A Knowledge Based Computer Aided Process Plan And CNC Code Generation

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ABSTRACT

Process planning knowledge is one of the most important knowledge in mechanical manufacturing field. Traditional process planning systems requires human input into interface between CAD and CAM systems. The purpose of the present study is the development of a generative process planning methodology for automated generation of CNC codes for 3 axis milling centers with the CAD geometry as the only primary input. On the basis of the widely application of computer aided process planning (CAPP) system in Mechanical field, the concept of process planning knowledge discovery is proposed on the process planning databases. The proposed methodology uses geometric reasoning algorithms for recognizing machinable volumes, set up planning, fixtures planning, tool selection and tool path selection to generate machine codes. Thus, allowing integration with commercially available software for CNC code generation.

Elementary application research in typical process knowledge discovery is described. The geometric reasoning algorithms use boundary representation to decompose removal volumes into discrete milling operations. The algorithms presented here encompasses planar and cylindrical faces, but are flexible in that they can be extended to handle more complex geometry. Matercam is then used to generate tool paths using scripted point-by-point specification of tool paths, machine linking parameters and tool settings for each of these milling operations. In the ensuing algorithms pertaining to set up analysis and volume decomposition are discussed in detail.

Key words : Process Planning, Knowledge Base, CNC, CAD-CAM

INTRODUCTION

Traditional manufacturing using Computer Numerically Controlled machines from design requires significant effort and time. With development of knowledge economic, knowledge resource becomes the most important resource in mechanical industries. The competition superiority of enterprises comes from the effectively development and management on knowledge resource [1].

Now-a-days, with the rapid application of enterprise information soft- wares, the location of knowledge resource is changing from employee's brain and paper document to digital databases in industries.

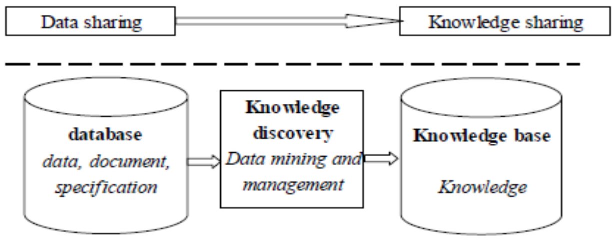

Figure 1. From data management to knowledge management

Fig.1. shows the aim of knowledge management.

With increase in global competition in manufacturing, there is a need to automate this process to reduce the lead time, improve quality, productivity and product development life cycles. In this regard, Computer Aided Process Planning (CAPP) was introduced as a bridge between CAD and CAM systems that were developed independently. CAPP refers to activities done either automatically or with minimum human intervention to convert component designs into manufacturing instructions that describe how components are to be produced.

To realize true automation of process planning systems, feature recognition, setup analysis, tool path generation and tool selection must all be addressed simultaneously. The purpose of this study is the development of an approach towards achieving this for orthogonal machining profiles. For this purpose a feature recognition model is developed where machining features are determined using machined and non-machined faces of part drawings. These features are mapped to machine tool paths in mastercam software.

OVERVIEW

The proposed approach uses geometric reasoning to determine possible tool approach directions, recognize machinable features and generate a process plan. A feature recognition algorithm is used to differentiate between machined and non-machined surfaces and decompose the part geometry into features that are recognizable by mastercam. Then this mastercam is used to generate G-codes for each feature and each setup in the process plan. A flow chart describing this approach is shown in fig.1.

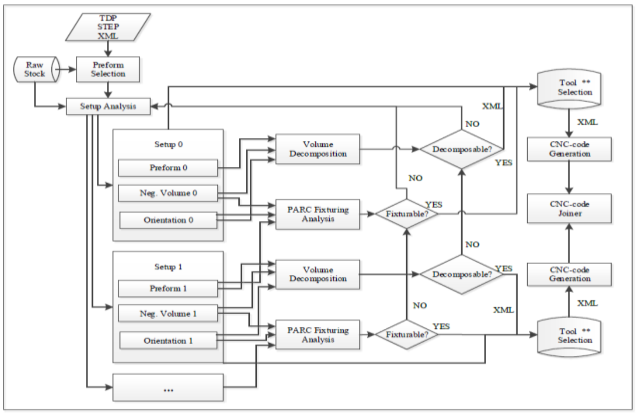

Fig 2 : Flow Chart generating G-Codes

The overall algorithm can be separated into four parts: model preparation and perform selection, setup analysis, volume decomposition and CNC-code generation. Here, the ensuing algorithms pertaining to setup analysis and volume decomposition are discussed in detail.

Process planning knowledge (PPK) in mechanical manufacturing industry includes foundation data, process planning specification and experience of expert etc. for process planning. All types of PPK are synthetically used generally, for example, selecting manufacturing method, designing fixture, arranging route etc. Commonly, PPK can be divided into four types:

1. Handbook knowledge: It includes data and knowledge in handbook and engineering standard for process planning, for eg. tolerance, material, cutting feed and process planning specification etc.
2. Manufacturing resource knowledge: It implies data and knowledge that has close relation with manufacturing environment, such as machine, cutter, fixture, process planning database etc.
3. Decision making knowledge: It is composed of experiential rule, procedure algorithm and control knowledge for process planning that commonly exists in engineering expert's brain.
4. Model knowledge: It includes process planning data model and process planning knowledge model, for instance, product, part, process planning, operation, step, fixture, machine, etc.

