BILKENT UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING

INDUSTRIAL DESIGN PROJECTS

2015 – 2016

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CONTENT

PREFACE

The primary goal of university-industry collaboration is to provide future engineers with a broad understanding of industry and business. In support of this goal, we have a two-semester long design activity for the senior-level students. This year, thirteen groups, each consisting of six students, were provided with design projects from leading industrial organizations. Projects were selected such that students could leverage their undergraduate studies to design a product needed in today's world, but also bring out their creativity in both the design phase, completed in the first semester, and in the manufacturing phase in the second semester.

At the project fair, the students are provided with the unique opportunity to present detailed design specifications of their products alongside the manufactured prototypes. The fair and this booklet explain the design and manufacturing goals, constraints, challenges, and, of course, the students' efforts that led to their accomplishments. The continuous guidance and advice provided by their academic and industrial mentors, instructors, and teaching assistants are very much appreciated.

On behalf of the Mechanical Engineering Department, I would like to thank all those who have generously contributed their time and resources that enabled tomorrow's engineers to gain invaluable experience during this process and demonstrate their capabilities.

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Mechanical Design of a "Clam Shell" Type Dome for TUBITAK National Observatory

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Abstract

Clam-shell dome project aims to design and manufacture a clam-shell dome with a diameter of 1.5 meters made up of fiberglass with integrated controller mechanisms. As a group, our motivation is to design and manufacture a clam-shell dome which coincides with the standards of TÜBİTAK National Observatory, and represent the name of Turkey with a delicately innovated design. Design process of the clam-shell dome has been dealt step by step. First step consisted of distinguished technical perspective and conceptual design. Other steps followed the predetermined technical perspective and the design has achieved its up to date form. Following such distinguished technical perspective allowed us to succeed in finalizing the project, and perform practical and experimental tests to prove our claims such as isolating the scientific instruments placed inside the dome from outer effects.

PROJECT DESCRIPTION

Clamshell domes are used to protect the telescope from the environmental conditions. That is needed, because telescopes are immobilized at the observatories and they need to stay there in all weather conditions. That is why there should be a protection for telescopes. Clamshell domes meet this demand. They are in shape of domes because the spherical structure is the best against weather conditions, especially drag force due to the wind.

Clamshell domes have four slices and two of them are on the one side of dome and the other two are on the other side. Motor turns and slices open with a belt from the top of the dome. So the telescope will be outside totally and ready to observe the space.

Figure 1: Standard Clamshell dome

We, as a group, were willing to design a clam-shell dome for TÜBİTAK National Observatory. They asked us to build up a clamshell dome with the diameter of 1.5 meters because they were in need of it which is not produced in Turkey.

The main goal of the project is to increase the isolation of clamshell, mostly around the end of the slices. To achieve this goal, we designed our clam-shell's slices to reduce the gaps among them. So, the telescope would be more isolated from the weather conditions and well protected.

Additionally, the main body of the clamshell should be resistant against the wind with the velocity of 300 km/h at most. Therefore, clamshell should be strong. Also, since slices move around the pivot tube with motor power, they need to be light. These requirements are satisfied with the fiberglass. Also, it is low cost material and easy to produce. These all features of fiberglass shaped our mind for the material of the main body. That is why we choose fiberglass to produce our clamshell dome.

MILESTONES AND ACCOMPLISHMENTS

Milestones for this project are determined in cooperation with TUG, and satisfied throughout the process of design and production

1. Acquisition of our own project through personal attempts and network capabilities

2. Satisfying the needs for initial documents and requirements of the project and obtaining BIDEB fund

3. Complete literature search for intended clam-shell dome type and establishing a final concept suited for all units and individuals involved

4. Successful design of components of the desired end-product and adequate solutions to the problems given in the definition

5. Scaled down, 3D printed version for a visual aid and mechanical analysis of the system

6. Proper mechanisms, motors, gears are selected suited for the conditions and requirements for the design

7. Recognition of the design to build a full-scale product by our mentor

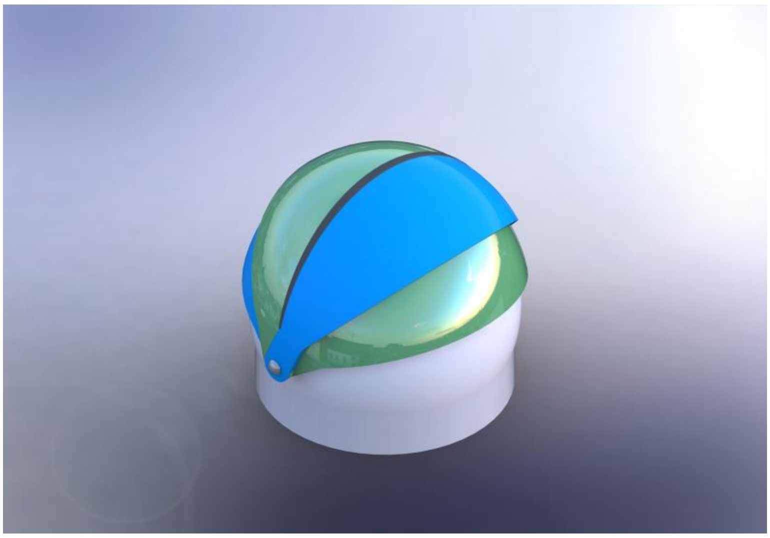

Figure 2: Final Design

MATERIALS AND METHODS

The materials used to produce such an integrated clam-shell dome can be listed as follows:

