<< **Figure 1:** Ball socket made of titanium webbing. >>

IMPLANTS FROM WATER

Innovative production procedure by means of fine or micro waterjets

LUKAS TONETTO

Micro waterjet cutting is already being used successfully in the production of implants. By means of a new injection procedure used by Swiss Microwaterjet AG, surface structures can now also be processed using pure water.

Medical technology is under a great deal of pressure to innovate, as are other medical areas, in particular with regard to implants. This pertains to medicine itself on the one hand, but also to the manufacture of the materials being used on the other hand, as well as the actual production of the implants. In addition to new procedures such as stereo-lithography for the manufacture of biocompatible implants made of bio-ceramics, boring and cutting, implants are also being produced in well-known procedures such as vulcanisation (silicone). In the field mentioned just above, a new branch is meanwhile making its presence felt, which just a few years ago was unheard of in medical technology: waterjet cutting and micro and precision waterjet cutting, a development of Swiss Waterjet Group with its Microwaterjet product and the procedure known as AWJMM (abrasive water jet micro machining).

Waterjet cutting is a cold separation process, which processes or cuts through any desired material using high kinetic energy. No thermal tension is generated inside the material thanks to the temperature-neutral process; the material's structure and strength are preserved. In this process, which was notably refined over the last 10 years by Microwaterjet AG — based in the Swiss city of Aarwangen — a specialist in abrasive procedures cut special materials such as titanium, nitinol or niobium. In the abrasive procedure, processed particles — usually garnet sand — are added to the water, and accelerated by the waterjet, making it possible to cut hard or complex materials. Today, in series-tested procedures and in addition to surgical tools such as levers made of tool steel or PEEK, Microwaterjet also produces implantable X-ray reflectors, ball sockets made of titanium webbing, or socket blanks made of chromium-nickel steel, ceramics or plastic. But when it comes to implants, the quality of the processed material is important along with the processed material itself. A properly altered surface quality promotes the growing together of implants with the human body.

Alongside popular procedures for processing surfaces, Microwaterjet uses a specifically developed procedure for injecting materials. Injection by means of waterjet occurs via a WJIP (water jet injection pulse) procedure, which Microwaterjet AG applied in the production of a hip joint socket made of plastic. With this procedure, with patent applied for by Waterjet Robotics, the properties of any number of materials can be changed and adapted. Injection involves relevant advantages compared to other procedures, in particular thermal or chemical procedures. Chemical procedures, such as coating, may contaminate the implant with residues.

>> Continued on page 36

<< Figure 2: Bone plates made of titanium. >>

<< Figure 3: Socket blank made of chromium-nickel steel. >>

Hygiene, ability to be sterilised and antibacterial effects are the end-all and be-all when using implants, with clean production making an important contribution right from the start. The hip joint sockets made of plastic were produced in a fully automatic process: a robotic arm with a 3-point gripping device grips the raw material and places it back down, so that the implants can be injected directly using the WJIP procedure. Thanks to automation, the entire value-added chain of production also proved to be even more efficient (known as 'lean management'). But automation is not only an essential aspect in the production of medical engineering products, as Matthias Straubhaar, Managing Director of Waterjet Robotics, explained. The serial use of robotic systems and intelligent control systems ultimately enhances the overall productivity in the micro business.

Just recently, a fine micro implant made of 0.3 mm titanium was processed using the Microwaterjet SK11-200 System. This is particularly remarkable, since waterjet cutting was a relatively crude and dirty procedure just 10 years ago. At that time, the manufacture of medically engineered accessories in the micro business was inconceivable. With the development of micro waterjet cutting, Microwaterjet AG revolutionised the traditional waterjet cutting process.

The development of the procedure proceeded in close cooperation with technical schools and universities. Together with the specialist for waterjet technology, Prof. Dr. Kurt C. Heiniger at the FHNW School of Engineering (University of Applied Sciences and Arts Northwestern Switzerland), the physics of jet production was researched in the Swiss Competence Center for Waterjet Technology SKWT in Windisch near Zurich. Only a liquid glass column with a smooth surface and a wall of water drops is suitable for the highly precise industrial manufacturing process. The research team of the Institute for Thermo- and Fluid Engineering at the FHNW investigated not only the flow within the collimation pipe, but also the abrasive influx into the mixing chamber and its acceleration in the focusing pipe. The jet changes with the design of the geometry of the water nozzle, by means of which the type of acceleration can be sharply influenced.

By permanently optimising the cutting heads, the cutting systems and the exterior factors and making them more precise, Microwaterjet has been able to increase precision to its current peak level. The people responsible emphasise the fact the precision knows no limits.

The newly developed procedure is meanwhile being used in series production and stands out for both its minimised cutting jet and maximum precision. Production today is therefore possible with the finest abrasive waterjet in the world of 0.17 mm, and a roundness of ±0.0015 mm. For this to be possible, the waterjet must feature a laminar flow with no visible turbulence, and be so conditioned that it does not burst open during high speeds on the way to its target. By permanently optimising the cutting heads, the cutting systems and the exterior factors and making them more precise, Microwaterjet has been able to increase precision to its current peak level. The people responsible emphasise the fact the precision knows no limits. They can already cut smaller than 0.17 mm in the lab, with a further increased positioning precision of 0.0025 mm.

