CAD-CAM Technology for Medical Components

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Many medical components contain free form surfaces, that need to be machined. Today this is done by using manual processes, robots or CNC machines in different constellations. These operations contain different steps in many stations and various kinds of programming, like teaching a robot or programing a CNC machine. The requirements in modern implant production are highest quality at most possible efficiency. So here is great potential for a closed manufacturing chain on a single production cell. All operations in this chain can be programmed by a single CAD-CAM system. On these conditions turning a blank into a finished workpiece is simple and efficient. NC technology in multiple axis is the base of this procedure. It provides a superior level of accuracy of the component and is the upcoming standard in future.

The following shows the principle of a complete CAD-CAM chain starting from a 3D-Model and going up to a finished part with a femoral knee as an example (figure 1).

Figure 1: Femoral knee as 3D-Model and real implant made of chrome cobalt alloy

The steps of this process (figure 2) are:

- creating a 3D CAD Model
- defining tools and working strategy in a CAM system
- generating the tool path
- postprocessing of the tool path with feed commands for a certain machine as a result
- inclusion of these feed commands in an NC-Program
- manufacturing the part on the machine

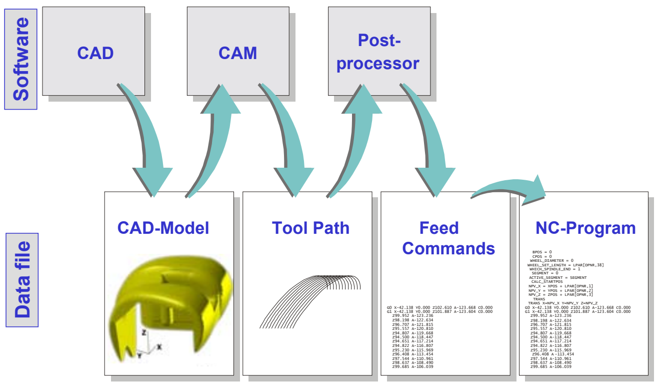

Figure 2: Principle of a CAD-CAM chain

The first step when manufacturing a femoral casting is removing most of the stock by grinding. According to different sizes left and right it is a big advantage to use a single grinding wheel with the ability to do the complete part family. The solution is an electro plated CBN grinding wheel with a full radius shape and grinding in lines.

Figure 3: A single electroplated CBN grinding wheel is used for all sizes of a part family

Today there are no CAM systems that support multi axes grinding as a special operation. So using a full radius grinding wheel as a tool in a CAM system requires the ability of the software to provide a torus toolshape and special experience of the programmer, because grinding totally differs from milling. As can be seen in figure 4 the relative positions of tool and workpiece have a certain influence over the contact situation.

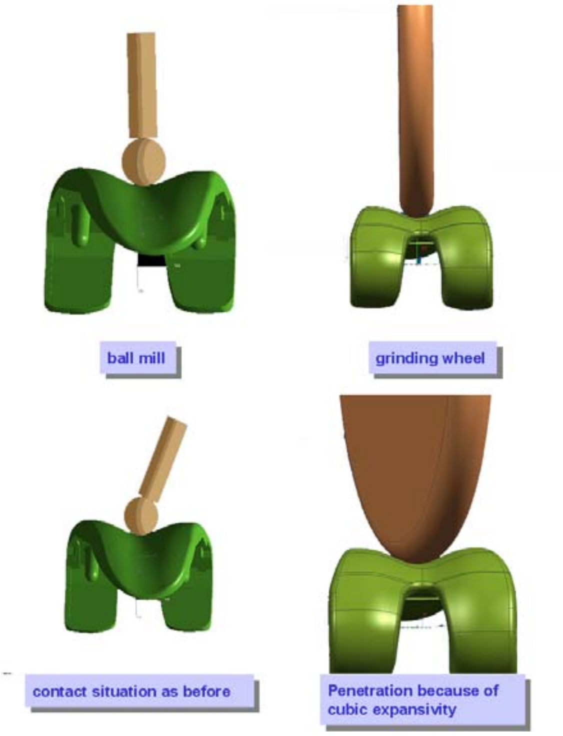

Figure 4: Differences between a ball mill and a grinding wheel in a CAM system

Keeping this in mind the programmer has to decide how many axes should be used for the machining of the part. Two possible strategies are shown in figure 5 and figure 6 exemplary.

Manufacturing in three axes for example leads to another point that the programmer can vary: The method of postprocessing. First of all the postprocessor must have the ability to translate the tool paths, that are generated by the CAM system, into feed commands fitting the kinematics of the production machine. The postprocessor determines as many axes as needed for the process. In some cases there is more than one possibility to combine the axes movements and an intelligent postprocessor can be switched to give the desired output (figure 7).

A polar or linear postprocessor method has influence over the contact situation and also over the dynamics of the moving axes. Which method fits to the task best can be decided by the experienced developer of the process.

