MODEL CASTING
WITH ADDITIVE MANUFACTURING
(THAT'S 3D PRINTING TO YOU AND ME)!

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Especially for the manufacture of prosthetic restorations made of non-precious metal alloys (NPM), generative manufacturing processes such as laser sintering offer dental laboratories significant advantages over classic analogue conventional casting or ablative CAD/CAM manufacturing processes.

Thus far, additive technology, in which micro grained cobalt chromium (CoCr) powder particles (>36m. grain size) are melted in layers using a laser beam, has mainly been used in the fabrication of prosthetic restorations such as single copings and large span bridge frameworks. This allows individual restorations with convincing density and fit to be fabricated in large quantities, free of porosity. The materials usage is particularly efficient. In contrast to ablative processes, such as milling technology as only the exact material is consumed that is actually required for the object digitally designed in the CAD software.

Model casting, digitally manufactured (3D Printing)

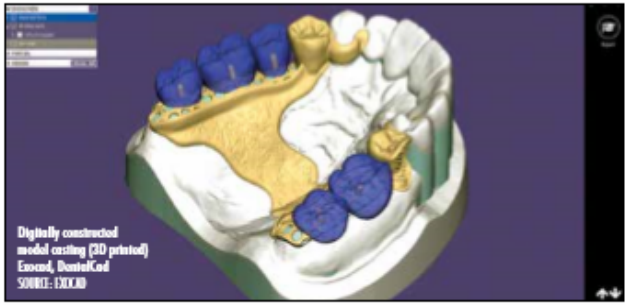
Another application ideally suited for the use of additive manufacturing is the digital fabrication of the classic removable partial denture. Partial dentures, which in Germany falls into the category of "health insurance coverage" is regarded worldwide as the standard treatment for partial dentition and is today usually still produced analogously. However, a great deal of

Additive manufacturing: Laser sintering technology
SOURCE: INFINIDENT SOLUTIONS

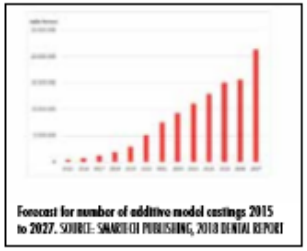
experience and time consuming manual work processes are required to produce a framework that is largely free of porosity.

Due to the large amount of time needed for the dental laboratory, this procedure is usually not economically speaking, well rewarded. Digitalisation, on the other hand, is already making it possible to virtually design any restoration, despite the complex design variations often required, relatively easily, step by step in common with CAD sofiware applications, such as Exocad, 3Shape or Dentsply Sirona.

In addition to the individuality of the restoration and the dictates of cost effectiveness, the complexity and diversity of the restoration designs are especially important in 3Dprinting. So it's not surprising that, for example, a study by SmartTech Publishing, predicts high growth for the additive production of 3D printing applications.



Digitally constructed model casting (3D printed) Exocad, DentalCad
SOURCE: EXOCAD

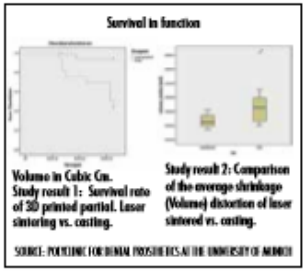


Forecast for number of additive model castings 2015 to 2027. SOURCE: SMARTECH PUBLISHING, 2018 DENTAL REPORT

Laser sintered 3D printed with support structures and framework finished (above) and centrally 3D printed manufactured (inset).
SOURCE: IOS, INFINIDENT SOLUTIONS

Trend towards CAD/CAST processes provides added value for 3D printers? In spite of the above mentioned advantages, a hybrid manufacturing method has been observed since the introduction of cheap 3D printers in the dental laboratory: The so called CAD/CAST process, in which the design is done digitally via the PC and the result is first "printed" from wax using the additive technique, but then finally cast conventionally.

This mix of digital and analogue workflow raises the question of the extent to which economic added value can be achieved. All complex analogous work steps of the casting process, model duplicating muffle preparation, preheating procedure, alloy melting, casting procedures, as well as the mechanical disadvantages of the casting technique (risk of shrinkage porosity) still exist.



Volume in Cubic Cm.
Study result 1: Survival rate of 3D printed partial. Laser sintering vs. casting.

Study result 2: Comparison of the average shrinkage (Volume) distortion of laser sintered vs. casting.

