Zpět

Use and influences of CAx Technologies on the Components Production Cycle

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This thesis focuses on the use and influences of CAx Technologies on component production cycle. At the same time it lists and describes computer aided technologies that deals with this subject.

This thesis identifies basic medical and stomatology concepts as well as methods used. It also contains a detailed example of manufacturing medical implants such as knee implant or dental crown. It further explains the detailed process of acquiring a digital description of implant shape and its subsequent modification. Attention is drawn to a analysis of ultrasonic machine ULTRASONIC 20 linear, which was used for manufacturing of dental bridge. In the centre of Excellence 5-axis machining in Trnava, where we manufactured a hip implant. The fabrication was accomplished by 4 - and 5 - axis kinematic structures of machining by the Eagle machine.

The last part of this thesis concentrates on the rapid protoyping technologies and comparating of direct and indirect methods of manufacturing of medical components.

Key words: CAD/CAM, Medical manufacturing, Ulstrasonic machining, Rapid prototyping

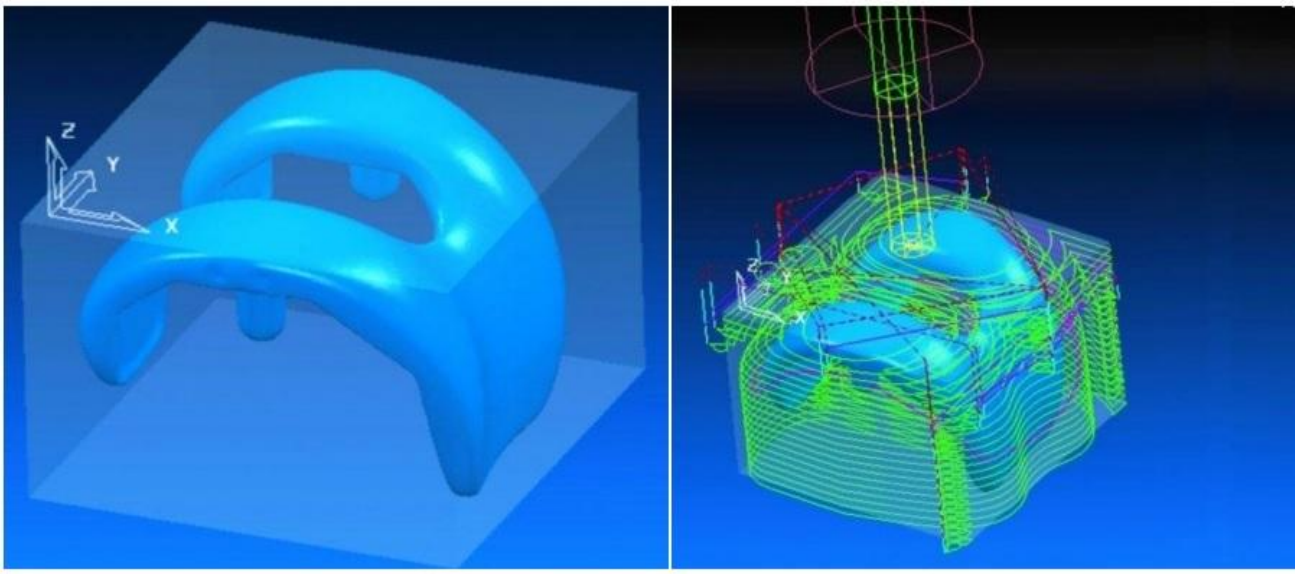
1 Introduction

In recent history, many technologies in the industry develops rapidly. Whether we mean policy, transport, engineering and medicine. Production of medicine and its associated production of artificial compensation in the form of implants is an area that I decided to dedicate. Achievements of modern technologies is becoming ever more affected by the trade unions, which were previously only in the plane of vision.

Last possibilities of science and technology, particularly in the areas of rapid prototyping and computer-aided technologies are the drivers of sustained demands for innovation in medical manufacturing. It is important to realize that medicine and the associated production of medicine is important not only for health and functional site, but often also on the aesthetic matter. Gradually increasing the average age of the human population and a growing awareness of the possibilities of their own health care are the drivers of sustained demands for innovation in this sector. It also represents a market segment with a highly interesting and prospective customer base, which is developing dynamically each year.

Production of medicine is currently very challenging, especially with regard to quality requirements. Among these requirements is one particularly extreme accuracy, which is the most important criterion artificial implants.

Only the smallest deviation in the production of medical implants may have for human health very negative effects or may be a significant obstacle in everyday use artificial implant. Very important is also the manufacturing reliability and good definability of all manufacturing steps.



a) b)

Fig. 1 Manufacturing of knee implant with the 5-axis machining technology in a CAM software

In this particular production are not important only a special 3-5-axis machining kinematic structures, but especially sophisticated CAD/CAM software used in the design and manufacture.

