Grinding of Ceramic Materials

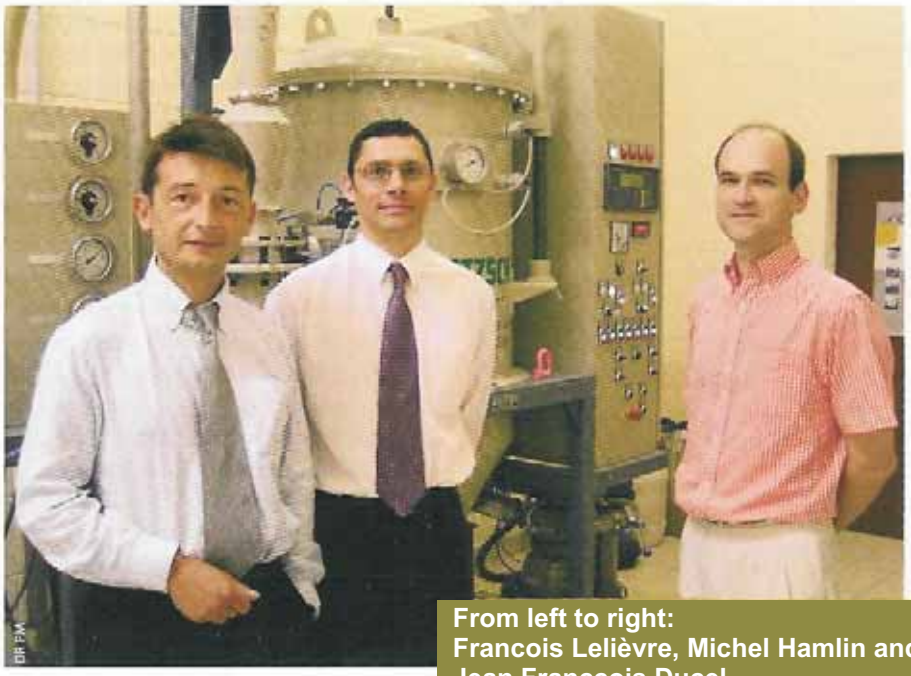
for Use in the Dental Sector: It´s the colour that counts!

Sofraced, the only company in France to manufacture ceramic powders for use in dental prostheses, has decided to diversify its grinding processes. At first glance, this seems simple, but the new process requires a ceramic powder devoid of all traces of other materials, in order to prevent alterations in its colour and bio-compatibility. Ceramic is highly abrasive. Netzsch-Condux, builder of grinding machines and equipment was asked to assist in finding some good solutions. This was not always easy!

An extremely fine grinding of ceramic is required for the dental sector

It is not necessary to be in advertising to know how much good teeth contribute to the harmony of a face. Nature has created a whole palette of different shades of teeth. If one of these teeth must be replaced by a tooth in artificial ceramic, the best criteria for judging the quality of the work is if no difference can be seen between the artificial tooth and the others. The patient expects this from his dentist who in turn counts on the company which makes the prostheses, which has absolute faith in the company supplying the ceramic material. Sofraced is indeed designer and manufacturer of such material. Located in Plessis Grammoire, several kilometres from Angers, this small company with around 15 employees, with very specialised know-how, belongs to the German group of companies Dentaurum. It delivers all it products to Espident, which itself is responsible for selling its products to the makers of dental prostheses under three brand names, Carmen, Triceram and Carmen CCS (Compact Ceramic System). “In our branch we do not deal with large quantities, as, in general, a ton of ceramic material is sufficient for making approximately one million teeth” states Francois Lelièvre, the president of Sofraced, However, this branch of production is growing

rapidly. Of the dozen manufacturers worldwide, which represent around 50 different brands, we are one of five which carry out research and development at a higher level. Although the structure of our company is only small, we are recognized in our sector of activity".



From left to right:
Francois Lelièvre, Michel Hamlin and Jean Franccois Ducel

The Principle of Manufacturing a Tooth from artificial Ceramic Material

In order to properly understand the requirements of grinding, it is necessary to make oneself familiar with the structure of an artificial tooth. A ceramic tooth is nearly always a ceramic-metallic tooth, i.e. a metal crown covered with ceramic. Depending on the metal used, different grades of ceramic are used, which have been developed to suit the varying degrees of dilaexpansion of the metals. Hence, at Sofraced, the brand Carmen is a range designed for precious metals based on gold, silver or for metals based on nickel chrome or chrome cobalt.The brand Triceram is adapted to titanium as well as a new group of materials for "ceramic-ceramic" prostheses, of which the support (goblet) is not made of metal but of zirconium (ZrO_2). The range Carmen CCS is destined to be used on the same metals as the Carmen range but has an advantageous mounting concept which gives an optimal aesthetic result using a minimum of different powders. Each range comprises about 50 to 100 different products which correspond to as many ceramic powders of various colours. Other parameters are of equal importance, as a tooth consists of several layers (between 3 and 10) of different ceramic materials. When a tooth is manufactured, the manufacturer uses several layers of ceramic powder or paste one after the other. Each of these layers has its own characteristics. The first layer has colour and adhesive properties, the second gives a intense colour basis, the third is necessary, for example, to form the heart of the tooth, while the fourth gives the tooth a certain transparency. During manufacturing, the person manufacturing the tooth can refer to all these parameters thanks to the numerous references about these powders which he has, and all these powders are available to him in small ready-to-use portions.

