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KNOWLEDGE-BASED VIRTUAL NC MACHINING

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Abstract: *This paper describes the architecture of a new intelligent CAD module for virtual NC machining. We have applied a knowledge-based approach to the object-oriented model of virtual NC machining.*
The object-oriented model of virtual NC machining consists of a set of classes and subclasses for the Virtual NC Machine's parts and tools organization as well as a set of classes and subclasses of a Virtual Product. The objects are connected with appropriate knowledge data as a set of attributes and functions defining its behavior and links to other objects. This module has a goal to verify the NC program through simulation of product's machining.
Keywords: *CAD, CAM, Knowledge-based programming, Simulation, Virtual Manufacturing.*

1. INTRODUCTION

Process planning can be defined as an activity which identifies methods and processes to be used for the manufacture of a part or a product (Krause, 1996). Various forms of knowledge used in process planning relate to the objects (entities in manufacturing environment) and connections between them. They include the knowledge of part design, manufacturing operations, tools, machines, and the relationships between these entities.
The rule-based and knowledge-based programming is most frequently used in developing process planning systems. A large number of research reports and several commercial products that deal with knowledge-based approach of automated process planning are available. A relatively new system 3I-PP (Khoshnevis, Sormaz, Park, 1999) with an object-oriented data model of knowledge representation, provides systematic links between design, process planning, and scheduling functions and allows their simultaneous execution in concurent engineering environment.
Between the design process and the production process there is a phase of NC program verification and detection. In the software technology world, last few years, several commercial programs successfully perform this operation (Virtual Gibbs, NCSIMUL, VERICUT). This phase has an opposite task of process planning, it provides error detection and verification in the NC program (NC tool path error, possible collisions and other problems) without any use of physical models, saving time and reducing production costs.
In this paper, we have made an attempt to create software for Virtual NC machining. The main concept is based on the object-oriented model of Virtual NC machining (Sidorenko, Dukovski, 1999), using the knowledge-based approach (Sormaz, Khoshnevis, 1997) and object-oriented paradigm (Tomiyama, 1989).

2. VIRTUAL NC MACHINING MODEL

We propose object-oriented model of Virtual NC machining that presents the production process as a set of interrelated objects exchanging messages during machining. The model has been established on the base of a real production process analysis.
Virtual production process is defined as class of complex objects, consisted of objects of VirtualNCMachine class and VirtualProduct class, using part-of hierarchy (fig. 1).
The objects of the VirtualNCMachine class are also complex objects. They consists of the objects of StaticPartMachine class, DynamicPartMachine class and Tool class.
The object of Dynamic part class contains a set of attributes into its private part, functions that define its behavior through appropriate methods and links to other objects. The private part of the VirtualNCMachine's class has the basic features of its objects and the basic methods behaving as translated operations to the real NC machine.
VirtualProduct class is derived from the ProductPiece class, as a base class. ProductPiece object, as well as a real rough stock material piece, through a set of material removal operations, performed by VirtualNCMachine object, modifies its geometry and topology becoming Virtual Product, and a real product as well.

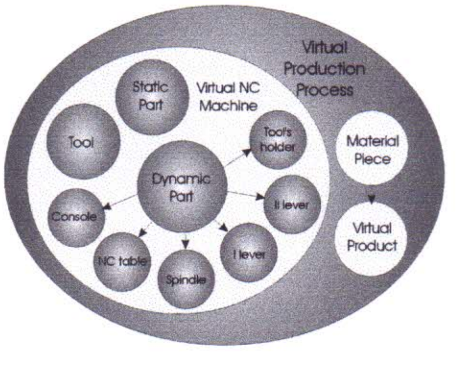

Fig. 1. Object-oriented model of a virtual NC machining

Various types of knowledge are applied in the presented model (fig.2). The knowledge used for presentation of the Virtual NC machine appearance and motion capabilities is classified in several types of data bases:

1. database of knowledge for shape, as solid model files for all of the machine parts;
2. database of knowledge for the motion capabilities (rotations, translations) as external functions that performs that motions;
3. database of knowledge for the NC operations as functions (methods) that perform translation of NC program into simulation scenario;
4. database of rules (constraints and links) to synchronize the whole machine working;

Each DynamicPartMachine object has to be associated with its own shape database, database of constraints of the appropriate motions and database of links to other objects. All of the DynamicPartMachine objects could share the same databases of motion types and databases of knowledge for NC operations.
The Tool class is organized on the similar principals. There is a database of knowledge for standard tools. All of the object's

private part features taking appropriate parameters from the database of knowledge for standard tools.

