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TECHNOLOGICAL CHALLENGES IN ADVANCED PRODUCTION

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Abstract: *There has been an on going debate both in industry and academia of the need to improve the cooperation between designers and technologists. Development of new materials and design of products with new functionalities demands the application of new technologies and by that the need of cooperation between the two expert groups becomes even more important. To facilitate this relation sophisticated technological databases are created. Their goal is to help the decision-making about technological issues in the early design phase of the product. The paper points out the importance of considering the application of non-conventional technologies in order to meet the challenges generated by new products. Future trends in design and production are outlined and the problems related to micromachining and its precision is pointed out.*

Key words: *non-conventional technologies, modern production, concurrent engineering.*

1. INTRODUCTION

Advanced production should follow the governing rules set by the classical but still predominant three factors, namely costs, quality and delivery time. Another characteristic, to which the modern production should be adapted to, is the capability to respond to quick changes of the global market requests. New products and innovations are the prerequisites of any production willing to remain on the market as shown in Fig. 1.

This can be achieved both by innovative products generated by intuitive and generative product conception and design, as well as by applying sophisticated new technologies available on the market.

In the paper we shall first discuss the basic features of production in the frame of concurrent engineering with the emphasis on both product technical and aesthetic functionality. Further on we shall present the most relevant characteristics of some non-conventional technologies, as a fabrication tool enabling to achieve higher production and product performance in view of the production triptych-costs, quality, delivery time. We shall then show some examples of best process candidate selection for the case of contour cutting. After that future trends in design and technology shall be discussed terminating with concluding remarks.

2. CONCEPTION OF DESIGN AND TECHNOLOGY

The performance of the product evaluated by its functionality and quality. It is reflected through its respective production performance, which in its turn is evaluated by the omnipresent factors-costs, quality and delivery time as illustrated in Fig. 2.

This production performance factors are closely related to the factors, which should be carefully conceived in the early design stage, namely the selection of material, technologies and product design shown in Fig. 3.

The interdependence of those design factors is crucial and is drastically influencing the overall success of the production as well as the success of the product sales on the evermore-competitive market. Here the importance of the compatibility of product design and its fabrication technologies is crucial. To this challenge the concurrent engineering approach shown in Fig. 4 enabling the consideration of technologies in the earliest stages of product conception seems to be the adequate answer.

Short product life cycle with demands of new design and functionality requirements displaced classical manufacturing paradigm characterized by large batch series produced by classical automated production to the modern

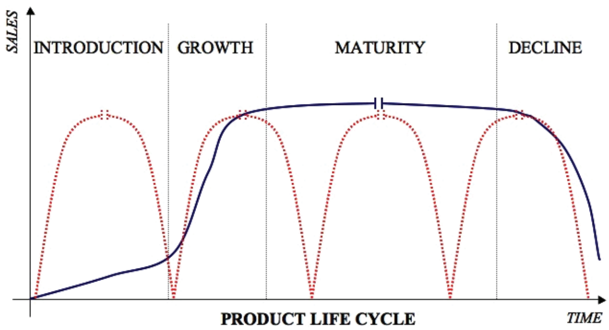

Fig. 1. Product innovation process.

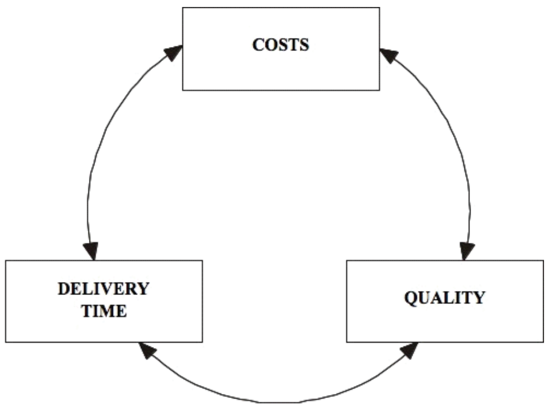

Fig. 2. Interdependence of costs, quality and delivery time.

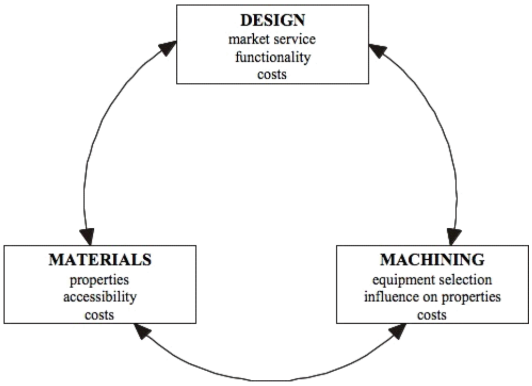

Fig. 3. Interdependence of design, machining and materials.