PROCESS PLANNING MODEL FOR MECHANICAL MANUFACTURING INDUSTRY

In order to represent the commonness of process planning knowledge (PPK) in mechanical manufacturing industry, process planning model (PPM) is founded based on the overall analysis of process planning. It includes all fundamentals process planning object (product, part, process planning, manufacturing resource, route etc.).

The realization of CAPP development platform design on object-oriented information model-driven is the guarantee to the universal, maintenance, expansion of CAPP system can running in uniform information model, which is a fundamental method to understand research domain in natural way, the definition and identification of information model entities are in human's impersonality thinking way. The knowledge base in CAPP development platform can be divided into 2 levels:

1. Special information model for a manufacturing industry: It includes product information model, part information model, process planning information model, manufacturing resource information model, process planning decision information model, process card information model, process file information model, work flow information model, organization information model, user information model and function configuration information model.
2. Based on the information model-driven mechanism: In CAPP development platform, the object instance and method is used in process planning knowledge base to describe process knowledge, such as typical process typical operation etc. The knowledge in process planning knowledge base can substitute handbook and can retrieve process instance to improve the design efficiency.

STAGES OF PROCESS PLANNING KNOWLEDGE DISCOVERY

The application process of CAPP system can be divided into three stages, they are foundation implementation, accumulation of process planning data, process planning knowledge discovery. The application tools of process planning knowledge discovery provide knowledge discovery rules and algorithm. It can be used to interact with user. The procedure is as follows:

1. Here the problem of what is the relative process planning data in PPKD is solved, Database tables and attributes is PPKD are defined. Relative object class, attribute and conditional are associated based on PPKM.
2. What type of knowledge to be discovery: In this phase, the problem of what type of knowledge in PPKD is solved. Such as concept, item, typical operation, process planning.
3. Background knowledge: It is high level domain knowledge that can be used in PPKD. It is very useful for instructing and evaluating of PPKD. Background knowledge is provided by system user, domain expert and knowledge engineer.
4. Measurement of interest degree: In this phase, the problem of what is the interest of PPKD is solved. Uninterested pattern can be separated in the procedure of PPKD. Application tool is provided for user to change the dataset, threshold value etc.
5. Knowledge representation and view: Users can select the display pattern of PPKD, for example, rule, table, graph, tree etc.

SETUP ANALYSIS

The setup analysis algorithm is responsible for generating a sequence of performance orientations through which a part will be machined. Using CAD models of the part and performance as input, the algorithm first calculates the total volume that is to be removed. This algorithm determines the sets of directions, computes visible volumes, scores, process plans and selects a preferred sequence.

The algorithm uses the above functions to produce a set of feasible plans. Initially it computes the set of directions followed by volumes. Each node in the tree representing and traversing tree in reverse gives us a feasible process plan. If the algorithm runs out of directions, but still has volume to remove then the plan is discarded.

Final process plan selection follows all the criteria mentioned above, a process plan that has no left over removal volume, has a fixturing solution and has the lowest process plan score is selected for analysis using volume decomposition.

VOLUME DECOMPOSISTION

It represents the large removal volumes produced in setup analysis into smaller pieces that map directly to standard machining operations such as pockets and holes. The algorithm uses the removal volume and post-forms from each setup of the plan. The algorithm defines the removal volume in terms of loops (eg. Closed profiles). The algorithm classifies features based on the type of loop and type of surfaces encountered. Currently, the algorithm is able to handle up to two loops in a single feature. Logic flow for the volume decomposition algorithm is displayed in fig.

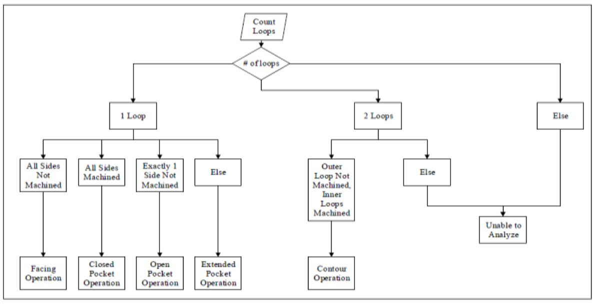

Fig 3: Logic flow for the volume decomposition algorithm

If only one loop is encountered, and all sides of the loop are non-machined, the algorithm recognizes the feature as a facing operation. If all sides of the single loop are machined, then it denotes the feature as a closed pocket. If exactly one side of the loop is not machined, then it distinguishes the feature as an open pocket. If none of the above criteria are met, with a single loop, the algorithm refers to the feature as an extended pocket. If the single loop is perfect cylindrical and terminates is a cone, it is recognized as a drilling operation.

If the algorithm encounters two loops in a feature and out loop is not machined, but the inner loop is, then it refers to the feature as a contoured operation.

SCOPE OF THE WORK

Though a level of automation is achieved in the process planning for 3-axis milling, the present implementation can be improved with incorporation of some additional fucionalities. Tool selection algorithms are needed to determine tooling sequences and accommodate automated speed and feed selection.

CONCLUSION

Process planning knowledge discovery and management is the important foundations work of mechanical manufacturing industry. It includes the concepts, terms, typical operations, typical step, typical process. The feature recognition algorithms described were used to generate process plans. Set up plans and machine code for a test part geometry. The algorithms developed in the present study also were integrated with commercial software (mastercam) that is used to generated tool paths. While this effort was successful in handling specific geometries, the algorithm presented here provides flexibility for addressing more complex geometries.

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