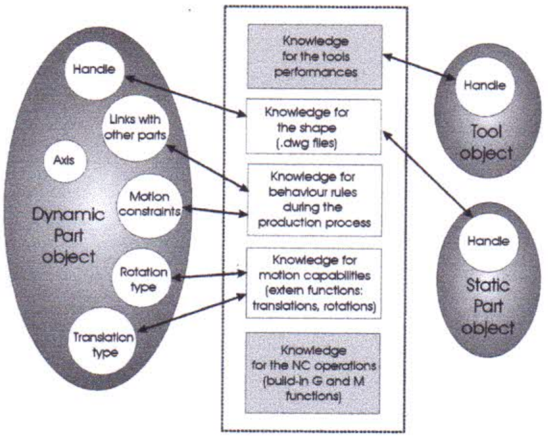

Fig. 2 Connections between the objects and databases of knowledge

3. ARHITECTURE OF THE SOFTWARE

The software is organized in several applications. The first application is designed as an interface where the user could make a primary selection: creation of a new model of virtual NC machine, simulation of virtual NC machining or evaluation of a virtual product (fig.3).

Application for creation of a new virtual NC machine has an aim to make classes for the new virtual machine parts with appropriate databases of knowledge from previously described schapes and rules.

The third application is created as an interface so that the user could make selections for virtual NC machining: type of virtual NC machine , NC program (from the presented list), set of tools and tooling fixtures, and material piece for machining.

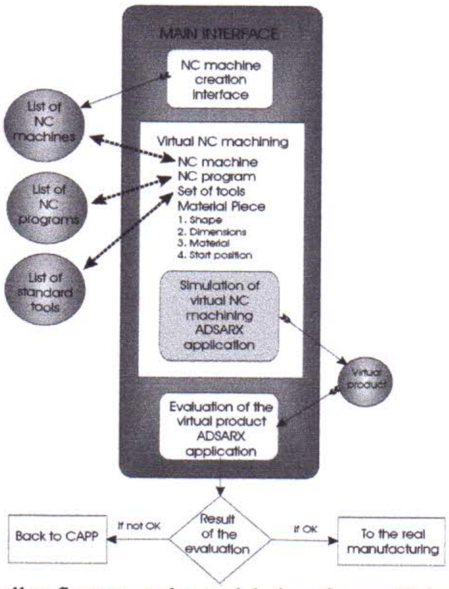

Fig. 3 Architecture of the software

Application for virtual NC machining is designed as an ADSARX module of AutoCAD R14. This application contains the core of an object-oriented code for virtual NC machining. This application performs translation of the selected NC program into simulation code. The simulation enables programmers to preview what is happening during the production process and are able to check possible collisions. It detects problems in the NC toolpath program. The final result is virtual product that could be evaluated using the last application, which is capable of performing cross sections, measuring, and comparison with the designed product. This application is designed as ADSARX module of AutoCAD R14 as the previous one.

The presented software provides simulation with full 3D solid models of all involved items (parts of machine, tools, and the product) in the production process, simulation of the motion and material removal by the tool.

4. CONCLUSION

Despite the existing commercial programs with similar performances, the presented model of the virtual NC machining attempts to apply a scientific approach to this matter, using object-oriented and knowledge-based programming ideologies.

The main advantage of this model is its flexibility and the possibility to be applied on a various kinds of NC machines. Also, it could be used in the construction phase of new NC machine types.

The databases of knowledge could be permanently upgraded with new data, new features, new rules, as well as new standard tools.

Presented software is acting as standalone, using only the graphical advantages of AutoCAD R14. However, it would be more considerable to be integrated as an intelligent module into a complete CAD/CAM system where it could share the same knowledge with the CAPP module. Our further research activities would be aimed to the overall integration of the process planning knowledge and manufacturing knowledge.

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