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Integration Of CAD / CAM System Towards High Speed Machining – Challenges And Remedies

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Abstract

Modern manufacturing enterprises are built from facilities spread around the globe, which contain equipment from hundreds of different manufacturers. Immense volumes of product information must be transferred between the various facilities and machines. Most computer numerical control (CNC) machines are programmed in the ISO 6983. Programs are typically generated by computer aided manufacturing (CAM) systems that use computer aided design (CAD) information. The purpose of this paper is to integrate the CAD/CAM System towards High Speed Machining and discuss the challenges and its remedies.

A methodology has been employed which provides all necessary information for machining products automatically. Use of these system results in reduced machining lead times and cost through designing machinable components, using available cutting tools, improving machining efficiency. The system is menu driven with a user friendly interface.

CAD/CAM integration is regarded as a solution for bridging the gap between design and manufacturing, one of the ultimate goals for concurrent engineering. Since the advent of CAD and CAM numerous attempts have been made to integrate these technologies, however, a full CAD/CAM integration is not yet achieved. This paper goes one step closer towards achieving a full CAD/CAM integration with High Speed Machining.

Keywords— CAD/CAM, CIM, High Speed Machining, Integration design, Manufacturing, Machinability, Challenges and Remedies.

1. Introduction

The current standard to program NC machine tools has had no significant change since the early 1950's when the first NC (numerical control) machine was developed at M.I.T. (Massachusetts Institute of Technology), U.S.A. These early NC machines and today's NC machines continue to use the same standard for programming namely G & M codes based on the ISO 6893 standard.

Industrial world has witnessed significant improvements in product design and manufacturing since the advent of computer aided design (CAD) and computer aided manufacturing (CAM) technologies. Although CAD and CAM have been significantly developed over the last three decades, they have traditionally been treated as separate activities. Many designers use CAD with little understanding of CAM. This sometimes results in design of non-machinable components or use of expensive tools and difficult operations to machine non-crucial geometries. In many cases, design must be modified several times, resulting in increased machining lead times and cost. Therefore, great savings in machining times and costs can be achieved if designers can solve machining problems of the products at the design stage. This can only be achieved through the use of fully integrated CAD/CAM systems. In most of the systems developed, user still must determine crucial manufacturing parameters such as cutting tools, cutting speeds, feed rates, cutting depths, etc., requiring expertise and considerable amount of time. In addition, contributions made to integrate CAD and CAM systems for milling operation are very limited, while this operation forms a considerable amount of machining operations. This paper describes development of an integrated CAD/CAM system for High Speed Machining operations.

1.1 CAD/CAM Overview

In the past fifteen years the interactive computer graphics and CAD/CAM technology have been impacting the drafting, design, and manufacturing tools significantly.

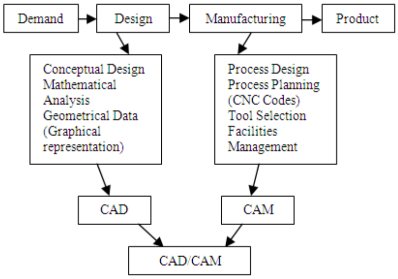

Fig. 1: The Structure of CAD/CAM

CAD/CAM has been utilized in different ways by different people. Some of the applications of this technology are:

- Production of drawings and design documents,
- Visualization tool for generating shaded images and animated displays,
- Engineering analysis of the geometric models (finite element analysis, kinematic analysis, etc.),
- Process planning and generation of NC part programs.

2. Integration of CAD/CAM System

There has been successful integration of CAD/CAM system.

Computer Aided Design (CAD): Used for creating solid models of the components to be designed, (Output is a Design.)

Computer Aided Manufacturing: M stands for Manufacturing; Manufacturing includes every step that is involved in creating the designed component, converting it from raw material into final form. (Output is a manufactured product).

