The latest NC programming automation technology for increasing part manufacturing efficiency

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White Paper

Machining efficiency and NC programming productivity are easily improved by using the latest advances in NC programming automation technology. Today's technologies deliver an enormous boost to manufacturing productivity while minimizing effort and expense. This paper provides an overview of the latest NC programming automation available in NX™ CAM software to help maximize your part manufacturing efficiency.

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Executive summary

Many of the common challenges faced by manufacturing businesses can be minimized or eliminated by using NC programming automation technology. Knowledge loss through staff turnover, high costs associated with maintaining and updating standards, the inability to effectively capture and re-use best practices, and the failure to improve productivity while simultaneously reducing costs are examples of business challenges that can be addressed by using a CAM system equipped with the latest programming automation technology.

The benefits gained from automated programming are extensive. Companies have achieved quantifiable benefits with automated programming, such as:

- 80 percent reduction in NC programming time
- Reduced programming mistakes
- Reduced machine setup time
- Increased machine tool utilization
- Ability to capture and re-use proven processes in the form of standards and best practices

The necessity for programming automation becomes apparent in the day-to-day activities of both the manufacturing engineering and shop floor machining departments. NC programmers and machinists who face the following challenges on a daily basis can gain significant benefits from programming automation:

NC programming

- Manual programming that results in errors and shop floor delays
- Redundant programming effort for similar types of parts
- Mistaken interpretation of drawings
- Excessive training time for less experienced personnel

Shop floor

- Incorrect NC programs (missed features, incorrect selection of tools)
- Incorrectly specified shop documentation
- Excessive training time for less experienced personnel
- Dependency on paper-based processes
- Standard machining processes/standards not properly followed

This paper highlights the latest NC programming automation technologies available from Siemens PLM Software, and how these technologies can improve manufacturing productivity.

- Feature-based machining (FBM)
- Product manufacturing information (PMI) driven machining

Feature-based machining (FBM)

Feature-based machining (FBM) is intended to make NC programming faster and easier with automated programming. FBM can provide higher quality as a result of fewer errors and deliver greater standardization through the use of proven and preferred processes and resources.

The FBM concept requires software that can recognize machining features, determine the best or preferred machining process for each feature, then generate the tool paths for each operation – all automatically.

Existing methods for selecting the FBM strategies

The common way to automate programming is to create a wide range of alternative machining sequences and store each one as some form of template, where each one effectively represents another variant of the machining process. When a feature is identified on the part, the FBM software selects and applies the closest matching machining process template for that type of feature.

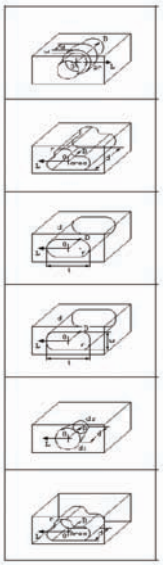

Figure 1: Example feature types.

One problem with this variant approach is the wide range of processes that can be required for a useful system. The type of feature, its size, its accuracy and finish are all examples of factors that can change the way a feature needs to be machined. One way to address this has been to build a system with hundreds, if not thousands, of feature machining templates to cover all the possible feature types and size permutations.

This proliferation of FBM process templates in the variant approach creates a management problem. When a common element such as preferred tool selection parameter needs to change, this change can appear in numerous separate templates. Updating them all and keeping them that way can be a significant overhead. It also leads to a lack of standardization and an increase in the tool inventory as the many different process variants increase the number of tooling variants called for.

To make these systems appealing for the user, they may be supplied with easy-to-use template builders or “feature-teachers” as they can be called. This allows a shop to quickly add machining processes to be applied by the system to a particular type of feature, but as indicated above, creating more and more process variants is not so productive in the long run.

Generative FBM

As an alternative to a basic template approach, it is possible to build some logic into the machining templates so that one process template could be applied to many different instances of the same feature type. For example, the machining process template may contain some kind of rules that check diameters, depths, tolerance and so on, then select or deselect optional process steps built into the template. These rules capture the decision-making process that the skilled programmer would follow when directly driving the CAM software in normal CAM programming. When the template is applied to a unique feature of the right type, the system uses the combination of the basic template and the rules built into it to generate a machining process as a series of operations.

This approach normally reduces the number of machining process templates. The downside is that the process templates become much more complex and special skills are required to build, test and later edit these rules. The task can require at least some form of basic computer programming and, in some cases, the use of proprietary coding methods to build the rules.

Next-generation FBM

The latest version of the NX CAM feature-based machining system represents a smarter way to apply a “generative” method of building machining operation sets for a given feature. This new system adopts building blocks representing the most common, most basic machining operations; these are maintained in a machining knowledge database. Each operation is defined by factors that govern its selection. With each

is a simple definition of the input and output states expected or required for that operation. This information is set up once only. Plus NX is delivered with a library of predefined operations ready to go.

Generating the process

The critical part of the system is the software that looks at each unique feature and literally builds the overall machining operation sequence on the fly from the available building blocks. This core software evaluates a range of options for each step in a machining sequence. The logic considers the requirements of each identified feature and matches these to the input and output states of available operations in the machining knowledge database. It selects those that meet all the dimension, tolerance and material requirements as well as for which a cutting tool is available.

When there are multiple alternative solutions possible, the software selects the one that has been assigned the highest preference rating – perhaps lowest cost or fastest machining time. The system also offers a number of key advantages over other methods.

