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Computer aided process planning for sheet metal based on information management

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Abstract

During the last few years, attention in the manufacturing cycle has shifted towards concurrent engineering (CE). With this, the integration of the different product life cycle processes has become a focus in both research and industry. However, it is obvious that the integration of all manufacturing processes, taking into account all life cycle aspects from initial functional requirements to final disposal, is hardly feasible in the traditional way.

In this paper, the execution of the manufacturing cycle based on information management is explained by describing the development of a generic architecture for computer aided process planning. This architecture is elaborated upon for the field of sheet metal manufacturing in a small batch part environment.

Keywords: Concurrent engineering; CAPP; Architecture

1. Introduction

In the research presented here, it is advocated that the sheer integration of manufacturing processes within the product life cycle is insufficient to achieve true integrated product development. For this purpose, the main focus should be on the information that is applied and generated in these manufacturing processes. If the information of the separate processes can be made available during the entire development cycle, it can be the basis for the control of the entire manufacturing cycle. In order to take full advantage of the modified role of information in the product development cycle, a different attitude with respect to the manufacturing processes is required.

One of the main differences is, that the phases in the manufacturing process become instrumental to the information required in the manufacturing process. This immediately implies that processes in the manufacturing cycle have to be defined as generic as much as possible. For example, it becomes practicable to interchange systems developed for different product types (prismatic, sheet metal, etc.). Moreover, if the interfaces of the mutual systems can be defined adequately, these systems can become independent modules, that are able to perform their tasks without being dependent on a predefined, sequential scenario. A first prerequisite for this is the ability to effectively manage the information that becomes the basis of the manufacturing process.

2. Information management

2.1. Manufacturing engineering reference model

In order to be able to deal with different views on a manufacturing system, the system is introduced by means of a reference model. A reference model represents a system as an organisation in terms of its structure of relatively independent, interacting components, and in terms of the globally defined tasks of these components [2]. The manufacturing engineering reference model proposed in the present context is shown in Fig. 1.

This manufacturing engineering reference model is based on the manufacturing planning & control reference model introduced by Arentsen [1]. However, adaptations have been made, in order to emphasize the equivalent importance of products, orders and resources in the entire manufacturing cycle [4].

Company management is concerned with the control of customer orders. It is responsible for the strategic decisions

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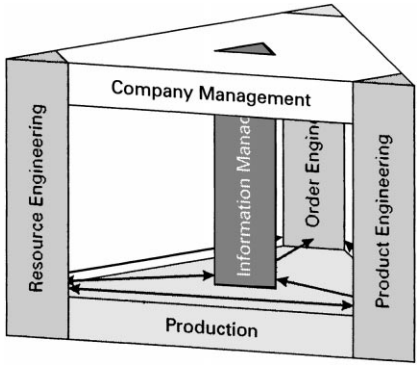

Fig. 1. The manufacturing engineering reference model.

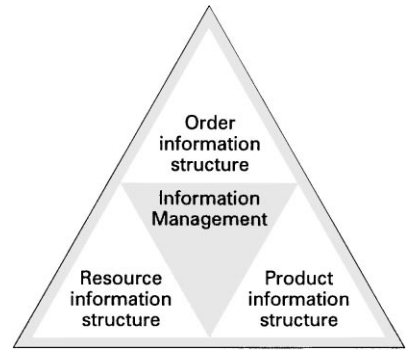

Fig. 2. The three co-operating information structures as part of information management.

concerning the range of products which will be produced and the processes and resources which are required to this end.

Product engineering refers to all the engineering activities related to the product life cycle of a specific type of product. It is concerned with the design and development of a product type and its variants, starting from functional requirements up to final recycling/disposal.

Order engineering addresses those activities that relate a customer order to a specific (variant of a) product. It is the task of order engineering to compose production orders and to decide when given batches of products must be processed and with which resources. The objective of order engineering is the in-time execution of the production orders.

Resource engineering refers to all (life cycle) aspects of the resources, required for the execution of the production activities. It therefore includes the specification, design, development, acquisition, preparation, use and maintenance of the resources of a company.

Production is concerned with the actual execution of the plans generated by the engineering tasks. From production, information is fed back to these engineering tasks.

In the manufacturing engineering reference model, *information management* is discerned as the kernel. This illustrates the opinion that the availability and accessibility of information is preferred over sheer data exchange.

2.2. Information management

In recognising the fact that each of the departments in a company makes myriad decisions in order to generate required information, it is obvious that the reasoning behind all these decisions can hardly be transferred together with the information. Consequently, the need for feedback and interdepartmental communication increases, which may lead to extremely complex and uncontrollable flows of information between the separate departments.

However, providing that information generated by the separate departments is attached to an overall and widely accessible model, this situation may change considerably. In this case, instead of 'pushing' information from one department to another, departments can 'pull' the information they require and are given access to. Hence, the focus can be on the information in support of the control of the manufacturing processes, and for this reason, the course of the manufacturing processes may be guided by the use of, and the need for information.

The types of objects the information is concerned with (orders, products, operators, etc.) can vary considerably. Despite this variation, for the way the information is structured and attached to an overall model, it is unimportant whether information bears reference to, e.g. a product, a machine or its operator. Still, it is important to distinguish between different types of objects, as their different significance for the manufacturing processes is apparent.

Each type of object can be attached to an overall model, a so-called information structure. In accordance with the three piles of the reference model, three of these information structures are discerned (see Fig. 2):

- product information structure;
- order information structure;
- resource information structure.

Because the structures evolve independently of each other, whereas the way of their mutual interactions remains the same, the entire range of manufacturing environments can be addressed: from engineer-to-order to mass production. For example, in an engineer-to-order environment, the order information structure and the product information structure evolve almost simultaneously and the resource information structure remains relatively unchanged. In a mass production environment, the product information structure and the resource information structure are developed concurrently and remain rather static henceforth. Subsequently, the order information structure is used to specify the choice of a certain product variant, and to determine the lead time and other logistic consequences.

The different behaviour of the information structures in different manufacturing environments implies that each of the structures has its own life cycle. In aiming for the integration of processes, the life cycles must be oriented on the information contained in the information structures, instead of on the processes concerned with this information. In elaborating this concept for the product information