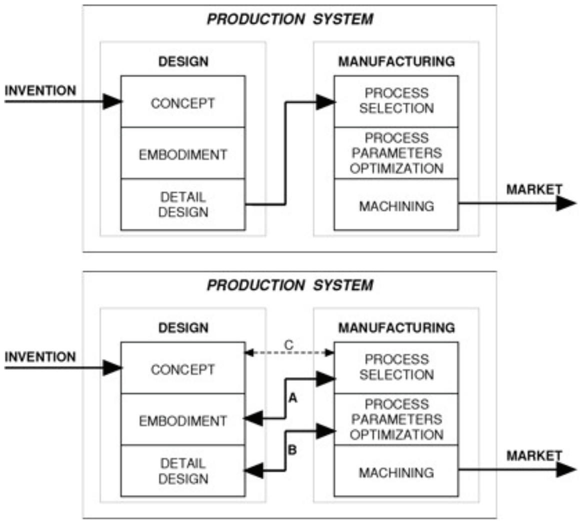

Fig. 4. Matching design and technology [1].

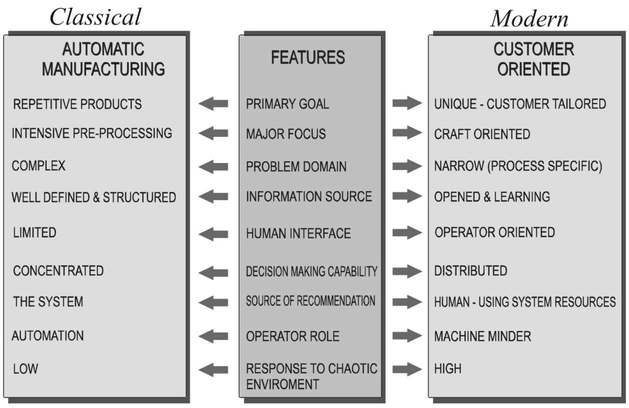

Fig. 5. Comparison of manufacturing concepts.

manufacturing concepts based on flexible manufacturing systems enabling customer oriented production which was once characteristic only for unique products (Fig. 5).

3. NON-CONVENTIONAL TECHNOLOGIES

New products conceived on new materials foster also the application of new technologies. New technologies of which the group of the so-called non-conventional or alternative technologies is following the same rules in their own conception as are the new products. They have to be innovative enabling ever more demanding performance

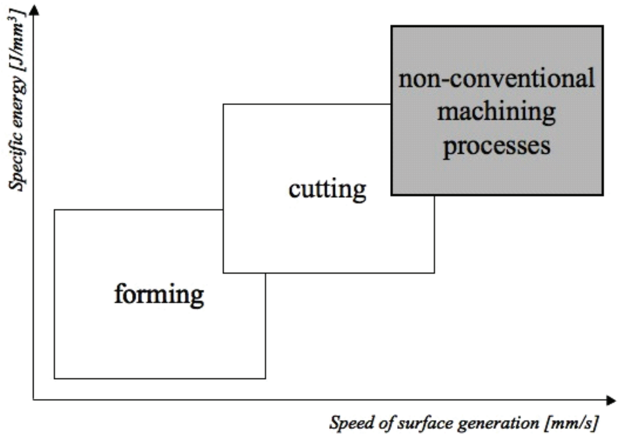

Fig. 6. Energy consumption for surface generation.

in view of machining new materials and ever more complex shapes and features of ever more miniaturized products. The main feature characterizing the non-conventional processes and the corresponding technologies such as laser, Electro Discharge Machining (EMD), Water Jet (WJ) based machining and Electro Chemical Machining (ECM), to name only the most frequently used processes, is the direct application of energy which generates the surface without the contact of a classical tool as depicted in Fig. 6.

This features bring new machining performances and advantages such as: high specific energy enabling to machine materials on the atomic scale; no susceptibility to mechanical properties of the material but rather to the physical, thermal and chemical ones; low, local or in the case of AWJ machining no thermal effects; flexibility of the tool, which in this case is represented by the beam or the jet or in the case of EDM by the discharge, which are highly responsive to control and easy to adapt and optimize.

These are all crucial requests set by the environment of an advanced production to which non-conventional processes listed in Fig. 7 can cope efficiently.

4. SELECTION OF BEST PROCESS CANDIDATE

There are always different ways of achieving a machining task like in case of a part shown in Fig. 8.

The appropriateness of the selected process for the chosen task reflects in a number of production and product performance indexes. In order to achieve or at least to come close to their optimum one should consider the most of available knowledge both at the stage of early product conception (Fig. 9) [2] and even more in detail on the level of fabrication when process final selection and parameter setting should be optimally defined (Fig. 10) [3].