Each separate machining process step (or building block as referred to above) only needs to exist once in the machining knowledge database. If the shop decides to change when this standard process should be used, under what conditions, or with a new type of tool, it is just one change. Then all subsequent use of the system automatically generates machining operations taking the one, central change into account.

There is far less data to manage and work with compared to traditional FBM systems that create copies and variants of many possible feature machining processes. Not only is this far superior from a change perspective, it also boosts performance. The system only deals with a finite number of basic building blocks rather than hundreds of templates that may have complex rules built into them.

There is no form of computer programming required to use the system or to create new machining processes. In fact, the system comes with a Machining Knowledge Editor designed to manage the simple task of working with the machining process data.

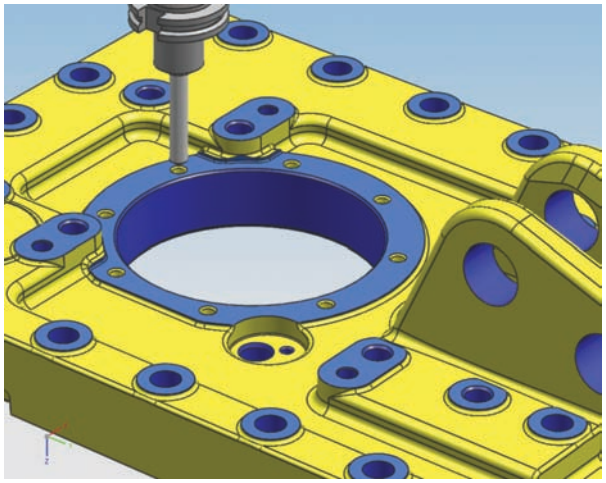

Figure 2: Use FBM to automate programming of parts with many similar features.

Product manufacturing information (PMI) driven machining and its role in automation

The methods described above for the next generation of feature-based machining offers a special opportunity to make practical use of nongeometric data that can be attached to a 3D CAD part model.

Siemens PLM Software has been active in supporting the definition of industry standards relating to the annotation of 3D models and the basis for what is known as product and manufacturing information or PMI.

The use of PMI data to annotate 3D models is effectively a step beyond adding similar data such as GD&T information to drawings. Although PMI can be used to refer to any data that is added to the geometry of a 3D model – for example, proprietary elements such as color coding – there is a set of standards that have been and are being developed to layout the content and formatting of model annotation including the ISO Technical Product Documentation standard 16792.

The FBM system in NX also offers the linking of NC programming to 3D model annotation. In step one of the FBM process – feature recognition – NX can look for and read nongeometric data attached to the model, the industry standard format PMI data.

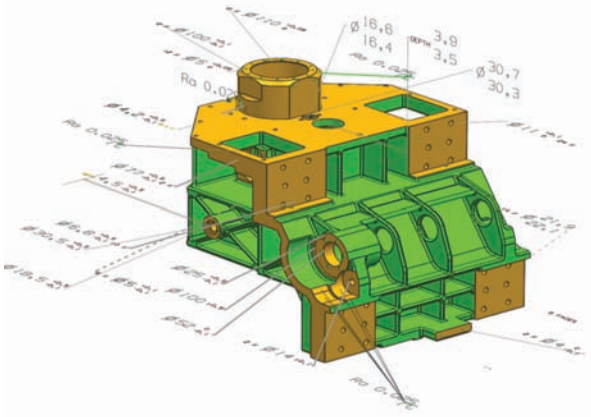

Figure 3: PMI added to the NX CAD model can be used to drive feature-based machining in NX CAM.

In this case, the key attributes that affect downstream machining operation selection, such as tolerances and surface finish labels, can be read and used by NX CAM in the FBM process. These PMI values attached to recognized features can be used to drive the machining method selection. This is done by checking against criteria held in the machining database. For example, a tight tolerance might require a specific finishing process and tool. This finishing process is selected as one step in the overall machining sequence for that feature. In this way the PMI data added to the NX CAM model during design is really driving the downstream process of NC programming and machining.

Combined with the generative feature-based machining capabilities in NX CAM, the PMI driven machining functions establish a significant position in the drive for standards-based NC programming automation. Until now, PMI has been used mostly by those downstream functions willing or able to interrogate and note the 3D data through manual interrogation in 3D viewers. The vision behind PMI data goes much further. Using PMI to communicate the designer's intent to downstream functions in an automated manner reduces errors, speeds up the process and leads to greater standardization. Siemens PLM Software expects to expand the use of PMI in terms of the elements used and in how they are applied to drive NC programming in NX CAM.

The results

Siemens PLM Software customers report an 80 percent reduction in NC programming time using FBM in NX. Users also reference a reduction in the mistakes that can happen with manual programming such as: the wrong tool selected, wrong holes picked for operations or features that are missed all together. Such mistakes, when not identified, result in extra costs due to rework or scrapping and remachining of a complete part. These mistakes cannot be identified 100 percent through NC simulation and verification so the use of FBM automation can deliver a very reliable and valuable NC programming process.

The feature-based machining – with PMI capability – is included in many existing NX CAM (and CAM Express) software packages or is available as an add-on module.

About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with 6.7 million licensed seats and more than 69,500 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with companies to deliver open solutions that help them turn more ideas into successful products. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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