2

Re-engineering through fractal structures

Dr.-Ing. Wilfried Sihn
Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)
Silberburgstr. 119a, 70176 Stuttgart, Germany
Tel: ++49 711 970-1964
Fax: ++49 711 970-1002
e-mail: whs@ipa.fhg.de

Abstract

Many branches of European industry have had to recognise that their lead in the world market has been caught up with, particularly through Asian competition. In many cases a deficit of up to 30% in costs and productivity already exists. The reasons are rigid, Tayloristic company structures. The companies are not in a position to react flexibly to constantly changing environmental conditions.

This article illustrates the methods of the "fractal company" which are necessary to solve the structure crisis. The fractal company distinguishes itself through its dynamics and its vitality, as well as its independent reaction to the changing circumstances.

The developed methods, procedures and framework conditions such as company structuring, human networking, hierarchy formation and models for remuneration and working time are explained. They are based on practical examples from IPA's work with the automobile industry, their suppliers and the engineering industry.

Keywords

fractal company, organisational structures, hierarchy formation, re-engineering

1 THE SHIFT OF GOALS

There has been a clear shift concerning the objectives of industrial production. See Figure 1. Goals of production that have been held up for decades are giving way in favour of speed objectives. This is mainly due to a shift from purchaser markets to seller markets. The cause for this shift is the saturation, or even the over-saturation, of markets. According to surveys, profit losses during commercialisation are highest if there is any delay in placing the product on the market. Other factors are less important. There are fewer products whose production is

J. Browne et al. (eds.), *Re-engineering the Enterprise*

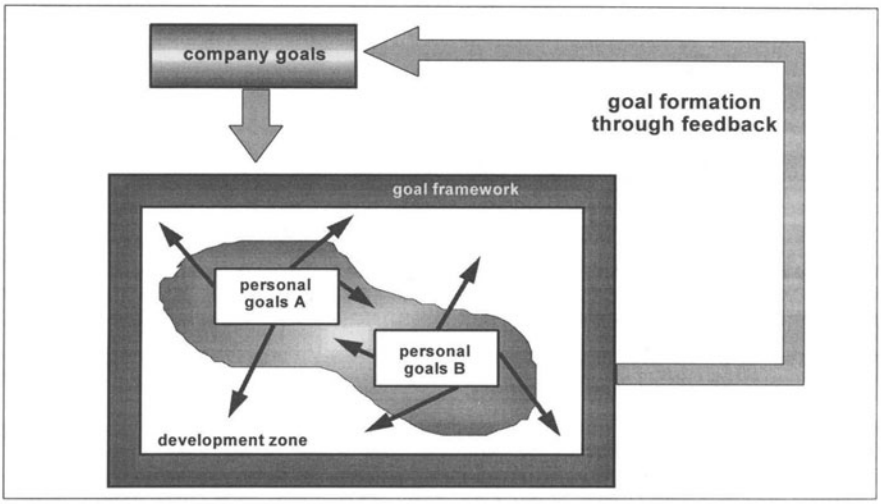

Figure 1 Goal formation process in the fractal factory.

complicated in the conventional sense. On the one hand, fully matured components whose assembly results in final products contribute to this. On the other hand, manufacturing technologies, becoming increasingly reliable, ensure consistent quality and allow the production of complicated parts by normally trained staff. This means there will be more suppliers serving the market with similar products. The result is an over-saturation of the market. See Figure 2.

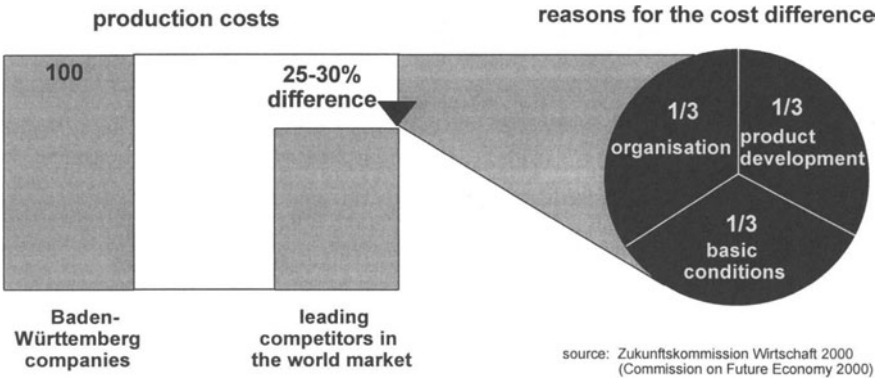

Figure 2 Cost disadvantages of companies in Baden-Württemberg.