Here the feedback between the design and fabrication department is very important since it effects the overall competitiveness of the production and thus of the product itself. Deep knowledge and awareness of the influences brought into the product material can reveal new insights and new possibilities of achieving better or even new functionality of the product, both in terms of its surface integrity as well as in attaining of up to now

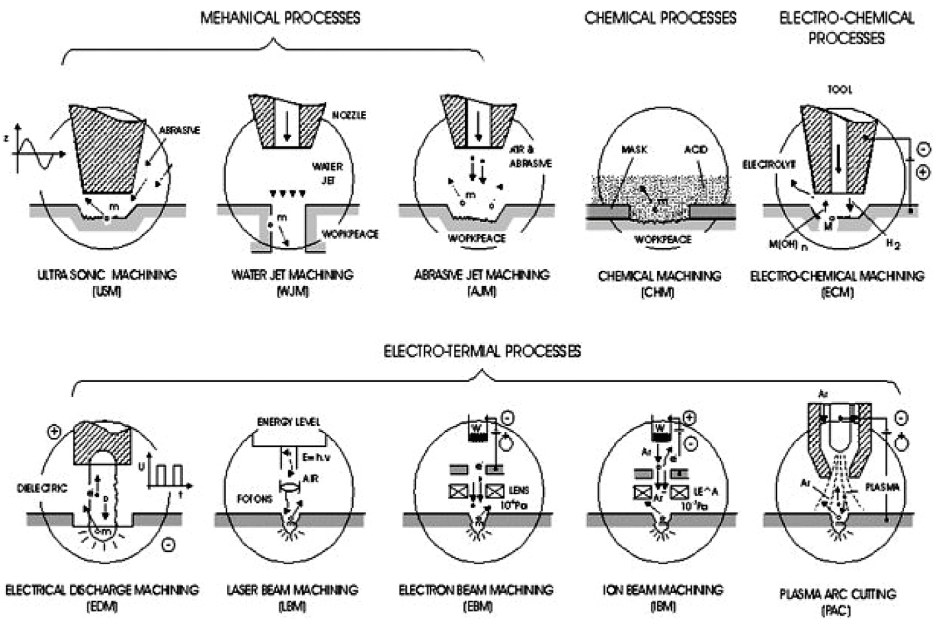

Fig. 7. Overview of non-conventional machining processes.

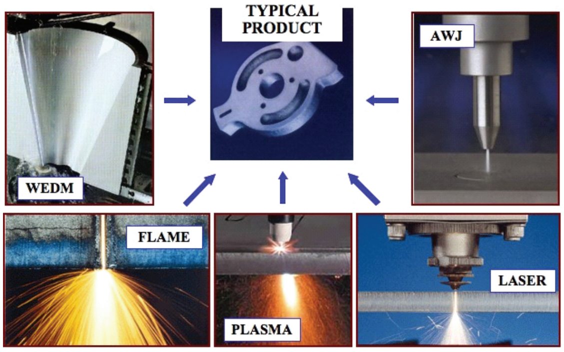

Fig. 8. Contour cutting processes.

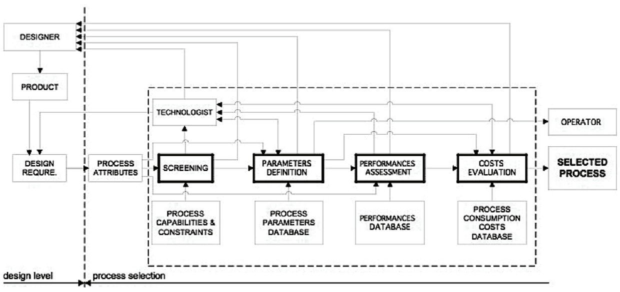

Fig. 9. Process selection procedure.

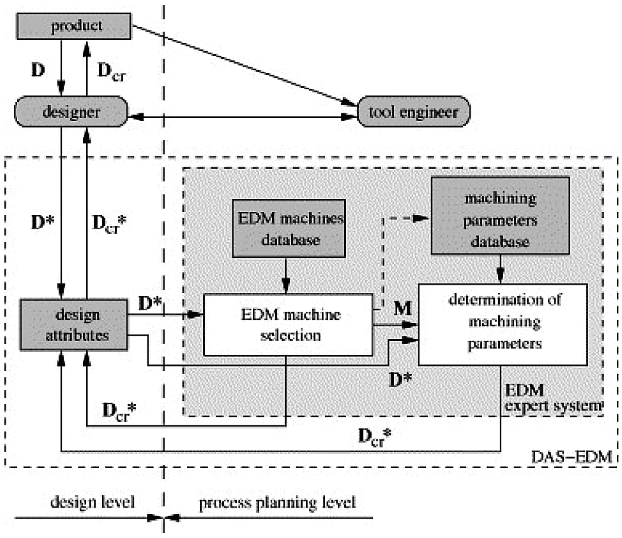

Fig. 10. EDM process optimization procedure.

unprecedented complexity and miniature features of the product. New technologies can thus bring about new design and push the development of new products to new limits.

