QUOTING GENERATION FOR SPECIAL TOOLS: AN ONTOLOGY-BASED METHOD

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Extended abstract

In the engineering industry, in particular in the field of high technology products, an increase of the complexity of the competitive market environments happens and there is a continuing drive towards an increasing degree of customization of the products. Therefore, the customers make orders of individual highly personalized products, which are not present in the catalog. The ability to generate accurate and timely offers has become a critical success factor for the companies, because this has a great impact on the profitability of the possible contract. The quotation process consists of the choice of production resources and of processes which allow the correct end complete realization of a customized product at the minimum cost.

The specific problem regarding the quote generation process of customized tools is taken in consideration. The first challenge for the companies producing these products is to be able to estimate in a short time and with a good level of accuracy the industrial production cost and the time needed to the realization of a tool, in order to respond quickly to the offer requests. The main task consists of a high level process plan definition, considering both machining and setup times estimation. This decisional process is very complex because the involved variables are many and not easy to be estimated. Furthermore, the quality of the quotes strongly depends on the skills and the experience of the people involved in this specific domain and the skilled operator becomes an irreplaceable resource. All these matters lead either to a limited or a not existing competences and knowledge sharing, making the quote generation process subjective, not uniform and affected by relevant operating times.

The authors propose the “knowledge engineering” as a possible solution to the problem, providing a low level semi-generative process plan able to automatically define all the operations and the relative times in order to realize a specific tool. The aim of this work is to propose a new approach in the field of Computer Aided Process Planning (CAPP) [1], trying to face a specific corporate problem. The developed approach is based on a knowledge base and on a method of problem solving and has been implemented in a software demonstrator; it provides in output the work cycle for the realization of the special tool for which the customer has requested a quote. The knowledge base contains geometrical and technological information regarding the families of products and components created according to criteria of similarity between individual items. The proposed method of problem solving is implemented in an expert system and generates the specific production process for the realization of a customized tool, modifying the standard work cycle related its family on the basis of rules and conditions.

The methodology used to formalize the knowledge is the creation of an Ontology [2] [3]. An ontology is a formal representation of a set of concepts within a domain and the relationships between those concepts; it consists of a hierarchical data structure containing all the entities (classes and subclasses) with its relevant attributes, relations between them, the rules, the axioms, restrictions and constraints of

the considered domain. Ontologies are commonly applied in the field of artificial intelligence and the representation and sharing of knowledge and may be used in developing software for the deductive reasoning, classification and various problem solving techniques. The choice of the ontology is linked to the possibility to represent in a single data model not only the declarative knowledge, but also the procedural knowledge. This first one consists of the information of product, process and system related to the specific domain of the special tool and its production and structured in a hierarchical multi-level data architecture containing classes and sub-classes. Each class has been characterized by data type properties, which are its quantitative and qualitative attributes; a set of relationships between those entities has been defined and are called object properties. The second one is composed by a set of rules and conditions that impose constraints and restrictions on the relationships between the classes of the ontology. The product information has been considered at different degrees of detail: from the level of manufacturing feature (derived by the standard ISO 14649 STEP-NC) to the level of component / sub-part of the tool and final product special tool. Similarly, the created process knowledge is modeled with elementary operations for the transformation of the workpiece and canned cycles, or batches of more operations that are considered as indivisible entities in order to make the quoting. The system information regards the data concerning all the production resources needed for the execution of the processes and which are cost centers: machining centers, fixtures, human operators etc. Object properties have been created in order to define the relationships which link the tool and its geometrical characterizations to the specific transformation processes; the process entities are connected to the relative production resource classes.

The developed method of problem solving is composed by three steps and works on a set of data provided in input by the user. This data represent the specifications on the special tool required by the client and regard body, coupling and material of the tool. The first step consists of an automatic feature recognition with the utilization of rules that act on the input information; the generic standard work cycle and the related production resources are instantiated. The second step executes the inference and generates the specific production processes for the realization of a specific customized tool, specializing the generic process and machine entities. The third step calculates an estimation of setup and execution times of the phases of the work cycle and the industrial cost associated to it. The user is then able to make an offer.

The authors have tested the proposed approach on real cases of quoting for special tools, provided by the company Sandvik Tooling Supply of Piacenza (Italy). The output of the method has been compared with the firm output, obtaining good results. In particular, the developed methodology proposes the same work cycle determined by Sandvik in all the analyzed cases and there are no significant deviations between the values of the operation times relative to the two solutions. A good precision in the times estimation is obtained for the phases with high cost per hour.

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