Kiddy Caps – Injection-Moulded Zirconium Oxide Dental Crowns for Children

These dental crowns, called kiddy-caps, imitate natural teeth down to the last detail and, despite the small material thickness of 0,1–0,7 mm, they can withstand 7 times the bite force of an adult. They are a low-cost, aesthetic and high-quality alternative for the primary molars. This product development was honoured with the 2nd Prize in the "Best Component Award Technical Ceramics" presented by CERAMIC APPLICATIONS at ceramitec 2018.

Fig. 1
Kiddy-caps have extreme smooth surfaces – easy to clean!

Introduction

In functional terms, metal caps do have the required effect, but they can be easily recognised as foreign objects in children's mouths, which sensitive children can experience as psychological strain. Moreover, for many patients, metallic crowns are not always compatible. Besides metallic crowns, in recent years crowns made from composite materials and custom-made crowns made of ceramic (ZrO_2) have become established on the market. A custom-made ceramic crown, however, is often too expensive and difficult to fit especially for milk teeth.

On account of the three dimensionality, the filigree geometry and the many variants, Ceramic Injection Moulding (CIM) was considered an appropriate method for fabrication.

Project description

Ten teeth grow in a child's upper jaw and ten in the lower jaw, these include molars, canines and incisors.

In the first project phase, solutions were developed for all molars.

The individual geometry of every tooth was determined based on the parameters of many impressions and scans. The data extracted in this way were accumulated to form a representative mean. From this mean value, three larger and two smaller tooth sizes were calculated and derived (sizes 2–7). With reverse engineering, the data were converted into CAD-usable STP data that are used as a basis for tool design and engineering.

Keywords
CIM, dental caps, zirconia

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For each molar (8 in total), an injection moulding tool each with 6 sizes was fabricated. As a result, 8 different tooth shapes (D and E), each in 6 different sizes, are available. To guarantee optimum fit, for the first milk molars (tooth shape D), besides the standard geometries, another 3 intermediate sizes with molar geometry were developed.

The 2nd project phase comprised the fabrication of tools for canines and incisors.

From the tools, the geometrically different front and canines, both for the upper and lower jaw, were fabricated in four different sizes.

Economic challenges were:

- low-cost production and
- price stability.

Technical challenges were:

- 21 different geometries;
- thin walls tapering off to almost nothing at the edge;
- component volume from 0,056 cm^3 in the smallest case (injection moulding weight min. 0,40 g);
- different component volumes within a tool with a difference of over 40 %;
- continuous, defect-free edge areas;
- burr-free, clean surface.

