CAM PROCESS CORRECTION WITH REVERSE ENGINEERING TOOLS

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Abstract: The objective of this paper is to reveal the possibility of new technologies in CNC milling process. After a typical cutting process on a milling machine tool, the correction of the CAM process can be done as the procedure described below. The manufactured part can be measured with normal instruments, but for complex shapes is very difficult to determine the profile without a CMM machine. In this case, the part must be taken out from the original setup, with all consequences. Our scheme is to use the scanning head similar to figure 2. The LASER beams can determine a points cloud, processed corresponding as in figure 3.

1. Introduction

A traditional milling process can be done on different CNC machine tools. After the process was finished the part is removed from the milling machine and is installed in a CMM machine for inspection. In this operation all setup (or setups) for the cutting process

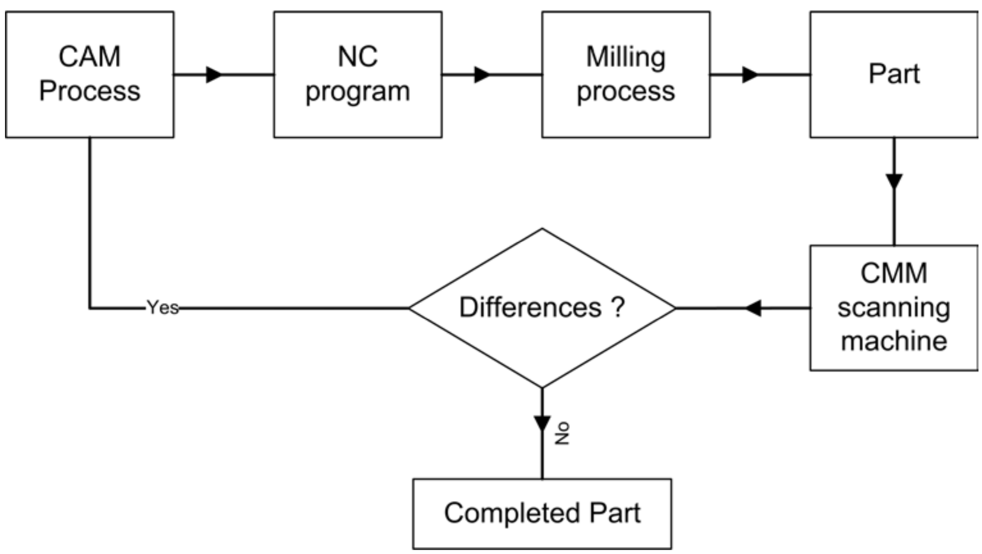

Figure 1

is lost. If the part was not well machined but some corrections can be made in order to obtain an acceptable part, the procedure starts again (an additional CAM process for correction, one more NC file and another milling process). In figure 1 an important item is not shown: the setup for the milling process. This is one of the greatest time consuming as well an important source of errors and accidents (tool damages, crashes of the machine tool or break up the workpiece or the jigs.

Today, worldwide manufacturing industry is operating the milling process as in figure 1. Special devices were created to measure the manufactured part on the milling machine, but that 3D probe can determine only few points of the piece. Leaded companies – like [1] – offer solutions to compare the manufactured part with the 3D geometry file, but the differences can be obtained only outside of milling machine environment.

2. CAM process correction

At the moment, the most software applications available in Reverse Engineering (R.E.) domain are capable to resolve the geometrical differences between the theoretical part and the manufactured part. All of those applications can transmit to a CAM module the material rest's positions for the subsequently CAM process and NC file.

No link is present today between the CAM system and the RE system although this connection can be created very easily, with major advantages for the entire process – saving the setup time, increasing quality of the part, reducing the number of wrong parts.

Our answer to this complicated assignment is the scheme shown in figure 2. Subsequent to milling process, the last cutting tool must be removed from the main spindle, and – instead – a LASER scanning head will be mounted.