There must be no risk of pollution during processing with the air jet grinder

Why invest in a Fluidised Bed Jet Mill?

The first reason why Sofraced decided to change from the technology of impact grinding to air jet grinding for certain applications was the need to produce large quantities of very-fine homogeneous powders. With the traditional technology it is very difficult to produce glass ceramic or glass powders smaller than 7 µm. By choosing the jet-grinding technology from Netzsch-Condux, it was then possible for Sofraced to reduce the particle size of their products to an average of 3 µm. This corresponded to a specific manufacturing requirement, i.e.: the mixing of ceramic powders with liquids in order to sell them in the form of

Ready - to - use pastes, which are applied with a brush to the tooth, like the application of paint. The rheological characteristics Of this paste depended on the size and the shape of these particles.

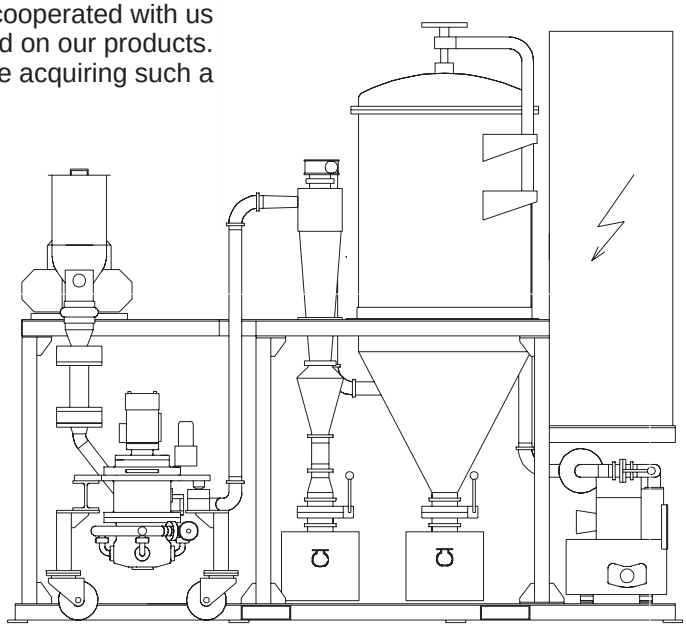
The second reason for this process change came from a need to increase production. After investing large amounts in the development of products, today, Sofraced must keep up with a rapidly developing market, which means producing large quantities. This has become possible with the air-jet technology, without forgetting a characteristic of these very technical products, as Francois Lelièvre explains:"We manufacture products of which the added value is due to numerous transformations and especially to the checks which make up approximately 30 % of the final price of the product. If we manufacture larger amounts, the checking costs will represent a smaller part of the final price."

The third and perhaps most important reason for this investment:It was also necessary to continue producing non-polluted powders after grinding, not always obtained with the impact grinding system. This was a grinder comprising only metal parts and the grey metal had a nasty tendency of colouring the white ceramic during the grinding processing. Unthinkable in the universe of dental prostheses.