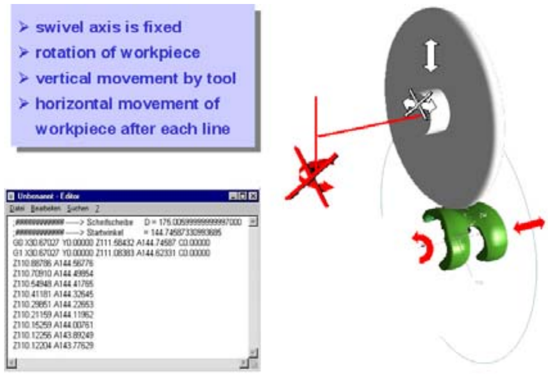

Figure 5: Manufacturing in three axes

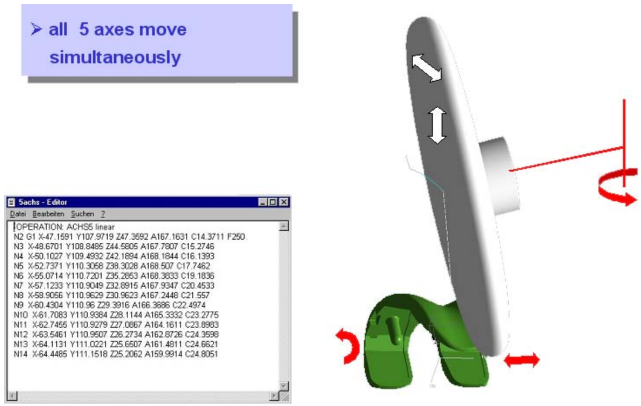

Figure 6: Manufacturing in five axes

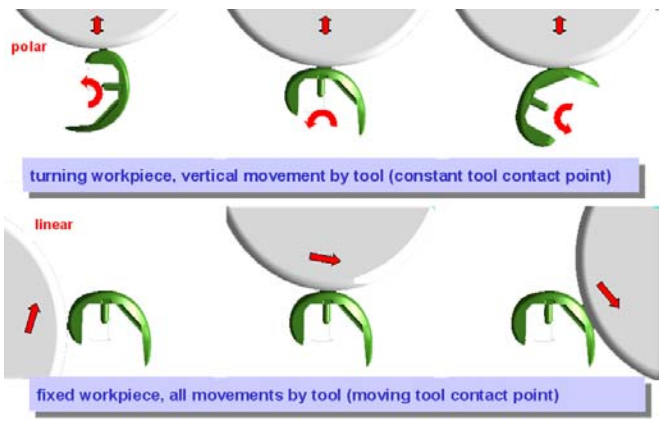

Figure 7: Postprocessor methods "polar" and "linear"

Grinding is the first and most important step in a row of downstream operations after casting. The surface after grinding gives the desired shape to the workpiece and has to fit the tolerances. The following operations mainly improve the surface quality. Therefore the grinding surface quality mainly determines the efforts for belt grinding and polishing.

Roughness after grinding is influenced by grit size of the grinding wheel, cutting speed and feedrate. But even the parameters of a CAM system like Unigraphics affect roughness by varying the calculating tolerances, scallop height or tool shape (figure 8, figure 9). These parameters are set at an early stage of the developing process, so the programmer does not only decide the rough structure of manufacturing, but takes influence on the machining parameters as well.

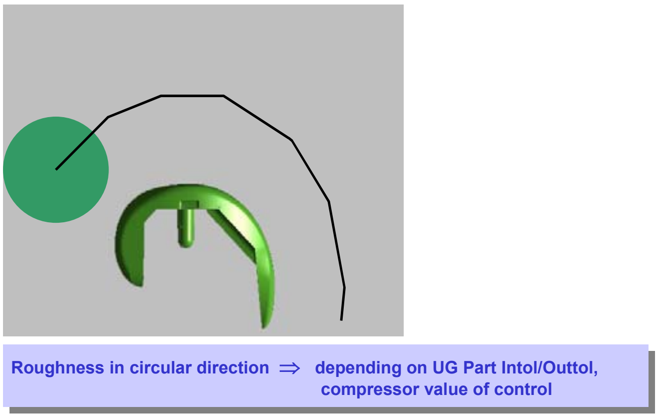

Figure 8: Roughness in circular direction

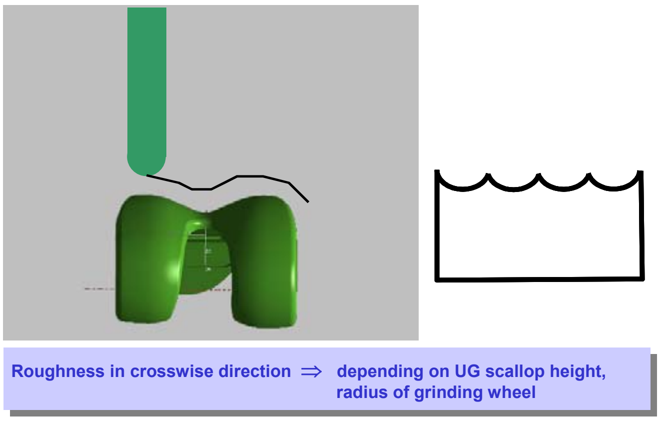

Figure 9: Roughness in crosswise direction

The operating procedures for machining a femoral knee could be grinding, disc cutting, belt grinding, milling and buffing. Every type of tool has its own requirements regarding the working strategy. This can be the relative position of tool and workpiece, overlap, cutting direction etc.

