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Intelligence in Computer-Aided Process Planning for Machining

A.G. Mamalis and G.C. Vosniakos

1 Introduction

Process planning is the systematic specification and sequencing of processes by which a product is to be manufactured economically within a given manufacturing system. A process plan usually contains the route of operations and specification of each operation in the route, i.e. type of operation, operation parameters (e.g. feed, speed etc.), machine, tool(s), jigs/fixtures, standard time, setup time, and additional instructions (e.g. for setup, in-process inspection etc.)

Process planning requires data on production equipment, general knowledge on technological capabilities of manufacturing processes and optimisation skills based on long experience. Therefore it is data-intensive, technological knowledge-intensive and experience-intensive. It is no wonder that manual process planning is dependent on few experts, inconsistent and slow, hence computer aided process planning (CAPP) is increasingly used [1].

Variant CAPP is based on the notion of Group Technology part families. All parts in a part family have similar shape and/or process plans (similar type, sequence and number of operations). When a new process plan needs to be produced, the standard process plan of the appropriate part family is retrieved and modified to tailor the plan to the particular part.

Generative CAPP relies on manufacturing knowledge captured in the system and not on standard process plans. Thus process plans are 'generated' from scratch. Such knowledge requirements are usually product type -specific and company-specific, resulting in dedicated CAPP systems, e.g. for sheet metal parts, forged parts, machined (or even turned) parts etc. [2].

Another distinction is that between interactive and automatic systems. Interactive CAPP systems tend to rely on the user’s decision based on presented information. Automatic systems minimise all user interaction. system intelligence,
although it appears strange at first, can be manifested equally in either type, although interactive systems by definition rely on human intelligence, too.

In general, the more intelligent the CAPP system, the less the user will be required to think about process planning problems and to suggest solutions or decide on system suggestions. In spite of the wide use of variant systems, in practice these are recognised as being too constrictive. Generative systems are by definition intelligent, but their scope is too wide to render them practical. This work advocates restriction of that scope to specific part types or families.

2 Process planning philosophy

Variant process planning based on rigidly defined standard process plans for part families as in Group Technology composite parts suffers various drawbacks, e.g. the plans need to encompass all possible features to enable editing by removal, and it is hard to accommodate variations that are due to feature interactions [1].

A parametric type of standard process plan is much more flexible and can accommodate variations of presence, dimension and interaction of features. This needs to be based on a language, though. Such a language is ALPS developed by NIST [3]. It provides conditional and Boolean structures as well as grouping mechanisms applied to operations that make up a standard process plan, see Fig. 1.

A standard process plan of that sort can be modified to suit a particular component deemed to be sufficiently represented by it. Strictly speaking, this kind of editing is definitely possible in the interactive mode. Otherwise, automatic editing has to be based on automatic comparison of the features of the particular part and those of the composite part representing the family. The rules according to which editing is performed could be coded into an expert system. However, the complexity added in this way may be too great to justify the standard plan approach. Instead, a structured rule set for process planning, i.e. mainly for choosing alternative operations associated to features, would normally be more straightforward.

In either case it is desirable that the process plan derived is fairly open, not committed to specific tools nor referring to processing conditions, but providing

![Figure 1 ALPS structure](image-url)