- 4 Specifically Designed, Identical Fiberglass Dome Slices
- 2 Fiberglass Cylindrical Dome Base
- 2 Pivot Tubes
- 150 W Brake Motors (2 pieces)
- 1/15 Ratio Worm Gearbox (2 pieces)
- Motor Drivers
- Hall Effect Sensors
- Power Distribution Board
- Safety Belts
- Pulleys
- Gaskets
- Bolts and Nuts

The fiberglass parts of the dome are manufactured in Antalya by using conventional fiberglass manufacturing techniques. Short fiber glass is chosen intentionally for this project in order to have material strength in all directions equally. The power required to supply to the system by motors is determined as 150 Watts. The thickness of the pivot tubes is calculated through basic beam deflection calculations.

RESULTS AND PERFORMANCE EVALUATION

First, multiple number of designs were investigated and engineering calculations were made with taking the desired mechanical problem into account. The main problem was to prevent external factors such as dust, snow, water etc. from infiltrating inside of the dome and resultant interfering with the proper operation of the telescopes and the dome itself.

Figure 3 show the drag force on the dome when closed and half open in which case parachute like effect is observed which increases the drag force.

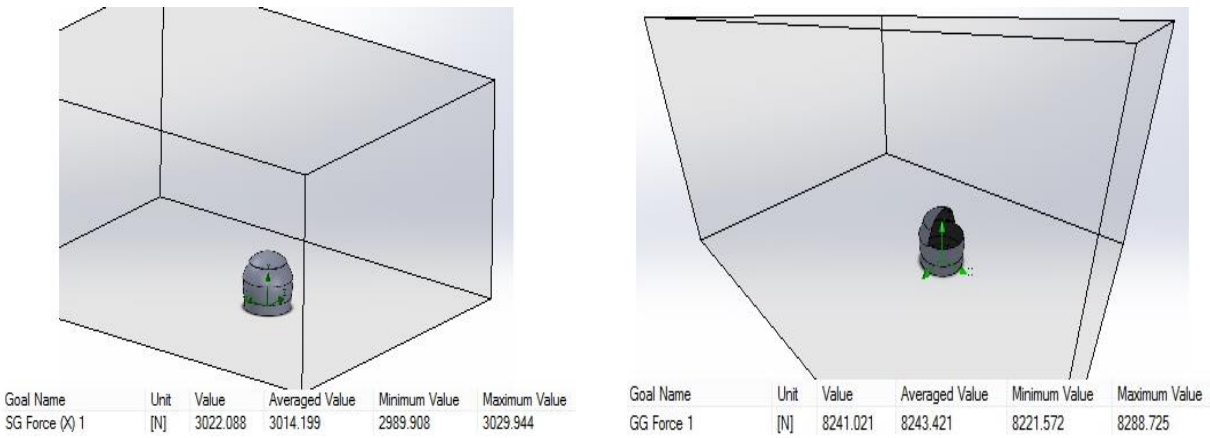

Figure 3: Drag force

The stress analysis of one slice of the dome satisfies the requirements as can be seen in figure 4. The stress analysis of the pivot tube, which carries the load of the slices and holds them stable, is also proved to be safe as can be seen in figure 5.

To test and evaluate the functionality and competence of the dome, a prototype was manufactured via 3D printer (figure 6). The prototype didn’t satisfy the desired mechanical and surface properties because of poor quality manufacturing, however it allowed us to confirm that the design solves the main problem of preventing external factors with satisfying functionality.

After manufacturing the first prototype, several tests were performed on the joint area where slices meet around the pivot tube. It was seen that the prototype succeeded and withstood the effects of wind, dust and low temperature. Several design changes such as thickness and orientation were made to improve the strength of the design.