2 HISTORICAL CHANGE

Taking a historical look at production development, the number of employed factors and their availability has been steadily increasing. This is remarkable, especially concerning the availability of mechanical energy and information which is crucial for industrial production, allowing the effective and timely usage of resources which results in reduction of the stock of resources. Because of this reduction it is not always possible to have a stable situation, that is, to always run production according to events calculated in advance. Rather, the dynamics of the events will increase. One will have to abandon certain processing stages without prior planning and leave them to their own devices, which means entrusting them to higher control circuits. As a consequence, it is of utmost importance to incorporate into the company and manufacturing strategies the greatest closeness to customers and an extreme ability to react promptly. The speed objective must be pursued vigorously, even regarding the development of operating technologies.

3 PRODUCTION FACTOR INFORMATION

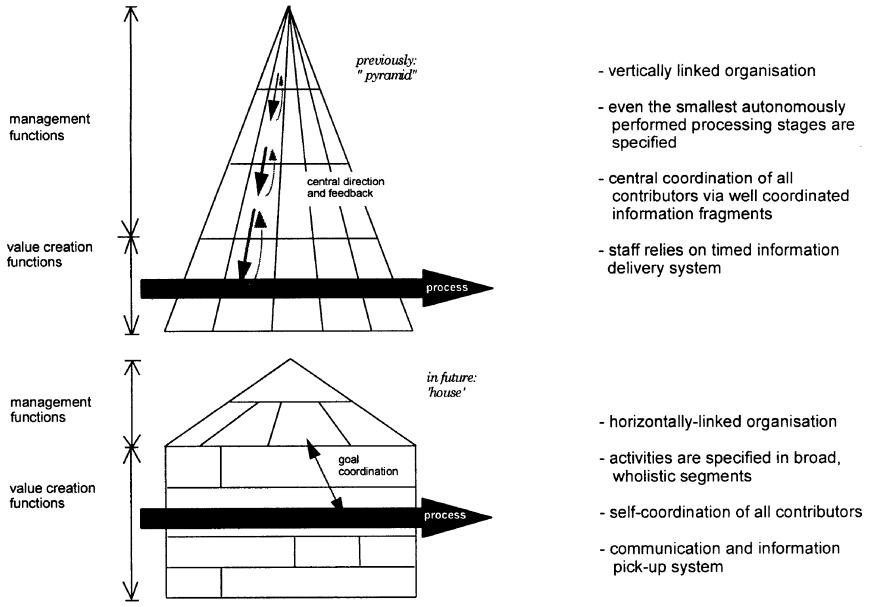

Figure 3 Interplay of organisation, information and value creation.

The decline in prices for electronic components, improvements in efficiency of data processing units and progress concerning communication technologies make any desired quantity of information available at any place at any time. Despite this fact, the processes in our industrial companies are still organised according to the old model in which the division of labour has also been used for minimising the effort for drawing up information. Although each worker could be included in the fetch-principle, as far as the required information is concerned, our organisational structures work according to the bring-principle for information by staff functions and through hierarchy levels. See Figure 3. Overcoming this discrepancy is the task of the coming years for each industrial company. These developments could enable the organisational structure to become flatter, and will result in more scope for decisions and more responsibility for each individual in the organisation. In the past, one believed the secret of effective performance specification consisted in Taylorism, applying appropriate coordination. Conditions have now radically changed. The summing up of contents of labour is required. Tasks must be interlinked and turned into processes. Also, flow design is called for. The organisational structures will increasingly turn into project organisations. See Figures 4 and 5.