Belt grinding and buffing are operating procedures which have a similar tool shape compared to a grinding wheel. But the contact wheel, that drives the grinding belt, must touch the surface at its normal vector and the buffing wheel has to dig into the workpiece to get a shining finish. To consider these exemplary requirements the working strategy varies from grinding.

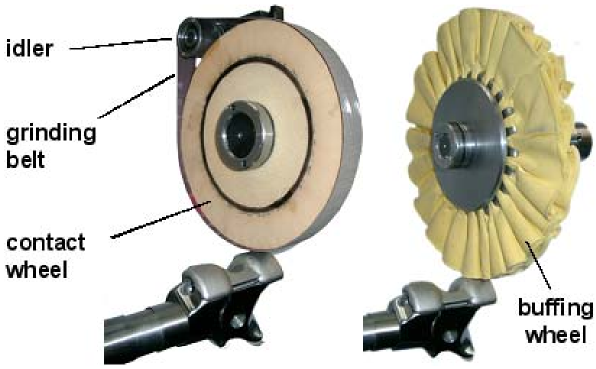

Figure 10: Belting Unit, specially designed by Schütte and treated buffing wheel

Milling might be necessary for surfaces, that cannot be reached completely by a grinding wheel, like the box section or the outer diameters (figure 11). Generating milling tool paths is no problem for the CAM system, which is in its element here. But the machine has to be able to realize the degree of freedom, that is necessary to mill a free form shape.

Figure 11: Milling the box section of a femoral implant

Using a five axes grinding machine for this kind of application gives the ability to follow almost any shape, but at the same time a very dynamic movement of all axes is requested.

Schütte is a manufacturer of tool and universal grinding machines (figure 12).

Figure 12: Schütte grinding machine WU305 linear

For producing and regrinding complex tools, a precise CNC grinding with simultaneous interpolation of up to five axes is requested (figure 13). These are requirements, that also fit for machining free form shapes.

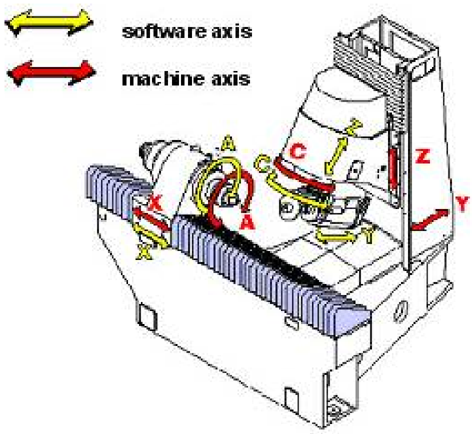

Figure 13: Kinematics of a Schütte five axes grinding machine

A compact and rigid machine concept is completed by five direct driven axes for most possible dynamics, which is the key to free form shape manufacturing. Two rotatory and three linear axes are driven by synchron motors, which are backlash-free and do not have to bear lateral forces.

To be flexible on different operating procedures the machine also has the ability of an automatic tool change. A magazine for four or five different tools is provided, so that grinding, belt grinding, polishing and also milling tools can be used in one setup (figure 14). The supply of coolant and polishing compound is controlled by the NC program and exactly fits to each tool, which is an important aspect for grinding of bad machineable materials like titanium.

Depending on lot sizes the automation of handling the workpiece is requested, too. Therefore a pick up loader can be provided in this machine (figure 15).

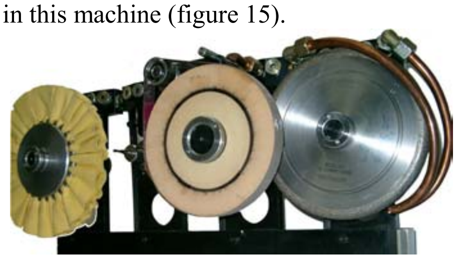

Figure 14: Magazine for automatic toolchange with grinding wheel, belting unit, buffing wheel and end mill

Figure 15: Pick up loader for handling of workpieces

Containing all these features, the Schütte WU305 linear is a complete manufacturing cell and highly suitable for implant manufacturing. The missing link from a tool grinding machine to a CAD-CAM system is a full five axes postprocessor, that was specially designed for this machine and can be used with Unigraphics as CAD-CAM software.

The advantages of this CAD-CAM system can be summarized as follows:

- the programmer uses only one programming platform (CAM System) and overviews all process steps
- the operation structure of the CAM file can be used as a template for all other part sizes
- the programmer defines input and output of each machining step
- the process chain only contains a single manufacturing cell and the programmer needs to know the kinematics of only one machine
- reducing cost because one tool setup for a complete part family is stored in one machine
- one chucking for all process steps is requested and automation of handling is possible, which reduces cost
- a higher repeatability of process output in dimension and surface roughness

The Schütte grinding machine can be used for universal applications. The complex kinematics and various features predestinate it for the production of medical components.