Medical manufacturing industry should observe future developments. Problems connected with medical production are particularly huge financial costs to be made.

It is caused mainly by the production of artificial implants, it is important to adhere to strict production conditions. It is also necessary to choose the right material to select thkie appropriate product or progressive or conventional production method.

2 Experimental methods

The main point of this work will be the examination of direct and indirect methods of manufacturing and their compare, and also examination of CAx technologies for the production cycle of medical components. This research will focus on the comparing of machining and 3D printing and also on computer aided technologies and their impact on the technological and production properties of components such as surface roughness, the quality of machined surface, tool wear, production costs etc. Meanwhile, I assume that will be examined especially technology CAD and CAM. Regarding CAD, I plan to examine how the impact of modeling the resulting properties of components such as the quality of the machined surface roughness and integrity.

Also, I plan on CAD systems to examine the scanning process and also what would be the process of scanning and subsequent triangulation affect the production cycle components.

In addition to CAD systems I plan to examine the impact of CAM strategies for the production cycle components. This means that I will pay particular attention to surface roughness, surface quality, tool wear and others.

The center of excellence 5-axis machining in Slovak university of technology, Faculty of material science and technology in Trnava managed to make a number of interesting experiments in the field of medical manufacturing. One of these experiments was as production of hip implant, which was produced with assistant of 4-axis milling with positioning on a machine EAGLE 1000. This hip implat was modeled in CAD software Powershape. After this, it was transformated to a CAM software powermill. The model of hip implant was insterted to a block of raw material with cylindrical shape. After this step, the stragies of machining were generated strategy: machining with projection [1].

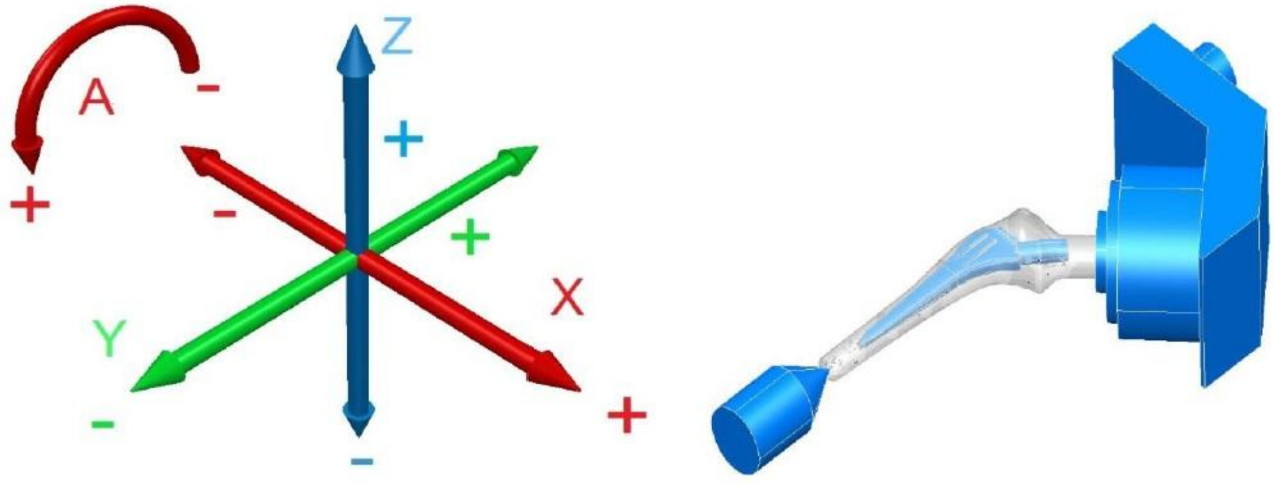


Fig. 2 Realizing of manufacturing hip implant with the 4-axis machining technology

In the centre of Excellence 5-axis machining in Trnava we have available the ultrasound machine ULTRASONIC 20 linear. The ULTRASONIC 20 linear combines dynamics, precision, compactness, versatility and intelligence in one high-tech machine tool. Highlights include a drive in X / Y / Z with > 2g, a 5-axis gantry construction with an integrated NC swivel rotary table, and a small 3,5 m² (37.67 ft.2) base. An actively cooled HSK-32/40 spindle capable of up to 42,000 rpm., high contour accuracy and automated real time feed adaptation further enhance this machine. The ULTRASONIC 20 linear combines 5-axis ULTRASONIC and HSC milling in a unique way, making it useful in the machining of a broad range of materials. In addition to the ULTRASONIC 20 linear, all other machines of the HSC Series are available as ULTRASONIC machine versions [2].

ULTRASONIC 20 linear milling machine is focused on five-axis machining technology with support for rotary ultrasonic machining, in which the instrument is not defined geometry of the cutting edge. Rotating tool with diamond grains axially oscillates with a frequency greater than 20 kHz, which gives him a piezoelectric transducer.

