shifts. The flexibility is limited by the cost structure and mainly by the level of fixed costs.

Changing order situations and the high dynamics of the capacity load need more technical flexibility including the permanent optimisation of the layout and structure of manufacturing systems. The shorter life time of products increase the quantity and volume of planning processes. Under these aspects, the early phases of product development and the costs of prototypes, pre-series and start up of series are of extreme importance.

The learning curve revealing the reduction of costs mainly in early phases of new products clearly characterises this. The curve show the reduction of costs per unit as a function of the cumulated number of manufactured products. Just in cases of products with shortest life time, a dramatic reduction of costs is to be realised in early phases of product development [2].

Learning effects are based on a series of different organisational and technical actions and improvements. Sometimes, a late realisation of the necessary technical equipment like tools and fixtures, missing qualification or the stabilisation of processes are causes for defects and higher costs. It is evident, that optimised planning can reduce the costs in early product phases. Just in these phases work and factory planning have to be integrated and oriented to the medium-term objectives.

Under these time conditions and the pressure of external and internal influencing factors, companies prefer to react than to act on strategic objectives - taking into account new technologies and innovations for future demands and development of the factory structures.

As an indication for this high speed of innovation, a research project in the German machine tool industry showed that within five years the productivity, measured as the time needed to produce one single part, can be reduced by half through an integrated new machining, tool and organisational concept (figure 3).

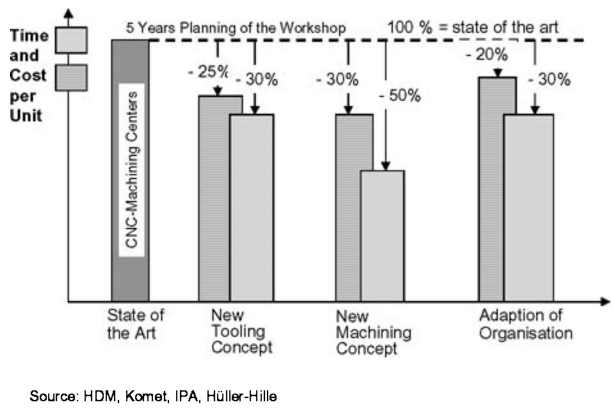

Figure 3: Improvements caused by technical optimisation of a factory

Owing to the existing structural inflexibility and the long investment periods caused by high investment volumes for manufacturing equipment, this adaptation did not mainly focus on the changes of the technical manufacturing structure itself, but on organisational means and on the aspects of production planning and control [3,4]. Structural inflexibility in this case can be described as the technical and economically caused inflexibility in the layout and in a later functional integration in systems and machines. Therefore, the idea of a continuous adaptation and a continuous improvement has had a strong relation to organisational and PPC aspects in the past [5].