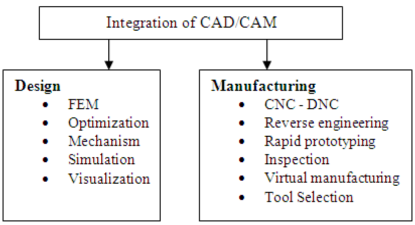

Fig. 2: CAD/CAM Structure

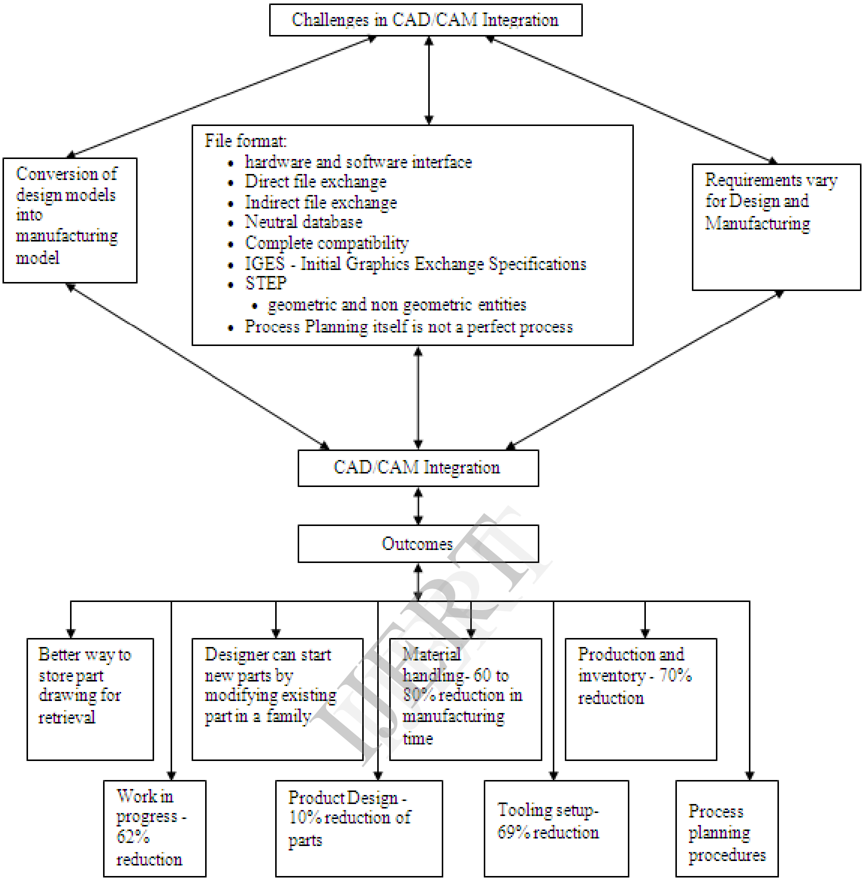

Fig. 3: CAD/CAM Integration

3. High Speed Machining- Challenges and Remedies

The system restores technological data determined by different components in the manufacturing data file (MDF) for use by the manufacturing module. MDF provides all necessary data for each step of machining operations that are required for NC program generation. An IGES file generated by the CAD system provides the geometric data. It is noteworthy that IGES is the most common method for data exchange in current CAD systems. Using these data, the manufacturing module generates required tool paths for each step of machining operation and determines all cutter locations.

User can either accept generated tool paths or modify them. Upon confirmation of generated tool paths, the required NC program is generated using an existing post-processor. The NC machine to produce the product can then use the generated program.[1]

3.1 Accuracy

A major benefit of HSM is the ability to machine parts accurately, with minimal thermal distortion and good surface finish. It's surprising to see how often the tolerances used to create the part model are coarser than the final machining tolerances.

A potential source of accuracy problems is data exchange. Parts are frequently designed in one CAD system and then transferred to different systems for additional design work and for machining. Each data transfer requires geometry to be converted from one format to another, and some of these conversions involve approximation to some finite tolerance. The effects of these tolerances are cumulative, so it is essential to make sure that they are set to be significantly (at least ten times) smaller than the finish machining tolerance.[3]

3.2 Trimming

Most parts are represented in CAD systems by a patchwork of "trimmed" surfaces – similar to the way clothes are assembled from several complex-shaped pieces of material. The accuracy with which these surfaces meet at their edges can have a critical effect on the quality of toolpaths.

Fig. 4 shows in exaggerated form what may happen when a cone is capped with a trimmed plane. The cone is exactly circular, but the planar cap is a polygon that may overlap the top of the cone in some positions. If these overlaps are significant they may result in unexpected spikes in the toolpaths and visible marks on the finished part.