With his softly pressing into the workpiece material removal occurs, which means that the rotary ultrasonic machining (RUM) is direct contact between the tool and the cultivated area.

In this method, a rotational tool which, in addition to oscillating and rotating thereby creating better conditions for the machining of small and fragile components. Ultrasonic machining is suitable for the machining of hard and brittle materials such as ceramics, which are used in dentistry in the manufacture of dentures.

With the industrialization in dental prosthetics the dental branch shifts from a closed to a completely open system. Therefore, all components of the dental process chain can be individually selected (depending on the application) thereby meeting the initial requirement for the production in modern milling centers. Within an open system, ULTRASONIC 20 offers the system through a unique product line including individual automation solutions and the flexible integration of the ULTRASONIC technology.

Fig. 3 ULTRASONIC 20 Linear

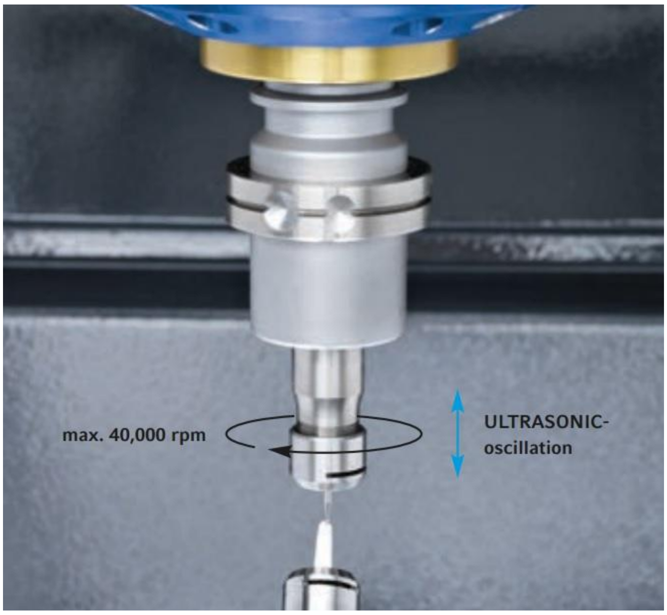


Fig. 4 Scheme of rotary ultrasonic machining

3 Research

During the development of this work in the next months of study, I will focus on rapid prototyping technologies and compare the direct and indirect methods of manucafturing medical components, I will also focus mainly on the production of dentures and I will examine the influence of CAx technologies to components production cycle and differences between machining and 3D printing.

3D printing is a form of additive manufacturing technology where a 3-dimensional object is created by laying down successive layers of material. It is also known as rapid prototyping, is a mechanized method whereby 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everywhere. This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost by eliminating the need to design; print and glue together separate model parts. Now, you can create a complete model in a single process using 3D printing. The basic principles include materia ls cartridges, flexibility of output, and translation of code into a visible pattern [4].

A 3D printer's fabrication technique is additive — most of them use a hot plastic extruder to "print" a plastic model. This contrasts with subtractive fabrication tools, which start with a solid block of material and use a cutter to remove the excess. Subtractive fabrication is far more common than additive. Lathes, mills, saws, drills, and other CNCs like laser and vinyl cutters are all subtractive tools.

3D printing is a method of manufacturing everything from tools to shoes to jewelery, or even car and aerospace parts using a computer-controlled printer. 3D printing is a method of manufacturing everything from medical implants to tools to shoes to jewelery, or even car and aerospace parts using a computer-controlled printer. The fundamental rule of 3D printing is that it's an additive manufacturing technique, unlike machining, turning, milling, and sawing which are subtractive . While there are different kinds of 3D printing, all 3D objects are generally built out of layers. A 3D printer starts with the bottom layer, waits for it to dry or solidify, and then works its way up. This layering process differsvdepending on the printer and the material it works with - metal, plaster, polymer, resin - but it also depends on whether it's an industrial or commercial 3D printer [5].