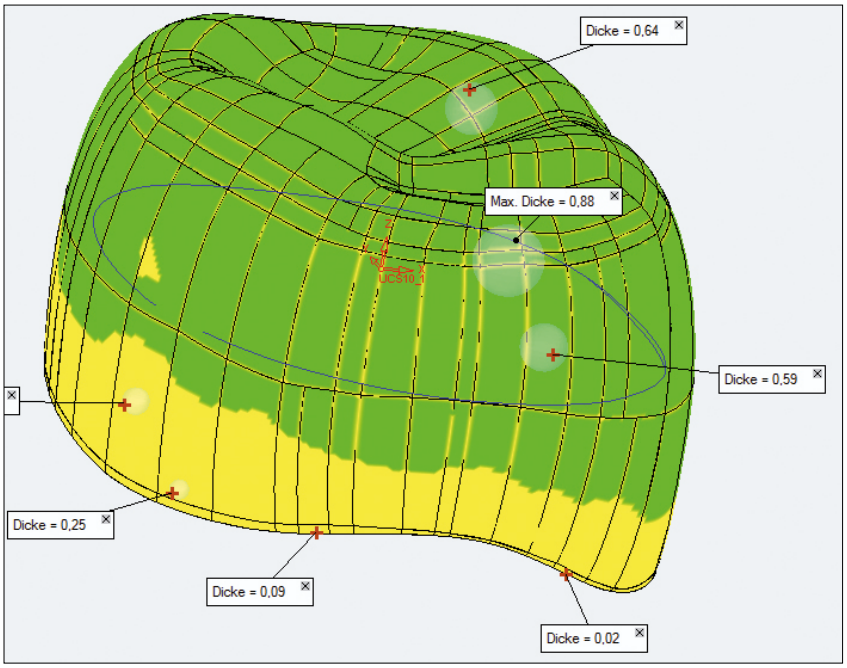

Fig. 2
CIM technology can produce low volumes an thin caps

Resulting and resolved issues

Geometry

Natural teeth were scanned by means of computer tomography and appropriate data generated. By means of reverse engineering, the acquired data were converted into usable STEP data. In this form, the geometries were reworked in line with the material and process and adapted before being used as basis data for tool making.

Tools

The problem with regard to the tool concept was finding the best possible solution to meet the contrary requirements on the technology side (filling of the components, arrangement, demoulding, take-off) and in terms of cost efficiency (more than one cavity, tool costs, production costs). Depending on the geometry, separate tools were used with segmented insets, which enable production of both single and multiple (2–6) components. The gating system and consequently the separate channels were specified and realised such that, in the case of common production of all six components, it is possible to compensate for different component volumes (difference up to 40 %) and accordingly for different filling times.

The tools are formed in a segmented configuration so that the cyclically necessary cleaning can be performed thoroughly and

The Partners

FIMA-CouronneTEC GmbH & Co. KG

FIMA-CouronneTEC GmbH & Co. KG/DE, the company founded in 2008 and owner-managed by Mattias Finzelberg, has specialised in the development and global sales of children's dental crowns made of zirconium oxide ceramic. In close cooperation with renowned institutes (including the University of Vienna/AT, Department of Paediatric Dentistry), the products and necessary peripheral systems (e.g. adhesives) are developed and tested and supplied in user-convenient packaging to customers. Headquartered in Mannheim with a logistics centre in Anzhausen, the company supplies dentists worldwide.

Systematic production in Germany, certification in compliance with the Medical Products Law DIN ISO 13485 and the country-specific certificates attest the high quality standard.

Kläger Spritzguss GmbH & Co. KG

Kläger is a leading manufacturer of complex injection-moulded components made of plastics and technical ceramics. It is a development partner, producer and system supplier of well-thought-out injection moulding solutions for technical plastics, high-performance ceramics and hybrid assemblies of the corresponding material composites. The range is optimally complemented with material-based engineering and the development and engineering of precision injection moulding tools.

Beginning with the design, through product development and toolmaking to the finished product, Kläger offers its customers everything from one source on the basis of the highly integrated value creation chain.

effectively. In the case of wear or any necessary corrections, this can be realised at low cost.

Material and feedstock selection

Corresponding to the functional requirements for the finished component (tensile and compressive stresses, biocompatibility, aesthetics), zirconium oxide (ZrO_2) was defined as the ceramic powder. After comprehensive production tests, a thermoplastic-based feedstock system was defined as suitable production material. Decision criteria from the technology perspective were the determined injection parameters, processability, and high process stability and reproducibility. In total, the best technical parameters therefore generate the most cost-efficient solution.

Forming

Separation of the component runs radial in the lower section in a wall area measuring around 0,3 mm. Consequently, the injection point is on this level so that entire components can be filled through the thin wall. The inner part is produced with the injector side, demoulding is performed with a contour ejector on this side.

Integrated in the ejector is the component marking so that this is integrated in the component formed in that specific tool. Costly, subsequent marking (e.g. with laser technology) is therefore not necessary.

Fully automatic production

To maximise process stability and cost efficiency, the different dental crowns are taken off fully automatically by means of a vacuum-based handling system. The components are stored separately according to their different geometry. In this way, mixing up of the different dental crowns after the injection moulding process is prevented by the separate storage. Only components with identical size and geometry are set on one kiln shelf and fed to downstream processes in single unmixed batches.

Mechanical finishing as final inspection

The components undergo a specially developed barrel finishing process to generate a surface adapted to natural teeth. Any last surface defects are eliminated. In addition, this process step is used as quality control (breakage test) with regard to the mechanical strength of the filigree geometry, especially at the edges.