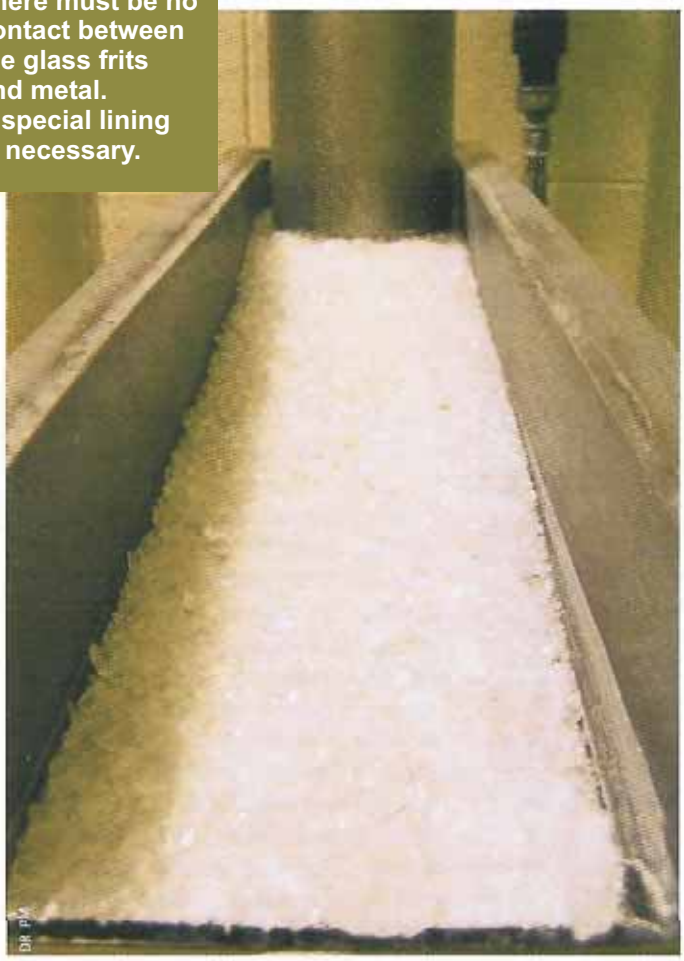
For Netzsch-Condux, the constructer of this grinder, this is a new experience in a very specific domain of activities. Sofraced´s wish is to invest in new technology, on condition that they can obtain good results. As Jean Francois Ducel, Sofraced´s production and development manager puts it, «There were no standard pieces ofequipment which suited our application.Therefore, we were obliged to modify equipment in order to adapt it to suit our individual requirements. Netzsch Condux took the challenge on and cooperated with us based on our products. Before acquiring such a grinding system, we wanted to be certain that it could fulfil our expectations Perfectly.

Extremely high Demands for Non-Contamination

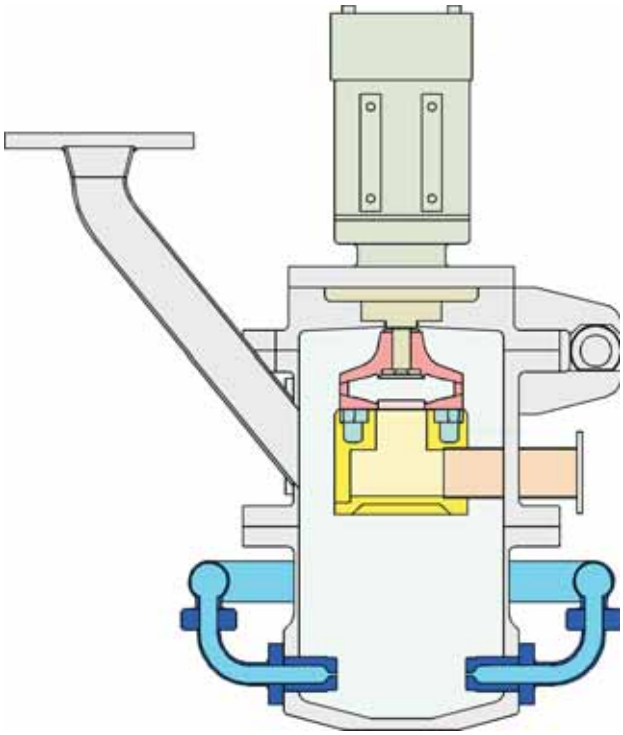
Michel Hamelin, commercial engineer with Netzsch Condux described the development stages of the new plant as follows: "We have a test lab in Germany, which has enabled us to easily determine the function parameters for obtaining the desired quantities with the required particle size. However, there was one point which we were not able to prove using the test lab, i.e. the non-contamination. For this purpose, it was necessary to carry out modifications to the machine and then measure the advantages obtained by this modification.". "The critical point" adds Jean Francois Ducel, "is that ceramic powder is very abrasive. The constant rubbing against materials such as stainless steel which covers all the surfaces of the system makes a pollution of the ceramic powder practically inevitable". The result is a grey powder which is not at all suitable. "We work with colour ranges in pastel



Installation with Fluidised Bed Jet mill CGS 16

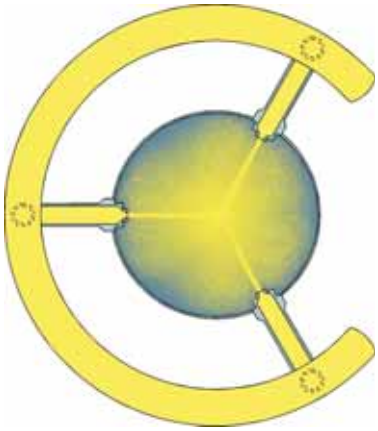


There must be no contact between the glass frits and metal.
A special lining Is necessary.



