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MACHINING IMPROVEMENT OF MILLING RAPID PROTOTYPING PROCESSES

Cristian COSMA, Adrian Ilie DUME, Eugen PAMINTAS, Tudor ICLANZAN

Abstract: *A CNC tool can be used in many ways for prototyping, reverse engineering and modeling. Whit rapid prototyping tool, we can machine foam, wood, plastics, and aluminum to efficiently create prototype and reproduction parts. This paper presents a technique for the manufacturing and finishing of parts by integrating RP and CNC machining.*

Key words: *rapid prototyping, milling, CNC, postprocessor, manufacturing.*

1. INTRODUCTION

The term *rapid prototyping* (RP) refers to a class of technologies that can automatically construct physical models from Computer-Aided Design (CAD) data.

Rapid prototyping techniques can be classified like in Fig. 1.

The application of CNC milling as an RP technology still is new, and has been made possible by a number of new developments. The use of CNC milling for prototype creation is of course well known, however until recently this technique was not exactly Rapid. Main problem was the calculation of the toolpaths, for which a skilled CAM software operator was needed.

This process involved the importing of several surface patches and the creation and checking of toolpaths for every separate surface, which would take several hours. [2] A CNC tool can be used in many ways for prototyping, reverse engineering and modeling. Whit rapid prototyping tool, we can machine foam, wood, plastics, and aluminum to efficiently create prototype and reproduction parts.

With a CNC tool, we will typically be doing "subtractive" prototyping, but it is a process that lets you machine quickly in materials that are similar to the end product. With a good CAD/CAM package and a CNC machine, it is possible to create different parts.

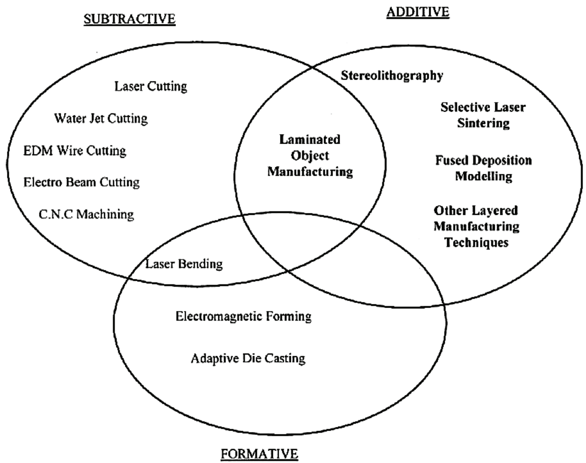

Fig. 1. Rapid prototyping techniques [1].

The new software has solved the above problems, making CNC very suitable for Rapid Prototyping. Its main characteristics are:

- import of IGES data instead;
- no CAM-training needed: automatic toolpath generation;
- low calculation times (fast);
- low cost [3].

2. ELEMENTS OF RAPID PROTOTYPING PROCESS THROUGH REMOVED MATERIALS (MILLING)

2.1. Input

- **material:** natural woods, wood composites and hard, fibrous or abrasive plastics, aluminum.
- **tool materials:**
  - *Solid Carbide:* Use for all natural woods, wood composites and hard, fibrous or abrasive plastics. Solid carbide is generally the toughest tool (next to diamond tooling) and holds the edge best;
  - *High-Speed Steel:* Use for aluminum, soft natural woods and ABS or poly plastics. High-speed steel is the most readily available tooling and is preferred for most metal work because of its cost and hardness. HSS is seldom used in wood applications because carbide tooling stays sharper longer. HSS is generally preferred for metal cutting and some plastic cutting operations.
- **fixturing & tool changing systems:** the surfaces of tables are usually slotted to allow for the mechanical fixturing of workpieces. The T-slots on the table accept T-nuts which the operator can use to secure clamps and bars. For tool changing we use a system presented in the Fig. 2.

  Even if the tool is not inserted to a consistent length, the tool tip is located precisely by the sensor.
- **cutting parameters:** these parameters are done by the soft. This type of software allows the user to input parameters such as cutter size, finish quality, and number of passes over the material. Based on the specified parameters, the CAM program then calculates the toolpath.
- **part complexity:** we can manufacturing 2-D and 3-D contours, pockets with island avoidance, surface of

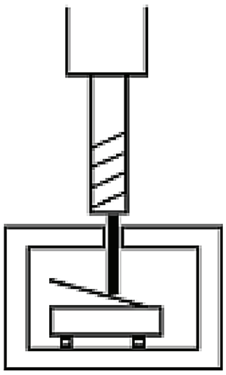

Fig. 2. Tool Touch-Off Sensor.

revolution, arbitrary 3-D surfaces, intersecting surfaces, inlays, etc.

