

A Portable Workstation: Implementing Techniques of Product Design Process

Nadia Tanzeem

Lecturer

Dept. of Industrial and Production Engineering
Military Institute of Science and Technology
Mirpur Cantonment, Dhaka-1216, Bangladesh
nadia@ipe.mist.ac.bd

Nafisa Ali Anika, Zareen Tasnim Safa, Ibrahim Hossain, Maliha Huq

Dept. of Industrial and Production Engineering
Military Institute of Science and Technology
Mirpur Cantonment, Dhaka-1216, Bangladesh
nafisaalink@gmail.com, safamarua82@gmail.com, 1677sohag@gmail.com,
huqmaliha19@gmail.com

Abstract

Mobility and compactness are two of the main criteria for a tangible Product Design Process(PDP) nowadays. This paper deals with the execution of modern engineering concepts while designing a workstation consisting of a desk, chair and personalized storage with modular and portable Scheme. Primarily, results from customer survey are used as Voice of Customer(VOC) and expert opinion as design requirements to propose a House of Quality(HOQ), part of Quality Function Deployment(QFD). Additionally, to easily understand the functionality of the workstation Functional Decomposition has been performed. Finally, designs are developed in SolidWorks and the outcomes of the stress analysis are implemented for design improvisation which results in reduced material and space consumption.

Keywords

Product Development Process(PDP), Voice of Customer(VOC), House of Quality(HOQ), Quality Function Deployment (QFD), Functional Decomposition.

1. Introduction

Product Development Process(PDP) includes the design of the product as well as the material selection, appearance, standardization, and many more aspects. There is a continuous need for new, innovative and economic product from the consumers. Customer judge a product by its function, appearance, quality, and many more features. Decisions made at the design process has a huge impact on the final cost of the product. If the design is changed after product launching, the costing ends up higher. So, to make a sustainable product, it is important to nurture the product from the design phase. According to (Ljungberg, 2007), a sustainable product is a product, which will give as little impact on the environment as possible during its life cycle. The life cycle in this simple definition includes the extraction of raw material, production, use, and final recycling.

To make a product sustainable, primary phase is to reduce material consumption. Conventional desk and chair need plenty of raw material as well as space. Nowadays, mass customization is a strategy of producing standardized goods or services but incorporating some degree of customization. One of the ways to make a product of mass customization is a modular design. Modular design is a form of standardization in which component parts are subdivided into modules that are easily replaced or interchanged

The aim of this research is to apply PDP to introduce a personalized workstation design which can be used with lesser space and moved with ease. The workstation is designed to part by part, so the parts can be interchanged or replaced

easily. Customer survey initiates with HOQ, a phase of QFD which describes the relationships between design requirement and customer survey in section 2. The functional Decomposition of the product has been performed in section 3 with a target of gaining a better understanding of the product. Finally, outputs of all PDP have been applied to the design section, described in section 4.

2. Implementation of Quality Function Deployment on Portable Desk

Quality Function Deployment (QFD) is a customer-oriented approach to product innovation (Govers, 1996). QFD employs a cross-functional team to determine customer needs and translate them into product designs through a structured and well-documented framework (Karsak E., 2002). House of Quality (HOQ) is the primary metrics for QFD. According to (Hauser & Clausing, 1988), the HOQ is a kind of conceptual map that provides the means for inter-functional planning and communications.

2.1 House of Quality

The HOQ is applied in the workstation in order to diagnose the relationship metrics between the voice of customers(VOC) and technical requirements. The voice of customer(VOC) means the customer requirements which can be determined by numerous ways. For our workstation, VOC is discerned by a qualitative analysis. First, the targeted customers were identified by experts' recommendation. Then the voice of customer(VOC) was captured by customer survey with the help of a relevant questionnaire. The design requirements were resolved by a tree diagram. Following figure (figure1) represents the desired HOQ where the VOC and the technical requirements are incorporated.

