Rapid Prototype Studies and Applications in İTÜ – FAA

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Abstract - **Rapid prototyping (RP) has decreased considerably product development times. The Objet Eden 500 Rapid Prototype Machine is used to produce wind tunnel models quickly and smoothly. It is also used for development studies. For example, various design studies were needed to reach an optimum form for antenna opening mechanism of a Cube Satellite (CubeSat) with strict restrictions. The RP system allowed rapid production of test subjects prior to the final actual metallic mechanism. RP is also used to produce complicated models such as vertical wind tunnel. The smooth surface requirement for an axial fan which is used for gathering data was accomplished with 16 micron layer capability of the RP.**

Keywords – **Rapid Prototyping, Modeling, CAD**

I. INTRODUCTION

Producing models both for measurement and demonstration purposes is a difficult, time taking task. Requirements originating from the actual usage of the model add to the difficulty. Smooth surface requirements for wind tunnel measurements, scaled production of complicated multi element multi thickness geometries are some examples.

Rapid prototyping machines are useful systems to help overcome those requirements. An OBJET EDEN500V system has been purchased to produce wind tunnel and demonstration, fit-check models for Reverse Engineering Laboratory of Faculty of Aeronautics and Astronautics. During the last 3 years various complicated models were produced successfully. The model production was relatively easy and fast. This helped reduce product development times considerably. For example an 10x10cm antenna opening mechanism plate was produced in several hours for modeling and usage verification before the final prototype was produced from metal with CNC. The relatively large cost of RP material is the main disadvantage. Following problem free first two years, the high maintenance requirement of the OBJET system is another disadvantage which may cause delays in the production on undesired times.

The present paper describes the current RP system available in FAA. Three examples of produced models are given to explain its usage and advantages: Antenna opening mechanism for pico satellite applications, axial fan and complicated multi element-multi layer 1/80 scaled vertical wind tunnel model. Problems encountered frequently during operation are also mentioned.

II. RP SYSTEM

The RP system is selected taking into consideration our modeling requirements and currently available systems nationwide. Although various RP machines were available in Istanbul and elsewhere in Turkey, none were able to produce very smooth surfaced models. Production of very small very fine details was also needed. The Objet EDEN500V system, Fig. 1, was selected since

i. It was able to produce fine details due to 16 layer micron capability,
ii. The tray size of 20x40x50cm was large enough for required productions,
iii. It was able to work for 72 hours.
iv. It was not available elsewhere in Turkey.

All the technical details of the EDEN500V are given in [1].

Fig 1. OBJET Eden500V System

III. APPLICATIONS

The FAA RP system is used extensively for various applications during the last three years. 3 different examples are given in the following sections: A axial fan, an antenna opening mechanism plate and 1/80 scaled vertical wind tunnel.

A. Axial Fan

the aero-acoustic noise of low-Mach-number axial fans mainly occurs due to inflow disturbances and the turbulent flow and separation developed over the blades. Fans with improper intake geometry often suffer from poor inflow conditions which varies from spatially asymmetric velocity profiles to ingested eddies that fluctuate with respect to time and lead to random forces acting on the blades. This produces broadband gust noise and, in most cases, trigger selectively organized structures over the blades causing tonal self-noise[2]. The RP model of the fan, Fig.2, is manufactured from transparent FullCure®720 material to add the numerical studies. The manufactured fan is directly used for measurements, Fig. 3.

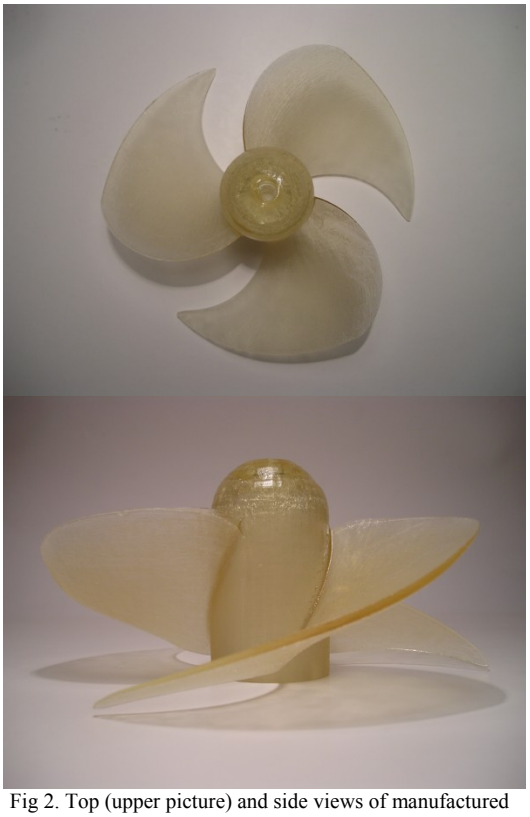


Fig 2. Top (upper picture) and side views of manufactured axial fan[3].

The fan's CAD data were supplied in STL format which is suitable for direct use in Objet RP system. The support material covering the bottom sections were cleaned using a water jet system before mounted in experimental setup.