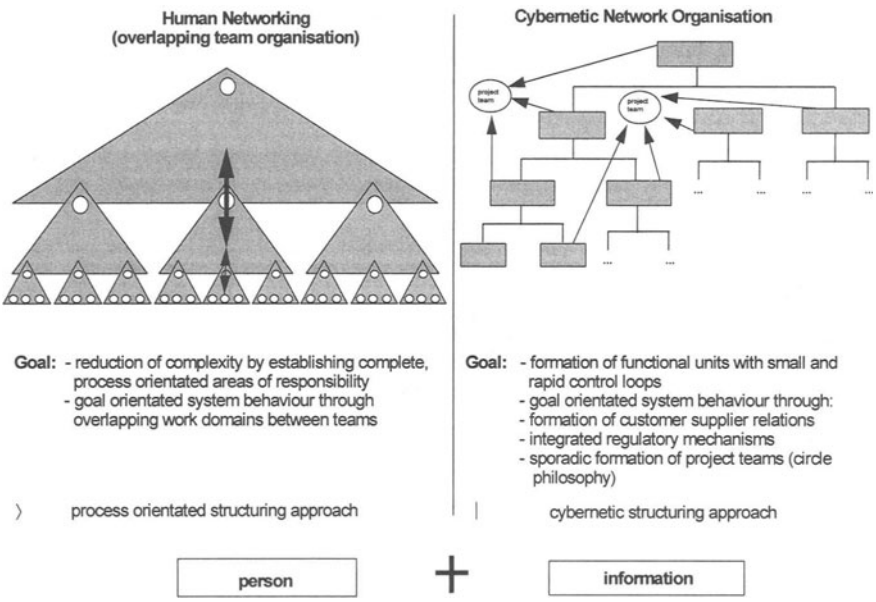

Figure 4 Organisation structures in the fractal factory.

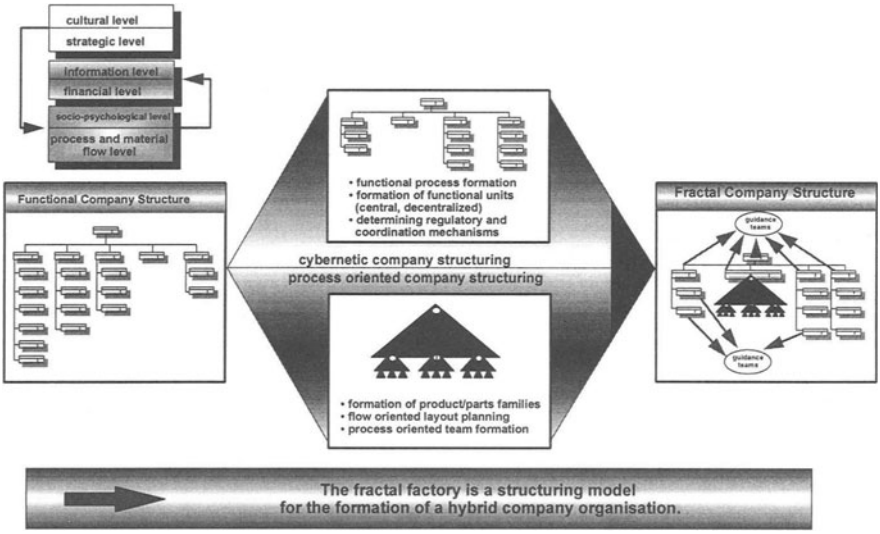

Figure 5 Company structuring in the fractal factory.

4 LIMITATIONS OF CURRENT SYSTEM CONSIDERATIONS

The faster moving markets, technologies and information systems available everywhere lead to higher pressure on the companies. There is an increased demand for innovation and speed concerning processes and adaptation. As a reaction to the environmental dynamics and fast-moving events, strong self-dynamics and the ability to evolve are required. However, our current view of a manufacturing company is static. We assume there are definite, clear-cut tasks and that a need exists for authorities who issue instructions on a rigid structure scale. A company develops in a linear fashion, and the economic and arithmetic models are static.

5 CHARACTERISTICS OF DYNAMIC CHANGE

With such above-described changes concerning important parameters for a manufacturing company, conventionally structured companies are no longer able to fulfil the required self-dynamics with the necessary speed of evolution. The results of this rigidity become increasingly perceptible to everyone in the company. Phenomena such as rising pressure concerning costs, a rapidly worsening profit situation, a waning ability to adapt to market situations and an increasing rush regarding the sequence of events should be mentioned. In such cases additional tasks, overtime and reorganisation cannot put things right. They

represent a specific consideration of single phenomena like operating times, wages or productivity which can only have a limited and temporary effect. A paradigm change is required — a new conceptional way of thinking which is the basis of the manufacturing company. It must consider that these changes take place with enormous dynamics. In order to survive, a company must learn to secure market shares and profitability in a turbulent environment by developing adaptability. In such an environment it does not develop linearly but with leaps in development and with transformations according to the laws of probability which, although they can be controlled, cannot be accurately predetermined. It is therefore a matter of establishing dynamic systems whose development can become complicated. The dynamics which a company has to develop under these conditions is called *evolution*. Only a continuous development secures an appropriate adaptation to the changing environment. As a key statement: a company is an open, complex, dynamic system whose logic — based on chaotic system thinking — is one of fractals, and whose dynamics are shaped according to laws of evolution.