Fluidised Bed Jet mill CGS

tones with very slight differences in shade". Jean Francois Ducel continues, "Therefore, we have to be very strict with regard to the purity of the powders we use".
In order to avoid such contamination there is just one solution; all parts of the machine in contact with the powder must be either in ceramic or lined with ceramic material, or with rubber stick-on material and flexible polyurethane. However, this is not enough. It took a lot of time and effort to find the cause of another less-evident kind of pollution, i.e. the air injected directly by nozzles into the middle of the powder being ground. "We needed a lot of time" admits Jean Francois Ducel "to uncover the evidence concerning this problem of drops of oil suspended in the injected-air, but we absolutely had to find the reason. The road was long and difficult, because, gradually, as we added protection to the machine to eliminate the risks of wear, source of pollution, the level of grey decreased, but without obtaining an acceptable result. We therefore looked for solutions in other areas until we found these traces of oil".



Nozzle arrangement

Since then, Sofraced has invested in a non-lubricated compressor from Atlas Copco and the problem has been solved.

Increasingly Finer Grinding

Artificial ceramic is manufactured from various natural raw materials which are introduced into gas fusion furnaces and the temperature is raised to up to 1400°C. After approximately 8 hours in the furnace, the melted glass is thrown into water in which it "explodes" and is transformed into pieces of glass, frits. When investing in new grinding equipment, Sofraced also wanted to be able to use quite large pieces of glass in order to avoid an intermediate step between the outlet of the fused glass and the final grinding stage.
During the actual grinding stage, the glass frits are tipped into the grinding chamber which is cylindrical and vertical. The grinding action is carried out in the lower part of the cylinder at the centre of a fluidised bed, formed by three air injector nozzles submerged in the material, which deliver air compressed at 7 bars. The ceramic particles are accelerated by the air jet and impact one against the other in the fluidised bed. When they have been reduced to the particle size required, these particles are evacuated diagonally to the classifying turbine, the product-contacted parts of which are in aluminium and which is installed in the upper part of the grinder. The particles are classified by centrifugal forces, the finest particles are sucked out and recuperated while the air is filtered, the larger particles are returned to the grinding chamber until they have been reduced to the desired fineness. Compared to the older method of impact grinding, this technology of air-jet grinding excludes the phenomenon of "over-grinding" particular to impact-grinding, and ensures the homogeneity of the ground particles. This homogeneity which is a delight for many branches of industry is actually a slight handicap for Sofraced and in particular for its applications. Jean Francois Ducel explains the reasons for this as follows: "When a dental prosthesis is made, the ceramic powder is mixed with a liquid to give a paste. Then, the tooth is sculpted and baked in the furnace. The presence of fine particles ensures a good cohesion of the paste. These fine particles which are systematically produced in the process of impact-grinding due to "over-grinding" are excluded by the technology of air jets. They would, however, be welcome for certain applications. Sofraced is therefore studying the possibility of mixing 2 different particles sizes, one of which is very fine, in order to obtain the cohesion necessary for certain applications.
Parallel to this, the company is continuing its research into the manufacture of pastes made from very fine products produced in the air-jet grinder. This material is completely adapted to produce very fine powders of 3 or 4 µm.

A Necessary Adaptation

Netzsch Condux is used to adapting its grinders to the client´s requirements, because if grinding technology remains static, each customer will require a tool made for his individual manufacturing conditions. Air-jet grinding is a

Left:
Triceram, the highest quality Product of the dental ceramic

technology which does require a lot of energy, which makes it suitable only for products with a high added value. However, it has the advantage that the sieving stage, which often causes waste which cannot always be recycled, is not required. The result is clear, the throughput increases from that of impact-grinding, 50 %, to that of air-jet grinding 95 %. Without counting a reduced conveying of the material and a possibility of continuous functioning without stopping after there has been checking of the line. At the moment the Netzsch Condux machine is being used for technology transfer. In the long run, it will replace most of the impact grinding stages as well as the sieving. If throughputs remain dependent on the hardness and the shape of the material to be processed, as well as the particle size to be obtained, the project managers believe that in order to go from a particle size of 50 µm towards 25µm, it will, according to the nature of the frits, be possible to obtain a throughput of between 5 and 15 kg/h, which would decrease to below 1 kg/h for smaller particle sizes. These are figures related to this kind of production as stated by Michel Hamelin: "We have installed a pilot plant on the site which is just slightly larger than the laboratory size. However, this does not mean we would not be able to manufacture machines using the same technology which could obtain a throughput of 120 times the throughput of this machine".

History of Men

This transfer of technology which opens new horizons nearly did not come to light as Francois Lelièvre explains: "We encountered difficulties which sometimes took a long time to overcome, but, the constructor and the user kept up their dialogue". Today, the technology transfer is on the right track. There are good perspectives for new developments for the 5000 dental prosthesis laboratories which are scattered around France and also for those around the world.

Products after grinding