5. FUTURE TRENDS IN PRODUCTION

Paradigm shifts in production happened thanks to brilliant ideas of great individuals. Laser technology is an example of the whole spectrum of new fields of application, research and innovated products in manufacturing, aeronautics, metrology, opto-acoustics etc., emerging from the basic idea of photon emission by exited electrons discovered by Einstein. Huge and brusque development in production is on one side pushed by such emerging technologies and competitive market pressure and pulled by performance productivity and product and process development on the other side [4] (Fig. 11).

Micromachining products are one example of market pull, where the demands for miniature products are augmenting significantly as shown in Fig. 12 [5].

On the other hand the miniaturization of products is putting the notion of precision and tolerancing into new prospective. Since the unit of material separated by new processes able to machine on atomic scale are small and even smaller of the material grain size the relative tolerance should be considered rather than the absolute one as shown in Fig. 13 [6].

The example of the emerging technology push can be descriptively presented by the case of water jet based technologies. The development of these technologies is one of the fastest growing [7]. Their application is broad and new almost unlimited possibilities are emerging as shown in Fig. 14.

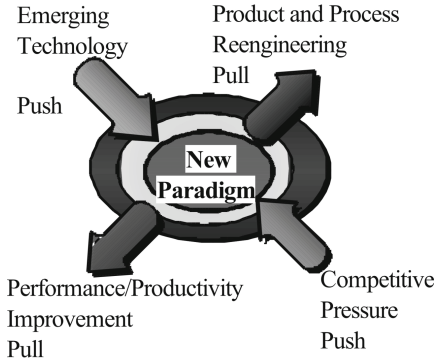

Fig. 11. Push and pull for a new paradigm.

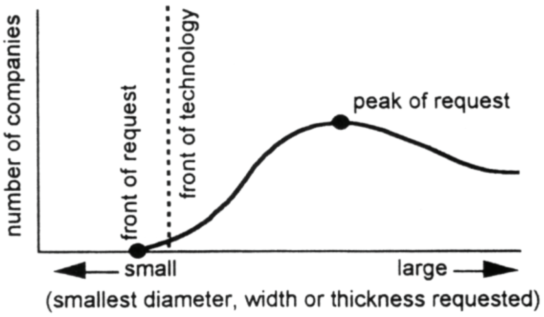

Fig. 12. Relationship between request and technology.

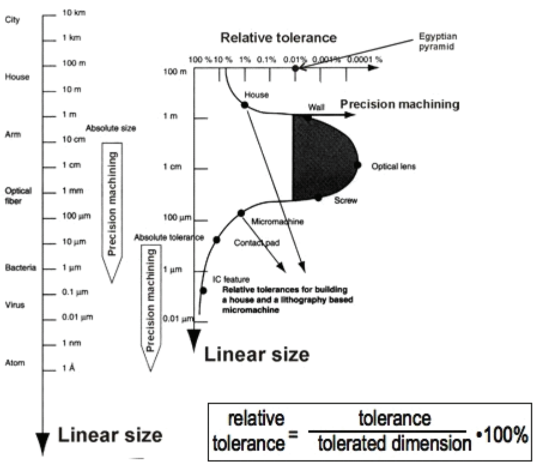

Fig. 13. Accuracy in micro manufacture.

6. CONCLUSSIONS

Boundaries between different disciplines are becoming blurred since the products and the processes to produce them are becoming more and more complex. Thus the coordination between product design and its fabrication seems to be a must.

The vast choice of new materials and processes makes the decision-making about their selection even harder and should be coordinated throughout the whole production stages.

Microproducts are the challenge for production, demanding thorough knowledge of design, materials and

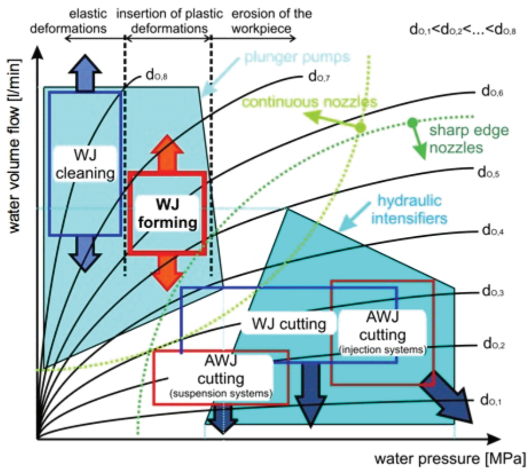

Fig. 14. Applications of water jetting technology.

technologies [8]. An advanced production environment supported by decision-making systems helping the designer and the technologist to select the best solution is thus the recommended approach to fight the competitive market.

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