2.2. Output

- quality of surface
- time of manufacturing
- rest of uncut material
- dynamic behavior in the manufacturing process

3. EQUIPMENT AND SOFT

3.1. Rapid prototyping machine

The isel-CNC base units of the **series GFM 4433** are stable C-frame-type CNC machines made of light-weight profiles (Fig. 3). All linear axes run on grinded steel shafts with linear ball bearings. Clearance-free ball screw drives with hardened and polished 5/8"-16 spindles with a pitch of, optionally, 5 or 10 mm are used as drives. The linear axes are driven by powerful and robust stepping motors (series GFS) and DC servo motors (series GFV) in easy-to-maintain drive modules.

The machine table, which is firmly screwed with the underframe, is made of plan-milled precision T-nut profiles. It provides optimal clamping possibilities for the most different and workpiece holders and devises. The protective hood, which features Perspex-lined glass and a swivelling door made of aluminum profiles, constitutes a closed working room with hood locking. The isel-CNC base units of the **series GFS 4433** are ideal for individually assembling applications in the fields: positioning, milling/drilling, graving, dosing, screwing, measuring, etc.

Fig. 3. The ISEL rapid prototyping machine.

3.2. Soft

We will use Edge Cam soft. Edge CAM offers a full range of surface machining functionality that can be used by the production machinist equally effectively to machine large quantity batches.

Intelligent approach strategies provide improved surface finish while optimizing machining times and maximizing tool life. With Edge CAM, everything is verified on screen before it goes to the machine. The operators can even check the level of surface finish that might be achieved. The numeric code is generated using Automatic Programming Tooling (APT).

3.3. Postprocessor for rapid prototyping machine

The rapid prototyping machine was getter from ISEL firm. In the moment of getter, it came accompaniment by a drawing soft that is on DOS; allow only drawing and 2D importation drawings.

Also, the CAM soft presented a disaffected communication interface, being deficient in menu. The fabrication was one of counter. Knowing that the machine is 2.5D, I wished to can realize 3D models importation. That was not possible, on display coming on each time messages who advertise me that this operation it is not possible. So I go on to write back the postprocessor of prototyping machine, refreshing his functions [4]. Current computer-aided manufacturing CAM software is readily capable of generating toolpaths given a set of surfaces of a part and a cutting orientation 3-axis machining [5].

The steps for postprocessor writhing are:

- **Definition of machine:** for this we will use Code Wizard module from Edge Cam soft (Fig. 4).
- **Instructions writing:** we will choose a postprocessor who will be adapted for our machine. We set up all the instruction. This is presented in Fig. 5.

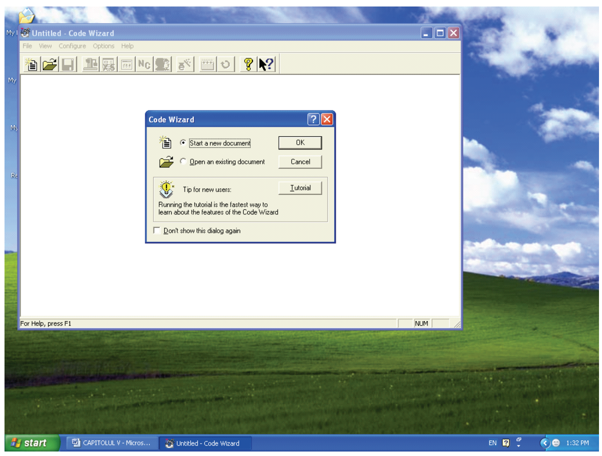

Fig. 4. Start of postprocessor writing.

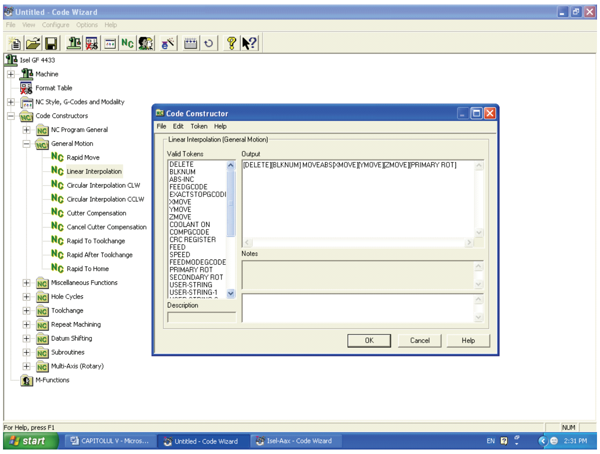

Fig. 5. Instructions writing.

4. TECHNIQUE FOR THE MANUFACTURING

This paper presents a technique for the manufacturing and finishing of parts by integrating RP and CNC machining. When using CNC machining to finish the parts, pre-processing of the original 3D model and quickly and correctly generating tool paths and machine code from the 3D model are very important issues.