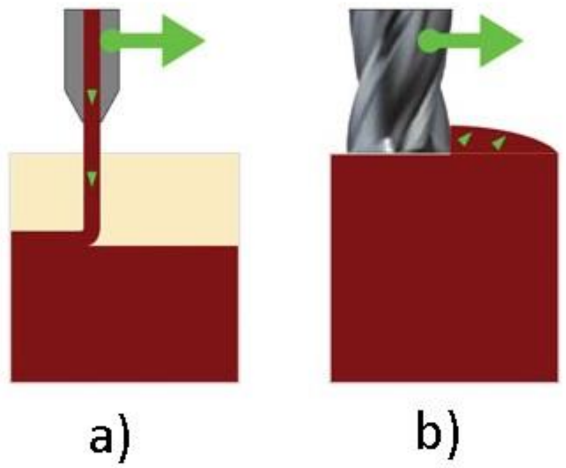


Fig. 5 Scheme manufacturing a) adding b) machining

In December 2014, I personally visited Comenius University in Bratislava, Faculty of medicine, where they use a 3D printing of medical implants. Faluty use a FDM technology for printing of medical implants as a dental bridges, dental crown, jaw implants and also aritifial organs, which assist in surgical procedures. In the next months of research, we will exmaninate a new sophisticate rapid prototyping technology Fast Ceramic Production (FCP). This technology, wich is based on stereolitography, can be used to produce components in successive layers with a laser that polymerizes a paste made of photosensitive resin and ceramic. The parts are then heat treated in order t oeliminate the resin and densify the ceramic to 100%. Giving them the exceptional biocompatibility that characterizes ceramic substitutes. The process does not break the digital design chain at any point.

FCP technology makes possible to control the location on geometry of the porosity of ceramic substitutes, unlike implants that are made porous by adding organic foam or porogens. Porosity structured in three domensions and constant diameter of the fully inter connected pores promote osteointegration and mechanical strength of substitues. Compressive mechanicak strength is between three and five times higher than that of conventional porous structures. FCP can therefore greatly reduce the risk of post-operation oflamation cause by micro debris that breaks whe handling positioning the implant.

Another rapid prototyping technology, which we will examinate will be Lytography-based Ceramic Manufacturing (LCM), which was developed by Lizhoz. LCM technology is also based on additive manufacturing of high-preformance ceramics. LCM technology makes the fast and ecomical generation of fully functional parts possible, with the material properties being equal to serial parts from conventional manufacturing processes [6].

4 Conclusion

I have chosen this post-gradual thesis, because in past, on my previous studies on Slovak university of Technology, faculty of material science and technology in Trnava, I have made a similar final thesis like a „Machining and medicine“ such a bachelor thesis on a bachelor degree, and „Use of the computer aided technologies in design and production on dental restoration“ like a diploma thesis on master degree. In my bachelor thesis, I focused on computer-aided technologies which are used in the fabrication of medical implants. It lists and characterized the main medical fields in which they are used. It also describes individual computer-aided systems and their division into categories and contains a detailed description of the fabrication method for an artificial implant from its design, machining simulation to production. It places an emphasis on the materials used for machining artificial implants, its advantages and disadvantages for machining and its suitability for the human body.

My diploma thesis was very similar as a bachelor thesis. This thesis focused on theoretical description of the use of computer aided technologies for designing and fabrication of dental restorations.

The diploma thesis identified basic stomatology and dentistry concepts as well as methods used. It also contains a detailed description of specific dental restorations such as dental implant, dental crown and dental bridge. It further explains the detailed process of acquiring a digital description of tooth’s shape and its subsequent modification. Attention was drawn to a detailed analysis of dental restorations’ design obtained from a digital description of a tooth in Cercon art software. The last part of this thesis concentrated on the fabrication of dental restorations, which took place at Zuba s.r.o. in Bratislava. The fabrication was accomplished by 4 - and 5 - axis kinematic structures of machining machines.

This acrticle focused on the use and influence of CAx technologies in medical manufacturing. The first point is about using of computer aided technologies in medical production. There is examples of medical production as a knee implant imported to a CAM software. Second point focused on centre of excelenece of 5-axis machining in Trnava. In the past, there was made a experiment of medical production as a manufacturing of hip implant, wich was manucaftured on the milling machine Eagle 1000. This hip implant was manucaftured by the assistance of 4-axis, with the support of separating device. It also content the detailed describle of the second machine ULTRASONIC 20 linear, wich is used in dental industry.

Last point focused on the Reseach. This research will be expecialy about examination of direct and indirect methods of manufacturing in medical production and consuctive comparation of this methods.

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Abstrakt

Název: **Použitie a vplyvy CAx technológií na výrobný cyklus súčiastok**

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Klíčová slova: Medicínska výroba, CAD/CAM, ultrazvuk

Táto téma sa zameriava na využitie a vplyvy CAx technológií na výrobný cyklus súčiastok v medicíne.V práci sú opísané počítačom podporované technológie, v ktorých sa stretávame s danou problematikou. Diplomová práca opisuje základné pojmy z oblasti stomatológie a medicíny a systémy využívané v danej oblasti. Taktiež práca obsahuje detailný opis a príklad výroby medicínskych implantátov ako napr. kolenný implantát alebo zubnú korunku. Ďalej je práci opísaný podrobný postup získania digitálneho tvaru implantátu a jeho následné úpravy. Pozornosť sa tiež kladie na ultrazvukový obrábací stroj ULTRASONIC 20 linear, ktorý bol použitý na výrobu zubného mostíka.

Zpět