6 DESIGN OF INDUSTRIAL PERFORMANCE PLANNING

In order to master the future, ways of thinking and points of view must be changed radically. The considerations must move away from static systems toward dynamic systems, away from mechanistic toward organic models of explanation and away from monocausal toward multidimensional explanations. We must learn to understand a manufacturing company as an integrated system with its own processes and structures, a system which does not develop in a linear way, which is not accurately predictable and whose interior and exterior limitations are fuzzy and permeable. The model of the *fractal company* is suggested.

The fractal company is an open system which consists of independently acting self-similar units — the fractals — and is a vital organism due to its dynamic organisational structure. This approach does not describe the world anew, but emphasises the dynamic and multicausal relations of the real world. The question is, how can you get units into the factory which, regarding their objectives, are self-similar, self-organising, and able to act independently? This is a structuring task of an integrated kind. Structures must be created which support and develop the above-mentioned abilities.

7 THE BASIS FOR THE FORMATION OF FRACTALS: THE LEVEL CONCEPT

The methodology must on the one hand contain a sequence of steps, and on the other, enable integrated views. A continuous development process must result. In order to reduce the complexity in a company, and with the goal of creating a "fractal company," only horizontal divisions into levels are imaginable. The intermediate results of all projects currently dealt with at IPA show that the basic pattern is a division into six levels which can be treated as a whole, but are separate: 1. Cultural, 2. Strategic, 3. Socio-psychological, 4. Financial, 5. Informational (Information Flow) and 6. Technological. See Figure 6.

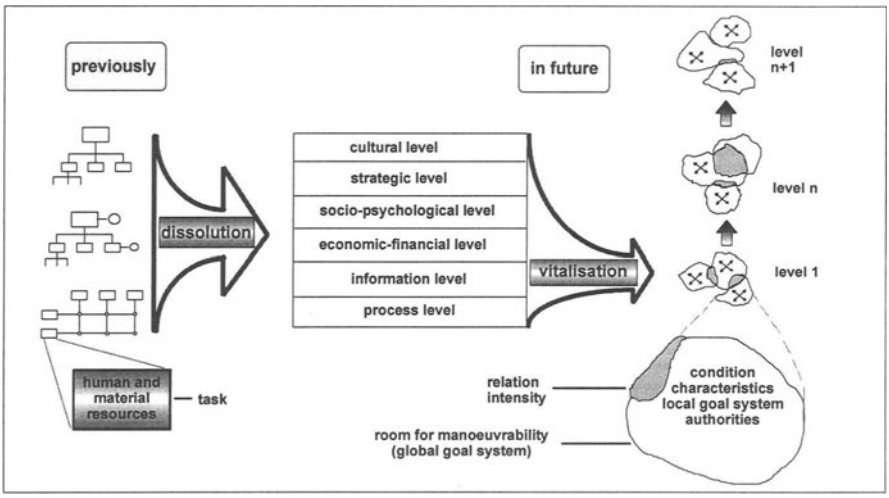

Figure 6 Dynamic organisation structures.

Organisation culture is the generic term which includes the company culture. Values are an essential part of organisation cultures. They express desires and contain the whole field of human preferences. Behaviour is value oriented. It becomes clear that a goal oriented company cannot get along without values or cultural elements. Ideals are developed, as are common views of values and principles concerning internal and external harmony.

Important *strategies* can be strategies of innovation, "me too" strategies, specialisation and diversification strategies, etc. However, the system of objectives must first be defined. A goal oriented approach is the basis for successful structuring which requires a minimum of time and cost. One must generate a system of objectives based on the philosophy, culture and strategic orientation of the company. According to the goal structures which are evaluated in this way, concrete planning can be established in order to compare the alternative principle solutions which have been worked out. See Figure 7.