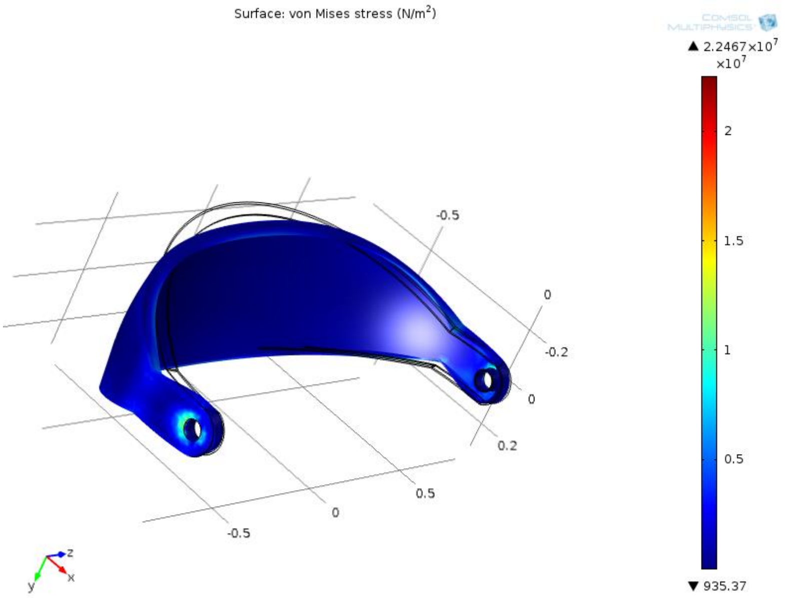

Figure 4: stress analysis of dome

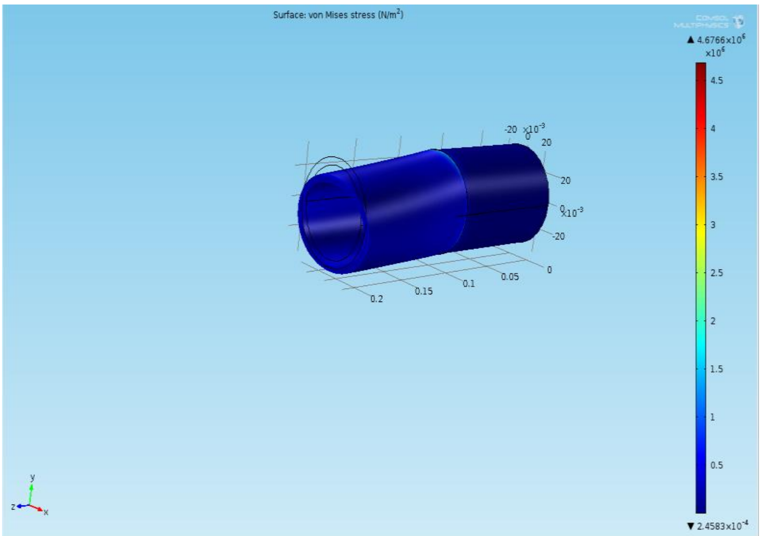

Figure 5: Stress analysis of pivot

As a group, we are satisfied with the final design of the dome. The common design problem in the existing Clamshell domes found in the industry is solved by our design. Moreover, installing the dome and investigating the operation of it in its real life conditions would help to enhance the design.

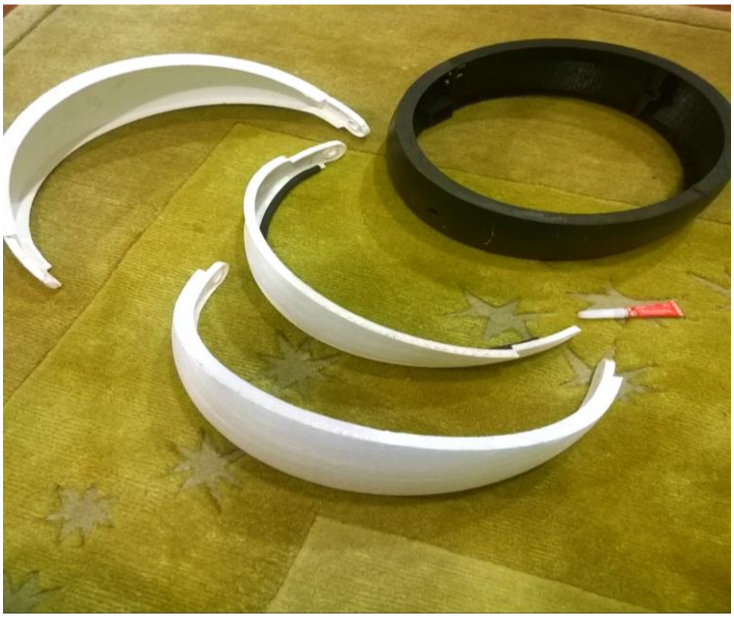

Figure 6: Components of prototype

CONCLUSION AND FUTURE DIRECTIONS

The produced clam-shell dome is capable of preserving a small telescope to be used for S-Dimm observations on the site of TÜBİTAK National Observatory (TNO), at top of the Saklıkent Mountain-Antalya. Alternatively, it can also be applicable for military cases. It is the first domestic clam-shell dome ever designed and produced in Turkey, with much less production costs than its foreign counterparts. Domestication will also eliminate the possible communication and transportation problems with foreign dome companies, where most of them are located in U.S.A. or Canada. Moreover, if the case of dome export trade may arise in future, it will provide revenue to national economy and recognition in markets. The research and development (R&D) in this area is currently inactive. This project assures know-how accumulation and will lead possible future R&D projects with the assistance of TNO.

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