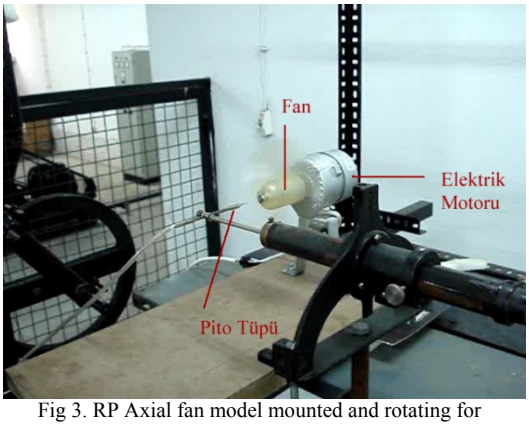


Fig 3. RP Axial fan model mounted and rotating for measurements[3].

B. Pico Satellite Antenna Opening Mechanism Plate

ITU FAA is engaged in design, manufacture, testing and launch of a pico satellite so called ITUpSAT1. The communication subsystem of the satellite requires an antenna system which needs to be properly folded and opened after launch and deployment prior to operation. Various design studies were carried out to obtain the optimum mechanism which will operate free of problems. The process required trial productions of the plate for fit checks and opening tries. The ITUpSAT1 is described in [4].

Transparent FullCure®720, VeroWhite and VeroBlue materials were used for plate productions. The very first mechanism which was manufactured from VeroBlue is given in Fig.4.

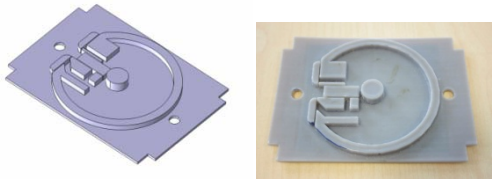


Fig 4. CAD model(left), and RP of antenna opening mechanism plate, early studies.

The drawbacks and heavy weight of the first system has lead to subsequent studies which resulted in integrated railed opening mechanism, Fig. 5. The actual metallic rails were difficult to manufacture. Finally pinned systems were found to yield the best solution, Fig. 6. The actual metallic model of the final plate is seen in Fig. 7, during trail tests. Fig. 8 presents the mechanism integrated to the flight model of the ITUpSAT1.

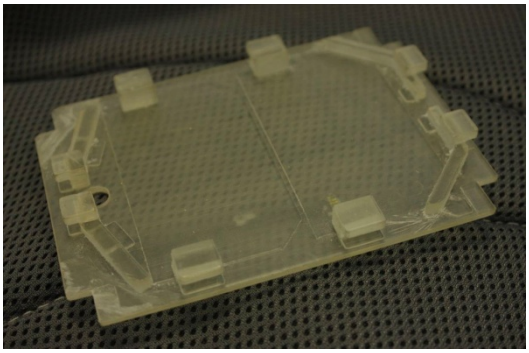
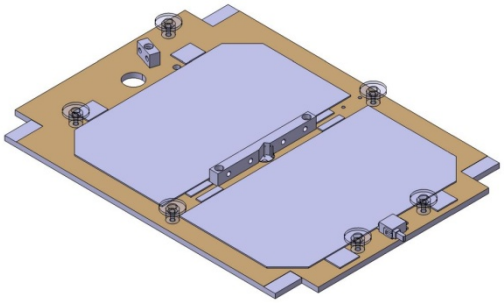


Fig 5. RP of railed antenna opening mechanism plate version 2.



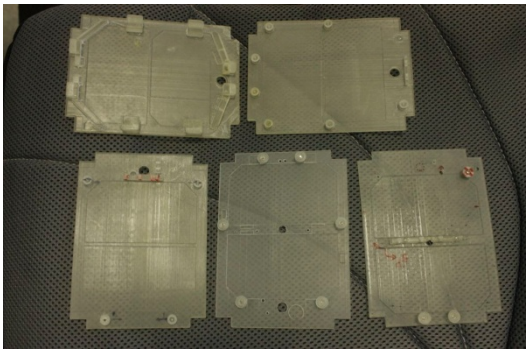


Fig 6.CAD model (upper) and various RP of pinned antenna opening mechanism plates.