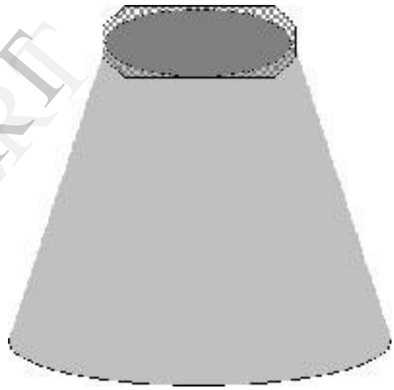

Fig. 4: Trimming Errors

Fig. 5 shows a more complex model with badly trimmed surfaces where a number of surfaces meet. This kind of problem is most often the result of using an unsuitable modeling tolerance, but trimming problems can sometimes be introduced by data exchange errors.

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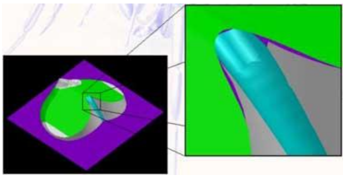

Fig. 5: Poorly Trimmed Modal

3.3 Incomplete Models

Many CAD/CAM operators have developed shortcuts to keep modeling time to a minimum. An often used shortcut is to omit fillets from internal corners on the basis that they will be formed directly by a milling cutter of a suitable radius. This approach requires that the tool be driven right into the sharp corner. This temporarily increases the load on the tool by a factor of about 4.5 compared with straight line cutting conditions.[3]

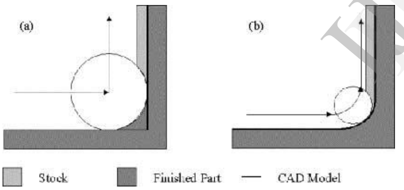

Fig. 6: Cutting Internal Files

Some CAD/CAM systems provide functions to cure this problem, but it is much better to prevent it in the first place by ensuring that the CAD model accurately represents the shape to be machined. It is best to form internal fillets using a cutter of smaller radius, so that the toolpath can flow smoothly round the corner rather than turning sharply. A tool radius of 70% or less of the fillet radius is suitable, and reduces the cutter load by a factor of about 3 compared with the sharp corner.

3.4 Un-machinable Features

Although HSM increases the range of features that can be milled directly, complex parts often include details that must be produced by EDM. The majority of parts also have holes that will simply be drilled. If the CAD model includes these features, most CAM systems will attempt to machine them. Typically the result is unwanted areas of toolpath where the tool dives into holes or runs into sharp corners. CAM operators can waste a significant amount of time avoiding and correcting these effects.

If possible, features that are not to be milled should be excluded from the CAD model used for generating toolpaths. Depending on the type of CAD system being used, this may be done my suppressing features or by covering them with additional surfaces.

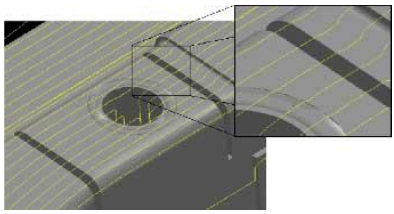

Fig. 7: Un-machinable Features

3.5 CAD/CAM for HSM

Despite years of research, nobody seems to have come up with a concise, accepted definition of HSM or a simple explanation of how it really works. The basic idea is that by taking light cuts at high speed, material can be removed faster than by taking heavy cuts at lower speed. Lighter cuts mean reduced cutting forces, so distortion and vibration effects are reduced. High cutting speeds enable very hard materials to be cut with suitable tooling. High cutting speeds also result in most of the energy of the process being dissipated as heat in the chips, reducing thermal distortion of the part.

None of these benefits will be seen of the machining strategy is inappropriate. Poor strategies usually cause unacceptably short tool life or catastrophic failure. A critical fact to remember is that HSM does not simply mean running existing toolpaths with increased spindle speed and feed rate.

3.6 HSM Toolpaths

A toolpath for High Speed Machining has to satisfy a number of constraints. Most of these are obvious when they are written down.

- The tool must not gouge the part
- The cutting load must be within the capabilities of the tool
- The toolpath should leave cusps no larger than the specified limit
- Abrupt changes in the rate of material removal should be avoided
- Speeds and accelerations must be within the capabilities of the machine
- The cut direction (climb/conventional) should be maintained
- Sharp changes of direction should be avoided
- Non-cutting moves should be minimized
- Toolpath execution time should be minimized

However, given a particular part it is often far from obvious how to generate a toolpath that satisfies them all. In fact, it is usually impossible to meet all of these constraints when finish machining real, complex-shaped parts. In this situation we must do the best we can, but where necessary relax one or more of the constraints. Some are clearly more critical than others, and I've listed them above in approximate priority order.