An important aspect is that the scanning head must have an active working area larger than the manufactured part, or – if not – the LASER head must be constructed with its own mechanics. On other words, is critical that the system will not be based on the precision of the machine tool's screws to scan the whole manufactured part. For small pieces this restriction can be completed effortless, but for large parts the scanning head becomes very sophisticated, and it induce its own inaccuracy. For large parts (more than L = 500 mm) the imprecision of the scanning head can be a predicament in the process. In this case, the method must be change in order to obtain a minimum performance in precision: it can be accepted that the part will be scanned in two slices and the shells will be registered by the RE software. Consequently:

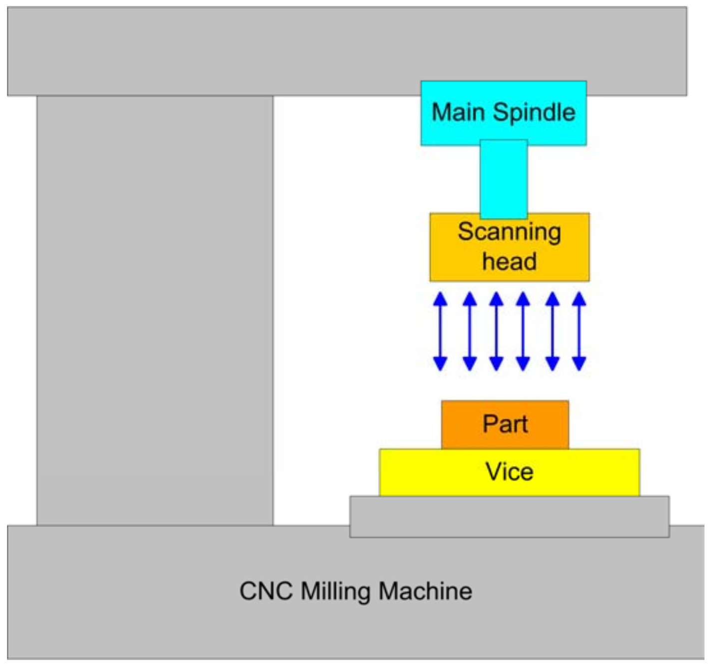

Figure 2

$$PC_P = f(L, N_S, SH_P) \quad (1)$$

where:

PC_P – point cloud precision;
L – length of the part;
N_S – number of shells;
SH_P – scanning head accuracy;

The RE process consist in an inspection of 3D file against the manufactured part. The first step is registering the shells. Registering multiple shell's effect is time consuming in scanning process.

Machine tool time represents a high cost. Is an ineffective technology to scan a complete piece if not all dimensions revealing some importance for assembly or for the functional aspect. So, the manufacturing engineer will decide the part's area to scan.

These zones will become in shells and the shells will be registered in a single shell – as in any traditional RE process. The number of shells depends as below:

$$Sh_{NO} = f\,(C_P,\, D_{NO},\, P_S,\, St,\, Is,\, F_S) \qquad (2)$$

where:

- Sh_{NO} – number of shells;
- D_{NO} – number of dimension for inspection;
- P_S – part size;
- St – manufacturing strategy;
- Is – inspection strategy;
- Fs – feature shape;

For this reason, the registering process can be prepared in one of the options: partial register, quick register, datum base register, reference point register or register with polygons.