The *social-informal level* includes all kinds of psychic, social and psychological factors which determine and influence the structure of relations of the entire staff. Organisational structure, communication and ability for teamwork can be identified as central variables on this level. The corresponding methods which must be adapted to the context of the fractal company would be: development of organisation, formation of teams and working groups, guidance of the teams, information and communication management and coaching.

The *financial level* of the fractal company deals with methods concerning account settlement of performance. Business management data must be judged with regard to their economic and efficiency related viabilities. This means that sales/cost considerations must be connected with the process design.

The *informational level* deals with the design of technical information flow. The central term is therefore process organisation. The main problem exists in maintaining continuity and

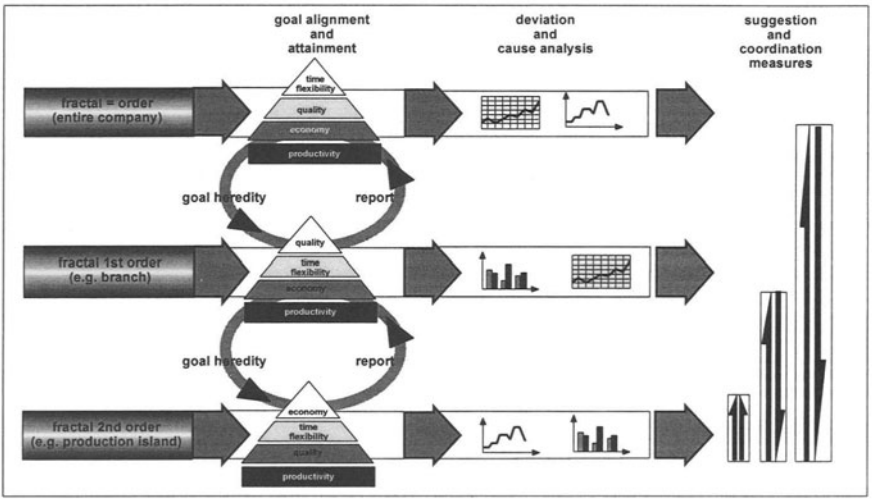

Figure 7 Interconnected cybernetic structures.

integrating information systems without hindering the dynamics of the structures. There are many possibilities for a realisation apart from computer-integrated manufacturing. The use of information must be adapted to the processes and not vice-versa.

The *technological level* of the fractal company is responsible for the technical design of material flow equipment. The whole complex of logistics and material management, including all kinds of parts of components, belongs to this.

Aimed variables, such as the increase of productivity and flexibility and maintaining schedules concern the entire order processing as well as the decrease of throughput time. They are becoming increasingly important and are the focus of attention. Pilot projects at IPA have already brought desired results such as transparent manufacturing processes, reduction of throughput times and reduction of stock value with simultaneous tripling of output. See Figures 8 and 9.

8 LEVEL MODEL AND VITALITY

The word *vitality* was coined as a superordinate term to measure the viability and efficiency of a fractal. The variables to be taken into account should have the ability to develop a dynamic system behaviour. Therefore, vitality must record and evaluate essentially those variables which are included in the individual characteristics and which can be used as a measure for the change or changeability of the individual characteristics of the levels. See Figure 10.

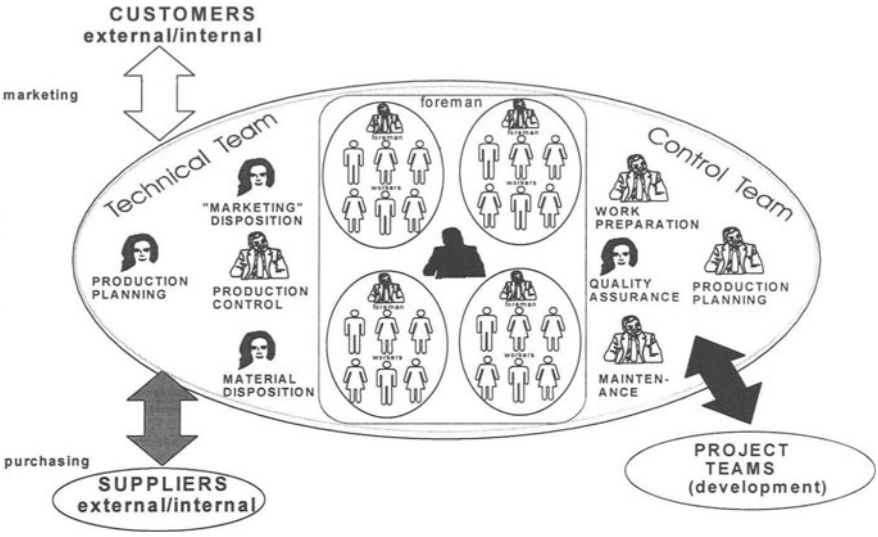

Figure 8 The production team at the point of manufacturing.