Finish machining poses a particular problem for HSM because the shape of the part is a constraint that cannot be relaxed, and compromises in cutting conditions frequently show up as visible marks on the finished surface. Of course these can be polished out, but that undermines the case for using HSM in the first place. Roughing and semi-finishing can be easier to optimize, because the CAD/CAM operator has some choice of the shape of the part after the operation, and any marks will be removed by finishing operations.[6]

3.7 Programming Capacity

Good HSM programs execute very quickly on the machine tool, but they can take a lot of time and effort to produce. In industries like mould and die making, where parts are produced in one-off quantities, it is common for machines to be held up waiting for programs. Clearly this is not an ideal strategy. To get the best out of HSM it is essential to provide adequate CAD/CAM capacity to keep machines fully loaded with high-quality programs.

- Choose CAD/CAM software that provides automatic HSM features. This will reduce the amount of effort operators must put into optimizing their programs.
- Choose CAD/CAM software that calculates gouge-free toolpaths quickly. Batch calculation features allow complex programs to be computed overnight.
- Use high-performance computers and keep them up to date. Ensure enough memory is installed to obtain maximum performance.
- Ensure you have enough CAD/CAM operators to keep up with the machines. Training and equipping machine operators to generate programs on the shop floor is one way to get the most out of on existing skills.
- Ensure operators are adequately trained to produce HSM programs.

4. Conclusions

HSM places exacting requirements on all elements of the process. It is essential to use the right physical equipment, and this can be specified quite accurately. It is much harder to specify in concrete terms what is required from the CAD and CAM functions; nevertheless these have a significant influence on the quality and stability of the HSM process.[7]

It is essential that CAD/CAM models for HSM be prepared to represent accurately the shape that will be milled. This means both that the accuracy of the model must exceed machining tolerances, and also that features that are not to be milled should be excluded from the model if possible.

The investment in HSM equipment must be supported by sufficient programming capacity in order to keep the machines loaded with high quality programs. Enabling machinists to do some of the programming on the shop floor may be an effective way to boost programming capacity.

Ensure CAD/CAM operators and machinists are properly trained and understand HSM thoroughly.

Careful planning of the machining sequence is critical. Making appropriate use of the strategies provided by the CAD/CAM system is the best way to get successful results.

5. Refrences

[1]. Roberto S.U. Rosso Jr*, R.D. Allen, and Stephen T. Newman, "*Future Issues For Cad/Cam And Intelligent Cnc Manufacture*", Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, LE11 3TU, Leicestershire, UK

[2]. International Organization for Standartization – ISO 6983/1 – *"Numerical control of machines – Program format and definition of address words*" – Part 1,: Data format for positioning, line and contouring control systems. First edition.

[3]. Sharon J. Kemmerer (Editor), STEP The Grand Experience. Manufacturing Engineering Laboratory. *"National Inst. of Standards and Technology"*. Gaithersburg (MD), July 1999.

[4]. International Organization for Standardization - ISO 10303 – "*Industrial Automation Systems and Integration -Product Data Representation and Exchange"* - Part 224: Application Protocol: Mechanical Product Definition for Process Planning Using Machining Features. December 2000.

[5]. International Organization for Standardization – ISO/DIS 14649-1 "*Industrial automation systems and integration"* – Physical device control – Data model for computerized numerical controllers – Part 1: Overview and fundamental principles.

[6]. International Organization for Standardization – ISO/DIS 14649-11 "*Industrial automation systems and integration*" – Physical device control – Data model for computerized numerical controllers – Part 11: Process data for milling.

[7]. R. D. Allen, R. S. U. Rosso Jr. and S. T. Newman. AB-CAM: an agent-based methodology for the manufacture of STEP compliant feature based components, In: "*Metal Cutting and High Speed Machining"*. Edited by D. Dudzinski et al., Kluwer Academic/Plenum (2002), 351-362. ISBN 0-306-46725-9

[8]. Paul S. Adler, "CAD/CAM Managerial Challenges & Research issues", IEEE Transactions of Engineering Management Vol. 36, No. 3.