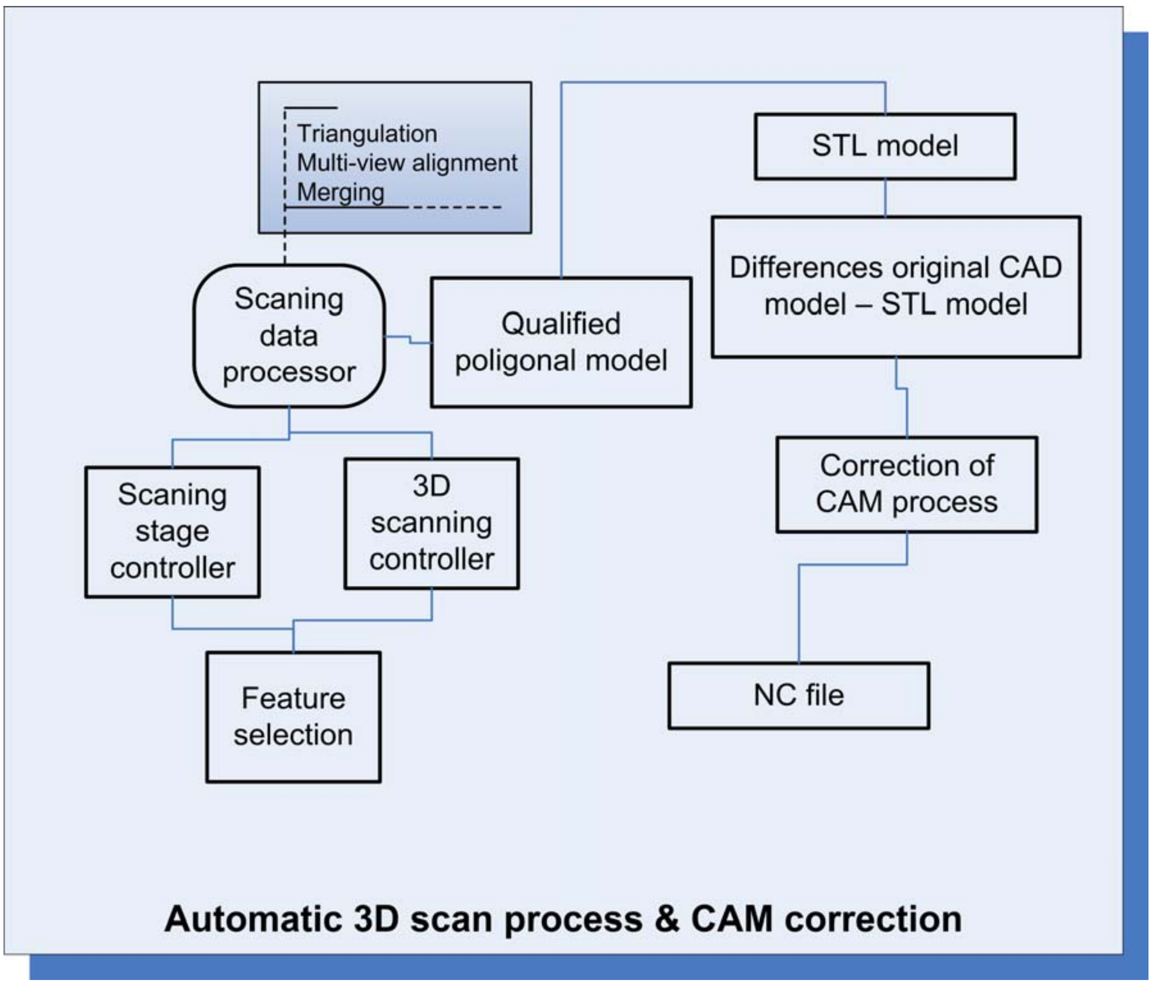

Figure 3

Decisive for the CAM process correction is deviation procedure. The deviation can be calculate as a determined surface against the 3D model, as a mesh (or polygons), as a section (using curves), as a dimension or as a geometric tolerance. For most of the CAM process correction important is the deviation calculated as manufactured surface against 3D model surface, but in same cases we can use also another pairs of geometric elements. The RE process is completed at this point. In general, RE process ends with a report (usually a HTML report), but in CAM process correction this phase is not necessary. Never the less, the report can be created only for information of the manufacturing engineer, to keep the trace of the manufacturing process, or for quality assurance process or for a better in sequence route.

Figure 3 shows an automatic 3D scan process and the CAM process correction as well. The CAD file was done with commercial software [2]. We make use of a milling machine with vertical spindle [4] and a CNC controller was Sinumerik 840 D + PCU 50, Windows based [5]. The scanning head was operating like [3]. The RE system was [1]. Actually, the entire figure 3 is based on a RE system (aprox. 70%) and a CAM system (aprox. 30%). The CAM system was [6].

3. Conclusions

As far we known, this is the first approach in the world to join together a CAM system with a RE system. We are aware that this first move toward has its own advantages and detriments:

- the scanning time is the key factor. If the time to scan the manufactured part is too long the method will be misplaced, for the reason that no one will stop a machine tool from work for 3…4 hours.
- also, the RE process time is an important factor. At this moment, it assuming that the workshop has the possibility to work with an RE engineer in real time.
- the CAM correction process is different than a traditional CAM process. That means the engineer will use special strategies to correct the part, as well special tools and cutting parameters. The CAM machinist must be a qualified person with special skills and experience.
- the precision obtained in the entire process depends on each stage's precision.

As expectations we consider that our work will be useful if we succeed to automate the whole process.

At this stage, the procedure can be functional for very expensive manufactured parts or complex pieces, not in mass or medium size production. We work to develop our technique, and we also expect the evolution of RE application software and scanning heads technology.

Finally, or approach makes the process correcting milling parts by creating parametric CAD models from real world parts faster and easier by utilizing a RE process and user interface that are instantly familiar to CAD users. CAM correction process allows engineers to solve the design intent and design parameters of real parts that may have lost their precision features during the manufacturing process.

References:
[1] http://www.rapidform.com , May 2007
[2] http://www.solidworks.com , May 2007
[3] http://www.tesabs.ch , May 2007
[4] http://www.gildemeister.com , May 2007
[5] http://www.automation.siemens.com/mc/mc-sol/de/6f1ffad8-535d-4cdc-bcd7-e9daef530780/index.aspx, May 2007
[6] http://www.dptechnology.com, May 2007