The accuracy and surface finish of parts manufactured by RP are material and process dependent. Considering both accuracy and machining efficiency, the machining strategy of adaptive raster milling of the surface, plus sharp edge contour machining, is applied to finish the RP parts and tools. For finish machining of rapid manufactured parts or tools, the degree of automation and the total time used to generate tool paths from the model are important criteria. It is more important to generate tool paths automatically and quickly than to generate high efficiency machine code. This study shows an initial applicability of the presented procedure and the improved capabilities of this machining strategy for finish machining of rapid manufactured parts.

To present the methodology of rapid prototyping we will use a car model. We begin whit the interior part.

Steps for manufactured parts in rapid prototyping process through removed material (milling):

First we will choose stock and CPL (Fig. 6).

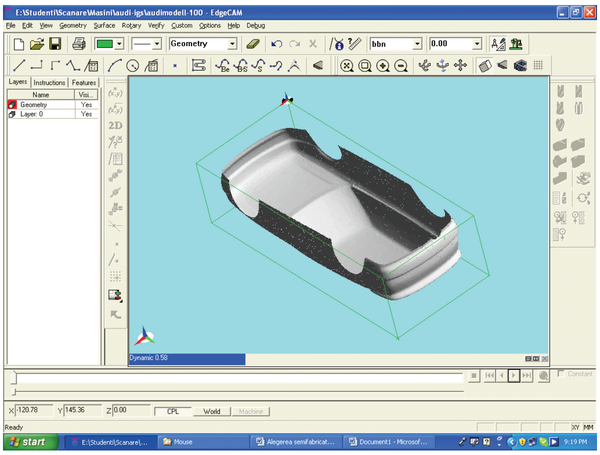

Fig. 6. Stock and CPL choosing.

Than we will initiation the first sequence and we will choose the right tool milling for Z Level Roughing Cycle (Fig. 7).

The next step is to establish the strategy of roughness, mill type, cutting parameters, etc. (Fig. 8).

Like the steps above, we will make the same thing but for finishing cycle (Fig. 9).

EdgeCAM Simulator provides full 4-axis representation, providing sequence verification before the machining process commences. In this way the probability to make a fault is minimal.

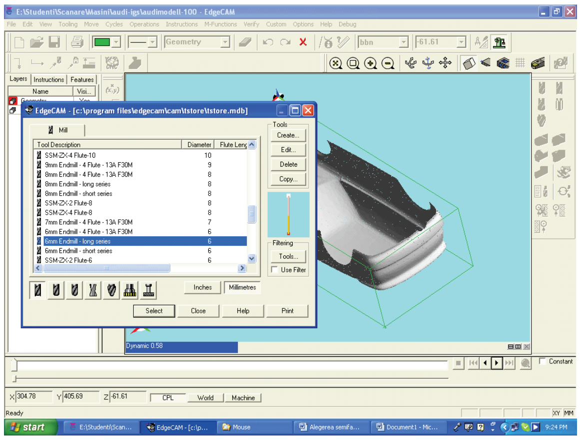

Fig. 7. Choosing tool milling.

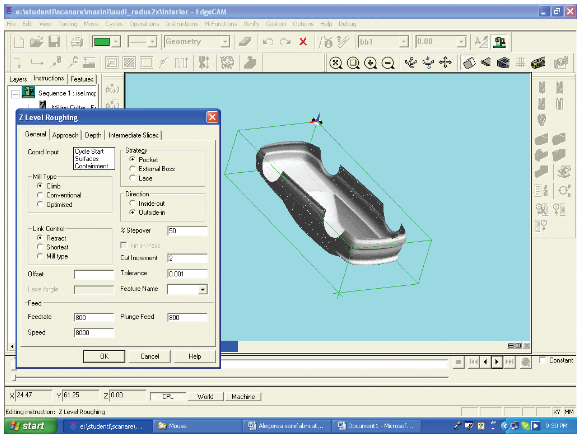

Fig. 8. Z Level Roughing Cycle.

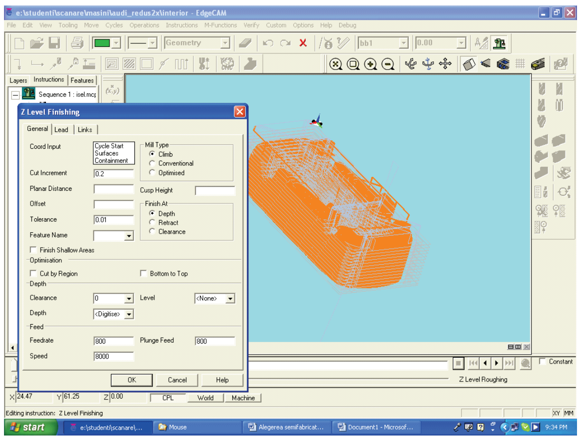

Fig. 9. Z Level Finishing Cycle.

