Rapid Prototyping and Additive Manufacturing in Egypt

Presented by:

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1. Notes on the development of Rapid Prototyping (Additive) Manufacturing in Egypt.

In July 2005, the "Egyptian Association for Additive Manufacturing (EAAM)" was established and headed by the Central Metallurgical Research and Development Institute (CMRDI) that is a governmental academic institute and it includes the first RP research lab in this region.

Currently EAAM contains 21 companies (5 RP technology owners and 17 users) and about 35 individual persons and university staff who have interest to explore and use these technologies.

At the current stage, EAAM is very small body because in Egypt the RP technologies are still not spread because of the expensive costs for the machines and materials comparing to low cost of human labor and traditional tools in Egypt.

Looking to the RP equipment in Egypt, there is an m3linear machine (by Concept Laser, Germany) and an Invision SI2 3D printer (by 3D Systems, USA) in CMRDI institute. There are two SLA machines owned a military research center. There are three FDM: Maximum, Prodogy and Dimensions machines (by Stratasys, USA) owned by large house appliances factory. In addition, there are two FDM Dimension machines and two Zcorp 310 machines owned by universities and service companies. Total number is about 11 machines. However, this includes most of the RP state-of-the-art technologies available. Picture is not so dark because the work has started very recently. Still it needs to build trust for this technology and overcome the barriers of machine and materials costs.

Case Study 1:

Computer and rapid prototyping guided segmental mandibular reconstruction using personalized biocermic materials.

1. Objective of the work.

In patients having tumor-deformed mandibles, this work was aiming at restoring mandibles to their original shapes and contours in a single surgery, without the need for autogenous bone grafts, by the rapid fabrication of Bioceramic implants (for example, from Silica Calcium Phosphate powders) using the techniques of rapid fabrication of reconstruction plates with the aid of SLA, SLS or MJM physical models.

2. Procedure.

2.1 The STL model

- Digital CT-scan images were obtained for each patient.
- Using the software: Mimics, 3D CAD models were constructed from the digital CT-scan images for the two sides of the mandible bones in which one side is defective and the other side is healthy.
- Using CAD software (Unigraphics NX4) a mirror model was generated for the healthy bones and matched in position and orientation to the grafted portion of the bone.
- After this step an accurate CAD model in STL format for the artificial graft was obtained and is ready for fabrication using RP techniques.

2.2 Rapid prototyping for the whole bone

Based on the objectives of the work, two plastic physical models are to be fabricated.

First model is for the whole mandible bone which will be used to form – by hand press or mechanical press – the shape of the titanium plate which will fix the graft in position till the complete build-up of the bones. This physical model should have sufficient strength to form the titanium plate to follow the shape of the bone, in addition to good accuracy in dimensions and geometry details. To achieve this and find out and compare results, different models were built using the following different RP machines:

- 3DSystems Viper machine (SLA) using two materials: Accura 25 [Strength= 38 MPa] and Accura 60 [Strength= 65 MPa].
- Objet Eden250 machine (MJM) using FullCure 720 material [Strength= 60 Mpa].
- Zcorp 310 using standard materials [very week].

Second model is for the graft portion and this should be directly or indirectly fabricate from an active bioceramic materials. In the direct approach, Zcorp 310 will be used while replacing the gypsum-like building material – normally used in this machine – with Bioceramic powders such as "Silica Calcium Phosphate" to directly build this part then cured and sintered in an oven until the required strength for the graft. In the indirect approach, a mold is formed for the STL file, either by direct CNC machining or SLS RP for metals or investment casting techniques. Then, this mold is used to fabricate the graft from Bioceramic materials.

3. Sample results.

Fig. 1 shows the STL CAD model for both the mandible side and the graft. Fig. 2 to 6 show the RP models fabricated using different techniques.

Work is still in progress until fabricating the final – ready for patient – graft.

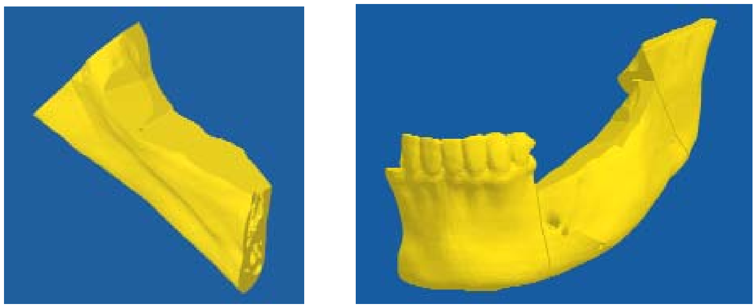

Fig. 1. STL CAD models for the mandible bone and the graft after regenerated from CT-scan images and trimmed by CAD software.