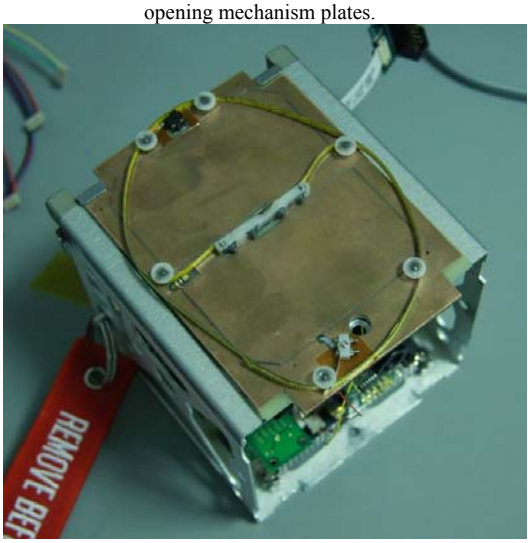


Fig 7.Antenna opening mechanism during trail test

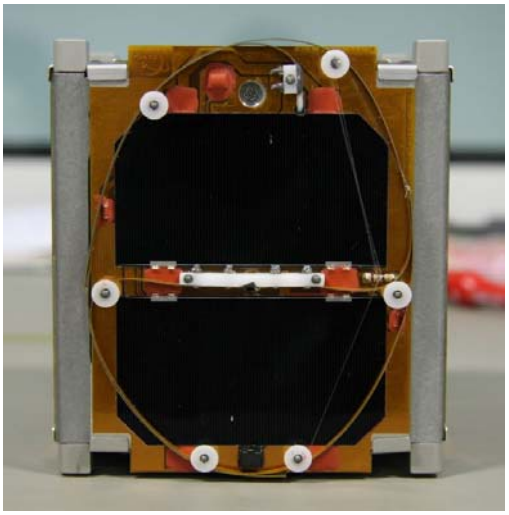


Fig 8. Antenna opening mechanism fully integrated to the flight model of ITUpSAT1.

C. Scaled Model of a Vertical Wind Tunnel

A vertical wind tunnel (VWT) used for parachutist training was designed and constructed. The actual approximate size of the VWT is 30x40x10m as seen in Fig. 9. A scaled down model of the VWT was required for demonstration and training purposes. The multi element, multi thickness complicated VWT drawings were first modified to allow for manufacturable thickness and simplified surfaces. Usually, surfaces under 1mm thickness could break or bend if too large (over 15mm). Some parts were produced from veroBlack materials whereas most were produced from transparent 720 materials for visibility. The scaled down RP model is shown in Fig. 10.

Fig 9.VWT ready to train

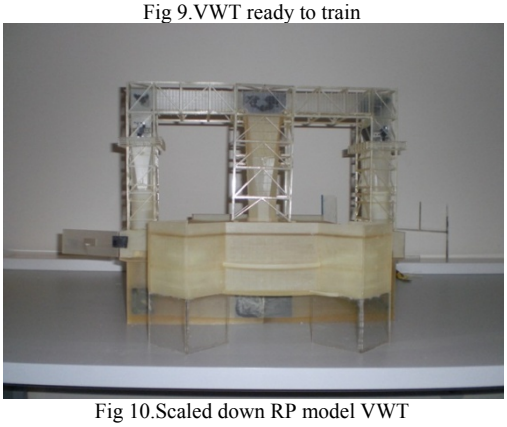


Fig 10.Scaled down RP model VWT

The VWT contains many small parts such as turning vanes and movables such as air exchange doors seen Fig. 11 used for thermal control of the VWT.

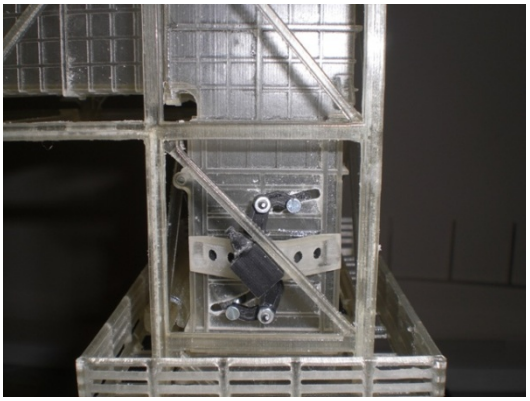


Fig 11.The air exchange doors of VWT.

VI. CONCLUSION

An OBJET EDEN500V system has been used to produce wind tunnel and demonstration, fit-check models for Reverse Engineering Laboratory of İTÜ-FAA. During the last 3 years various complicated models were produced successfully. The model production was relatively easy and fast.

The relatively large cost of RP material is the main disadvantage. Following problem free first two years, the high maintenance requirement of the OBJET system is another disadvantage which may cause delays in the production on undesired times.

The usual problems encountered during RP manufacturing are:

i. Vacuum error: Any voltage change during material flow from the cartridges may stop the manufacturing with a possibility of manual continuation.
ii. Both model and support heads require replacement due to nozzle blockage, every 6-7 months.
iii. The cartridge change necessary for material change results in considerable time and material loss.
iv. The reduction in the power of UV lamps results in erratic manufacturing.

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REFERENCES

[1] *www.objet.com, Eden500V_Brochure.pdf*
[2] S. Doğramacı, and B. Özdemir, "Computational Analysis of an Axial Fan using Large Eddy Simulation', İ.T.Ü. Graduate Institute for Science and Technology, MsC Thesis, 2008, (http://www.akis.itu.edu.tr/research/Computational%20Analysis%20of%20an%20Axial%20Fan%20wirh%20Large%20Eddy%20Simulation.pdf)
[3] http://www.akis.itu.edu.tr/research/lownoiseaxialfan.htm
[4] C.Kurtuluş, T. Baltacı, B. Toktamış, I. Akbulut, O. O. Haktanır, G. Inalhan, M. F. Ünal and A. R. Aslan ''İTÜ pSAT I: Getting Ready For Launch'', International Workshop on Small Satellites , New Missions and New Technologies,, 5-7 June 2008, İstanbul, Turkey.