SOURCE: POLYCLINIC FOR DENTAL PROSTHETICS AT THE UNIVERSITY OF MUNICH

Added value of laser sintering process

Is the laser sintering process really better suited for the production of partial denture frames? The answer is a resounding yes! This is underlined by a study conducted in 2018 on the mechanical properties of the clasps of laser sintered vs analogue model casting. The client was the company EOS, while the Polyclinic for Dental Prosthetics at the University of Munich conducted the study. The study investigated the staple removal forces, the microstructure quality and the survival rate of laser sintered partials compared to conventionally cast partials.

The study showed significant advantages in terms of constant partial removal forces with no loss in retention and a survival rate of >93%. (Based on a simulated survival rate of 60 years). But also demonstrating a much improved and homogenous, microstructure quality of additive production.

In particular, the danger of large volume porosity, which unfortunately remains constant during casting, is largely negligible, in the laser sintering process, due to the homogeneous microstructural properties. Although the number of cavities detected in the additive process is higher, these are purely superficial porosity, which results in a rougher surface which can be easily removed as part of the polishing process.

Laser sintered production of restorations can be really efficient with up to 30 model casting restorations fabricated on a so called "mid frame" laser sintering system (EOS M270, construction platform 250 x250 mm) in an average 15 hour construction process. The virtual positioning of the components during data preparation is essential for the final fit of the parts. A lot of experience is required to achieve optimal fitting results. Especially for the virtual setting of support structures on the components, which serve to avoid distortion on the basal as well as oral side of the base, in order to guarantee the best possible fit of the laser sintered partials. The subsequent necessary stress annealing of the components, as well as the thermal post treatment to obtain ductility (spring elasticity) of the clamps, are also crucial for the later fit.

In-house vs. external production

Because 3D printing is usually not considered the dental laboratory's most popular procedure, out-sourcing is probably the answer. However, because any form of reworking should be avoided as much as possible you must ensure the chosen laboratory source for the 3D printing digital processes, is really up to date and capable of producing the quality the system has to offer. Familiarity with the virtual model creation and design is the essential requirement. The digital system is undoubtedly capable of the very highest of quality demands but it has to be governed by the technician who is designing the Virtual model.

Laser sintered 3D printed partials with support structures on building panel. SOURCE: IOS

By comparing the advantages of purely digital versus conventional production of 3D printing, the added value of purely digital production can be clearly illustrated:

Advantages of purely digital manufacturing (3D printing laser sintering process):

- Requires a lower number of work stages and therefore an increase in productivity.
- Reduced risk of error and casting anomalies, with a lower risk of porosity.
- Largely homogeneous microstructural properties guaranteed.
- Constant retention forces as well as increased flexibility of the clasps.
- Design freedom and simple correction options.
- Reproducibility

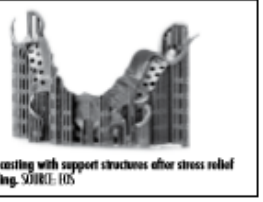
ADVANTAGES OF CONVENTIONAL PRODUCTION MODEL CASTING (ANALOGUE PROCEDURE):

- The time advantage due to in house production.
- The Technicians Familiarity with analogue manufacturing process.
- Lower material costs per unit.

It is to be expected that digital manufacturing methods will replace conventional casting in the dental laboratory in the medium term. Laser sintering technology will become established as a suitable manufacturing process, especially for 3D printing. Due to the still high investment costs for plant and equipment for this technology process, it does not seem realistic, however, that these will pay off for use in the medium sized "generic" laboratory. Thus, the use of specialised suppliers is probably a means of choice. However, it is precisely here that clear differences in quality can be seen with regard to the manufacturing service providers active on the market, who already offer digitally produced model castings (3D printing) today.

Only those manufacturing service providers who have intensively dealt with application specific production and possess the corresponding technology in the high end quality sector can deliver satisfactory results with regard to fit, surface and clasp ductility, of the laser sintered 3D printed restorations in both the upper and lower Jaw.

The advantage of purely digital production based on laser sintering and 3D printing is clear. The high quality plus high volume production potential together with predictable running costs are very desirable. The only disadvantage being the plant and machinery investment required. Out sourcing to a specialist production provider with the necessary expertise seems a good option for the smaller laboratory. With the Understandable restriction on large scale investment it makes great sense to team up with your chosen expert and build a good working relationship. The future use Undoubtedly Digital manufacture is the future, but starting now!



Model casting with support structures after stress relief annealing. SOURCE: IOS