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Variety Management in Manufacturing. Proceedings of the 47th CIRP Conference on Manufacturing Systems

Exploitation-oriented Manufacturing Technology Development

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Abstract

In consideration of the fact that production technologies are resources that can be exploited across various industrial sectors, their current and prospective technological properties are likely to face requirements from different target industries. Because these requirements can diverge extremely between industries, a methodology will be proposed that enables to assess the compatibility of diverging requirements. It aims at composing consistent, cross-industrial clusters of technological requirements that can potentially be met without significantly adapting the key features of the production technology at hand. These clusters are then mapped with the purpose of deriving an optimized technology development path that increases both long-term market security and overall exploitation potential.

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1. Introduction

Today, many market environments are characterized by rising raw material costs, technological and economic uncertainty and decreasing profit margins. In order to maintain long-term competitiveness the improvement of profitability has therefore become a top strategic priority for many companies acting within a global competition arena. The advantage held by western companies over their competitors from emerging markets is often attributed to the high performance and quality of their products [1]. However, this technological lead is rapidly being eroded as the Asian and South American economies catch up [2].

Market and production-oriented development strategies provide an approach to safeguarding competitive strength in the long term by improving profitability [1]. However, this approach comprises a dilemma, which arises from the divergent requirements of the multitude of products that could potentially be addressed by a production technology. This dilemma has to be solved in consideration of all available resources of the technology development process. This is being achieved under increasingly complex conditions. Intense pressure on time and costs in conjunction with more exacting quality-related requirements, steadily escalating complexity of production technologies and simultaneously decreasing product life cycles are just a few examples of the growing challenges product and technology development have to deal with (c.f. [3], [4]).

At present the improvement of profitability mainly rests on two strategic pillars: ambitious and innovative new product and technology development initiatives as well as comprehensive cost-saving projects. But how can companies simultaneously increase development efficiency and economic effectiveness while additionally maintaining these improvements in the long term? This question demonstrates that structured technology management in companies with limited availability of personnel and financial development resources is becoming increasingly relevant. Mistakes relating to the development of new technologies can put the entire existence of a company, particularly SMEs, at risk, since these frequently do not have the capital or adequate alternative technologies required to absorb failures [5]. Therefore, a dedicated methodology to derive an optimized, effective technology development path based on cross-industrial exploitation options while safeguarding development efficiency is needed.

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The methodology outlined in this paper considers manufacturing and production technologies as a widely applicable resource across various industries and particularly aims at supporting technology planners to utilize and leverage this cross-industry exploitation potential.

2. Problem

Even though production technologies are particularly well placed to meet demands from a broad variety of diverse industry sectors, the assessment as to which of the technological requirements in the available technological performance spectrum can effectively be combined in order to obtain a successful machine concept, presents an enormous challenge. The overall objective is to ensure that technology development is focused from a very early stage on attractive target markets by bundling the technological requirements of products from a range of target sectors in homogenous requirement clusters, which can be addressed economically.

The need to ensure timely identification and assessment of technology options presents companies with the following problems:

1) **From a practical point of view**, there is an extremely wide range of diverse technological requirements imposed on manufacturing technologies by different sectors of industry. Consequently, the entrepreneurial decision-making cascade becomes inefficient and slow due to the excessive amount of information to be processed. Additionally, there is a tendency arising from the limited resources to focus on the solutions, which present themselves most readily and to concentrate on known target markets, thus severely restricting the potential for multi-sectoral application from the very beginning of the development process.

2) **From a scientific point of view**, it is apparent that to date the need for targeted evaluation of the economic efficiency and feasibility for combination of cross-sectoral requirements regarding the deployed production technologies have not been systematically addressed. Despite the fact that various models have been developed for technology evaluation, these are all generic and abstract in nature, frequently making no allowance for monetary prioritization of development options. A realistic estimate of the monetary exploitation potential is, however, a major evaluation criterion in any meaningful exploitation decision.

3. Hypothetical solution and aim

The presented concept is based on the hypothesis that the technological principle of a production technology has the potential for cross-industry exploitation.

Not until design parameters for the production technology are defined as part of the product development process, exploitation-related restrictions, e.g. relating to the dimensions which can be machined or the surface qualities and tolerances which can be achieved, become effective. These restricting decisions regarding target markets and products reduce the cross-industry applicability of the technology already in an early planning stage, there-by necessitating iterations and adaptations in the further course of the development process.

The diversity of the possible applications and the requirements relating to the production technology associated with these in conjunction with market uncertainty and the availability only of qualitative information in early planning stages, are among the main problems to be addressed via a systematic evaluation method. The aim is to provide users with a method, which will permit targeted technology management by rendering the potential, but not yet visible added value of wider technology exploitation, to be weighed up against the additional development cost more quickly and more easily. The boundaries between technology and product development are somewhat fuzzy in this context. Technology development can be regarded as the process which determines the performance limits of the technology principle. Within the scope of the performance limits of a manufacturing technology, which are ultimately set via the design of the product in the form of a machine, the product development process subsequently decreases the performance range, which can be effectively utilized within the theoretical performance limits of a given technology principle. In this context, it is important to align the two paradigms of market-pull and technology-push already at the technology planning stage to ensure that they are optimized and that they are coordinated with one another in the long term.

The hypothetical solution is based on the assumption that multi-sectoral, technologically homogeneous requirement profiles can be described by a fixed set of design parameters. Therefore, development options can be derived in the course of requirement clustering, given that these clusters are consistent with a set of homogeneity criteria in the form of feasible margin widths around a mean reference value for each design parameter. As a starting point for an economic evaluation, a reference performance profile – e.g. in the form of a reference machine either specified in the development process or a comparable reference machine already commercially available – specifies a preliminary limitation on the design parameters for the production technology within the framework of the physical performance limits of the underlying technological principle. The influence exerted by adaptations to the design parameters can then be evaluated on the basis of the reference performance profile. A further assumption is that the economic efficiency of a development option can be assessed within a specific company by pursuing various systems engineering approaches and optimized by carrying out selective adaptations. The hypothesis underlying this assumption is that the derivation of a theoretical net value for each of the homogeneous clusters of requirements permits distinctions to be drawn between various development options. The approach subsequently enables the definition of a development path with optimized exploitation potential in terms of providing a net-value-based product-requirements catalogue for technology development at different times.