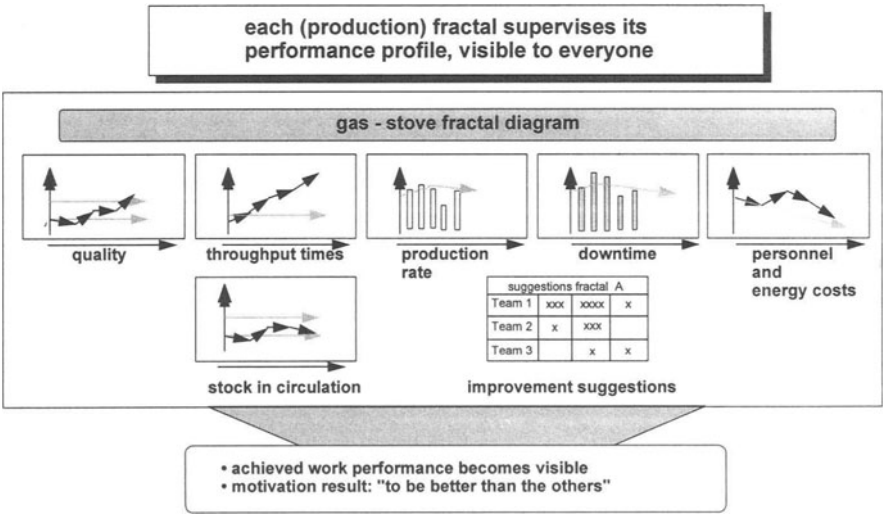

Figure 9 Optical Control

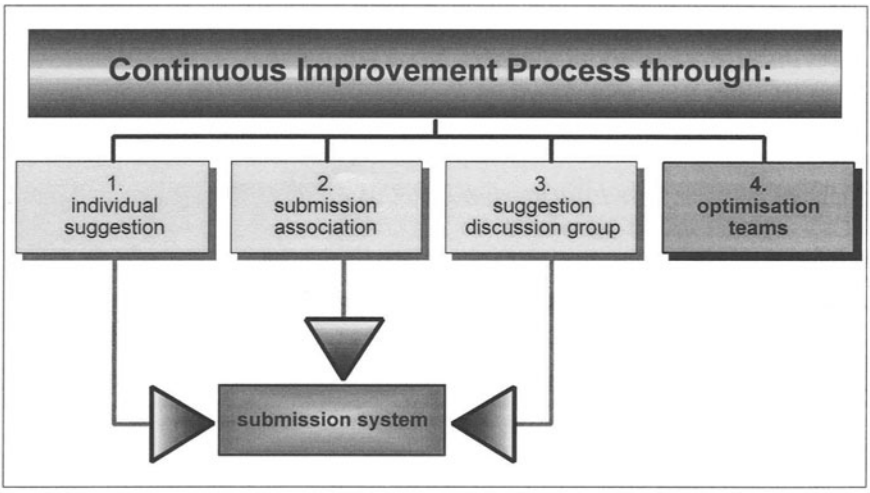

Figure 10 Continuous improvement process system.

9 SUMMARY

The concept of the fractal company, based on western structures, mentality and strengths, is a European answer to Japanese "lean production". With reference to natural organisms, vital and dynamic structures reacting flexibly to environmental conditions were created.

In addition to the fundamental elements and structures of a fractal company, the practical relevance gained from various companies was elucidated.

10 BIOGRAPHY

Dr Wilfried Sihn was born in 1955 in Pforzheim, Germany and studied commercial industrial engineering at Karlsruhe Technical College. He has been with the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart since 1982 and is the director of the Corporate Management Department. Dr. Sihn is the author of numerous publications and is a member of various committees. He has worked on over 200 research and industrial projects. During the last 3 years he has been principally involved with the concept of the "fractal factory" which has been successfully implemented in over 50 companies.