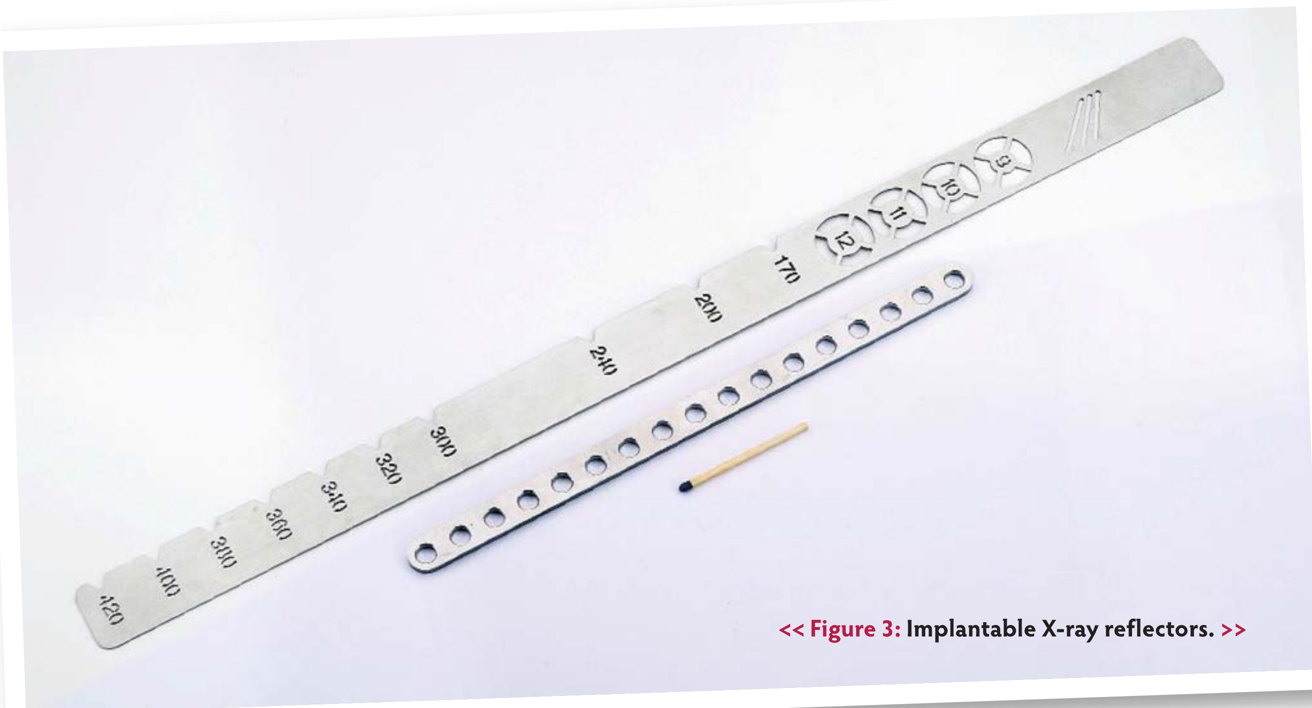
The Faculty of Engineering of the University of Nottingham was significantly involved in the further development of the technology. It is to a certain extent the competence centre of Microwaterjet AG in the UK. Prof. Dragos Axinte is a specialist in the monitoring and optimisation of innovative manufacturing processes and abrasive waterjet machining and is a major participant in the European research project Conform Jet, of which Microwaterjet is also a partner. The goal of this project is to develop so-called HEFJets (High Energy Fluid Jets). This procedure is a niche technology with

>> Continued on page 38

extraordinary characteristics and cuts and bores all materials, including very hard ones, and is intended to become a self-learning control system – Know-How, which in turn has some influence on the research and development of Microwaterjet.

The high level of development of Microwaterjet can be traced back to a special corporate philosophy. The company has always been directly involved at the forefront in developing new technologies. The founder and chairman of the company management, Walter Maurer, sees an essential cycle through which the company first rose to become one of the leading high-tech ventures: the company's R&D department always adopted customer requests that were considered to be utopian 10 years ago, and as a result, developed a thinner and thinner cutting jet one step at a time. The company also built prototypes of waterjet cutters and expanded its role as a specialist for micro waterjets to also include being a machine developer. Today, the in-house development of the Type F4 sets worldwide standards in micro waterjet cutting. Part of the know-how from the production of med-tech components therefore had some influence on the development of machines. Waterjet cutters throughout the world currently profit from this. The Waterjet Robotics director describes this cycle as a win-win principle: "Micro waterjet cutting is a very complex procedure. We not only sell machines to other waterjet cutters, we also develop procedures together with them, which they can then use successfully for actual customer orders, such as in the med-tech field. We also offer them long-term support and assist them in their growth strategy."

The result of this corporate philosophy and the high-quality R&D of Microwaterjet is a ground-breaking technology, which through its microscopic jet widths in the low micrometre range offers new opportunities to the material-sensitive field of medical technology. As has been proven, the further development of this already highly precise procedure is not simply a gimmick by people who like to do finicky things, but can truly accelerate advances needed in medical technology. The world of implants is currently at a crossroad, and must continue to evolve with respect to materials. This also depends primarily on the increase in rejection of certain implants that are foreign to the body. With reference to the future of micro waterjet cutting, it is a matter of not only cutting smaller and more precisely, but also cutting innovative materials; materials that do not allow for any structural transformations or thermal deformations. Development, according to Matthias Straubhaar, will go even further, to some extent into utopian territories: "There are temporary implants such as screws for fixing bones, which to this day had to be removed by operation. Materials that dissolve inside the body are currently being developed." This includes for instance the biocompatible magnesium alloy developed by the Austrian Institute of Technology, which dissolves in the body and makes post-operative intervention superfluous. Accordingly, the challenge for the waterjet cutting specialists of Microwaterjet AG is therefore: using water to cut and process water soluble materials with high precision and with a fineness not yet known throughout the world. Whether this remains a utopia for the Swiss specialists — only the future will tell.



<< Figure 3: Implantable X-ray reflectors. >>