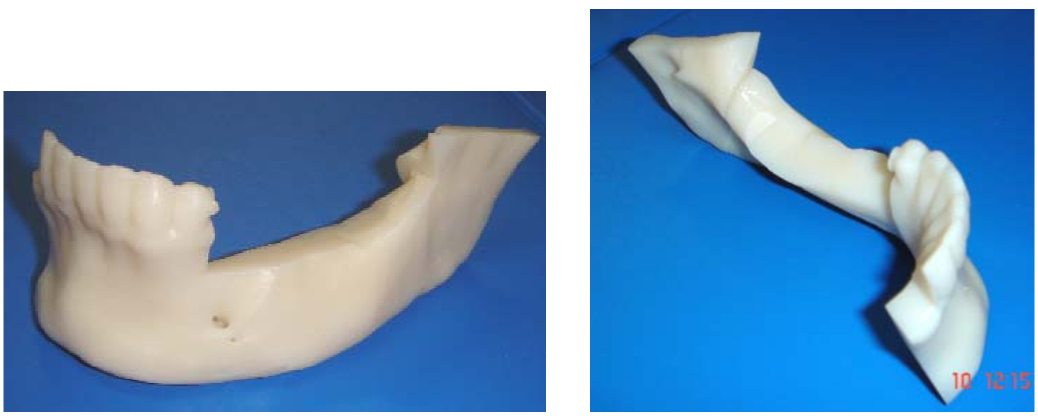

Fig. 2. Mandible bone from Accura 25 (3DSystems SLA machine.)

Fig. 3. Mandible bone from Accura 60 (3DSystems SLA machine.)

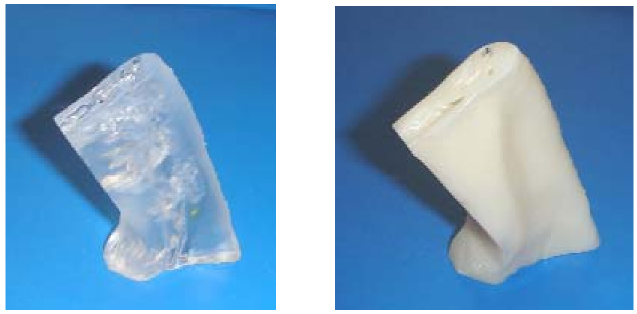

Fig. 4. Physical model for the graft that will be fabricated from Bioceramics.

Fig. 5. Mandible bone and graft from FullCure 720 (Eden MJM machine.)

Fig. 6. Mandible bone built by ZCorp 310 machine.

<u>Case Study 2:</u>

Fabrication of the top cover of a natural gas pump using rapid prototyping and investment casting.

1. Summary

The top cover of the natural gas pump (shown in Fig. 1) mainly is being fabricated using high pressure aluminum die casting and finished by machining. This technique needs to start by making a complicated mold because it has many fine details. For producing few number of this product, the cost of the mold will be very expensive in addition to that the mold will take several weeks to be designed, optimized and manufactured.

In this work, this part is being re-designed. Because this part is subjected to high gas pressure – from inside the pump – several defects such as surface deformation and cracks were observed and reported. According, a CAD model (Fig. 2) was generated for this part using the 3D Digitizing system Cyclone II (manufactured by Renishaw, UK). Then, the model transferred to Ansys to simulate the non-linear materials behavior under non-linear pressure and fatigue loads ending with new optimized design (Fig. 3).

Finally, a RP physical model was built using invision Si2 3D Printer (Fig. 4) and after validating the shape and dimensions of the new part, investment casting process was used to produce the required number of this part.

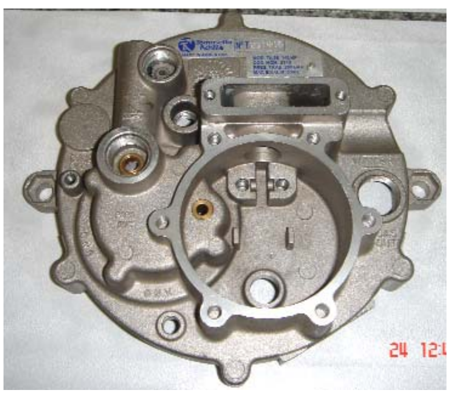

Fig. 1. The original part: Cover of the gas pump**.**

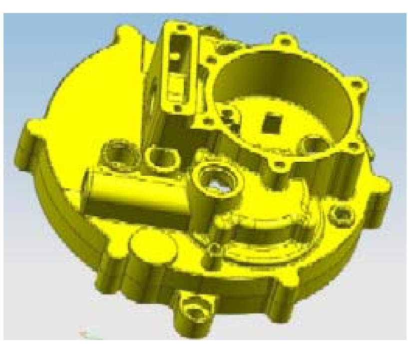

Fig. 2. CAD model of the part was developed with the aid of the 3D digitizing machine**.**

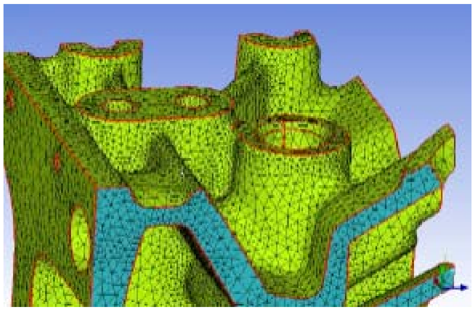

Fig. 3. Finite element model – using Ansys 10 – was used to optimize part wall thickness and dimensions according to the applied pressure inside the pump**.**

Fig. 4. Rapid prototyping model was developed using Invision 3D printer. This model will be used to re-produce the optimized part with the new dimensions and modified details through the Investment casting techniques**.**