In figure below is presented the part after the simulation of the virtual manufacturing (Fig. 10).

The exterior part after the simulation of the virtual manufacturing is presented in figure below (Fig. 11).

The last step is to generate numeric command:

N000001 IMF_PBL
N000002 FASTVEL 10000
N000003 FASTABS X0 Y0
N000004 FASTABS Z10
N000005 ;(USER DEFINED)
N000006 COOLANT ON
N000007 FASTABS X12622 Y86771
N000008 FASTABS Z61341
N000009 FASTABS X12622 Y86771 Z5000
N000010 MOVEABS X12622 Y86771 Z-2000
……………………………………………………
N000115 MOVEABS X9965 Y54866 Z-2000
N000116 CCWABS I12960 J55207 X10115 Y54212 Z-2000
N000117 MOVEABS X10209 Y53965 Z-2000
……………………………………………………
N061661 MOVEABS X20730 Y3357 Z-27400
N061662 CCWABS I20147 J-1609 X15288 Y-433 Z-27400
N061663 MOVEABS X15181 Y-1027 Z-27400
N061664 MOVEABS X25092 Y-2208 Z-27400

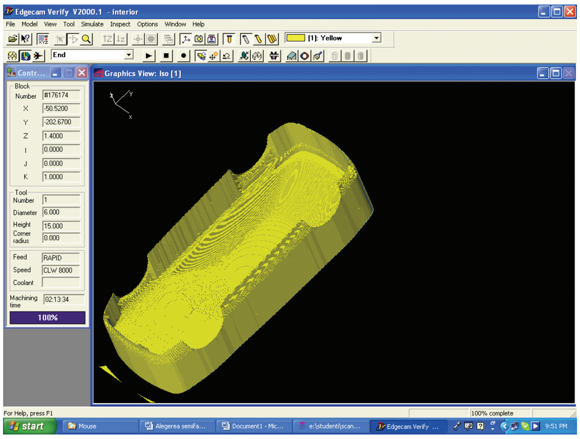

Fig. 10. Part in simulation mode.

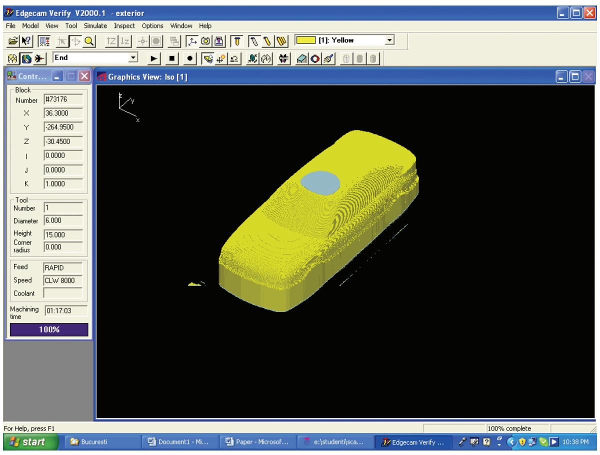

Fig. 11. Exterior part in simulation mode.

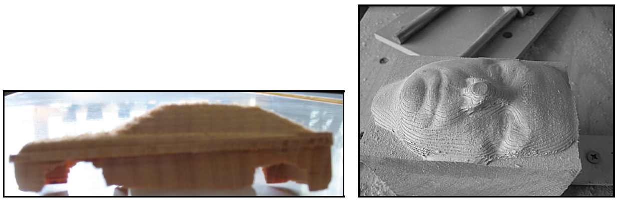

Fig. 12. Some examples of different parts.

N061665 MOVEABS X25092 Y-2208 Z-27600
N061666 CCWABS I20128 J-1607 X20730 Y3357 Z-27600
N061667 MOVEABS X18688 Y3604 Z-27600.

5. CONCLUSION

This paper presented a methodology for rapid prototyping in CNC milling. The method makes it possible to rapidly create machined parts and prototypes with little or no human intervention. The method can be used for moderately complex part geometries.

We have shown that CNC milling is a competing technology for Rapid Prototyping. Some examples of different parts make in rapid prototyping process through removed material is present in Fig. 12.

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Authors:

Cristian COSMA, Ph.D. Student, “Politehnica” University of Timişoara, Manufacturing and Material Engineering,
E-mail: `ccosma@eng.upt.ro`
Adrian Ilie DUME, Ph.D. Student, “Politehnica” University of Timişoara, Manufacturing and Material Engineering,
E-mail: `adume@eng.upt.ro`
Eugen PAMINTAS, Assoc. Prof., “Politehnica” University of Timişoara, Manufacturing and Material Engineering,
E-mail: `epamintas@eng.upt.ro`
Tudor ICLANZAN, Prof., “Politehnica” University of Timişoara, Manufacturing and Material Engineering,
E-mail: `ticlanzan@eng.upt.ro`