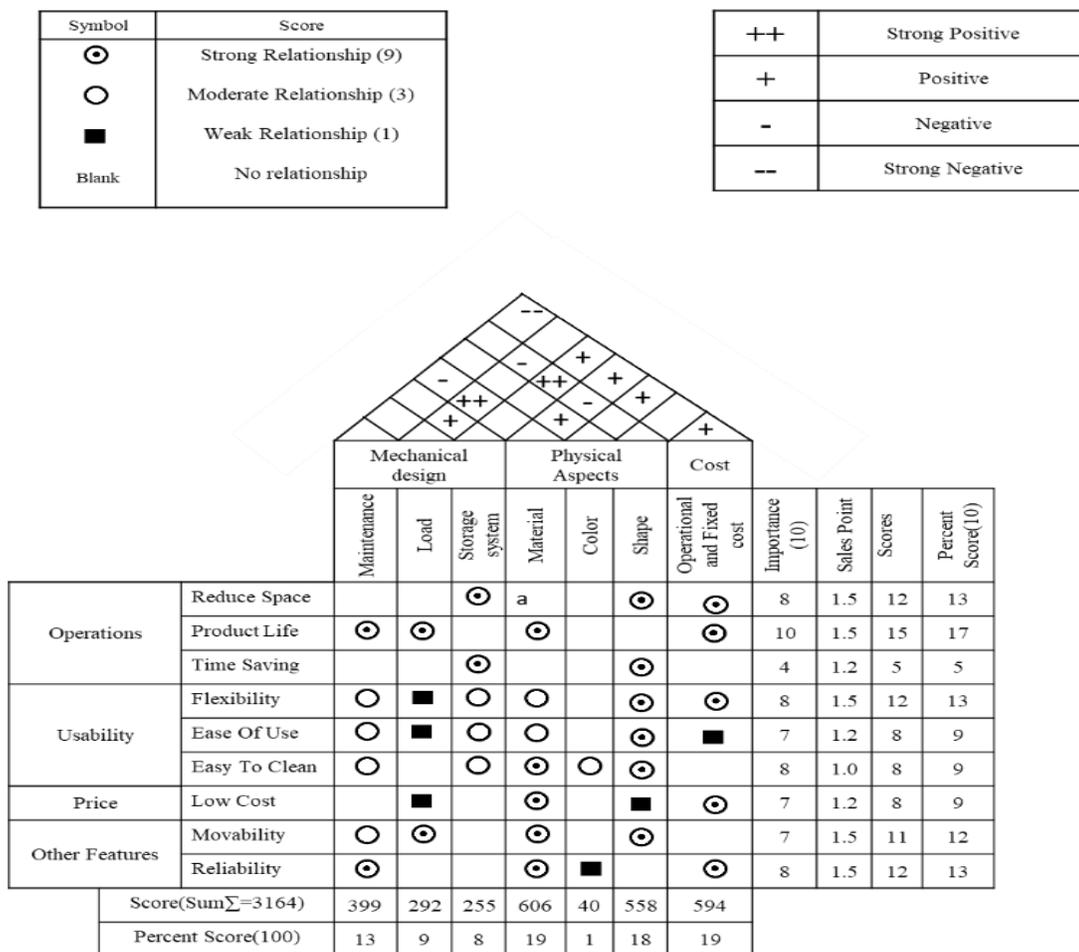


Figure 1: House of Quality for Workstation

After applying HOQ for the workstation, it was determined how much emphasis is needed to be applied in which customer requirement or design requirement. In this way, it wound up conceivable to prioritize the more essential customer requirements or design requirements in order to design the product.

3. Implementing Functional Decomposition on product

According to Suh, the design is the transformation of functional needs into design parameters. As products being more complex, it has become necessary not only to break down the design process into organized tasks (Ullman, 2003), but also to break down the design problem into more easily manageable sub-problems (Pailhès, Sallaou, Nadeau, & M. Fadel, 2011) Functional modelling is defined as a process of decomposing the global function of a product into sub-functions and these authors propose a standard vocabulary known as the functional base. Functional decomposition is a term that engineers use to describe a set of steps in which they break down the overall function of a device, system, or process into its smaller parts. This is usually accomplished through thoughtful analysis and team discussions of project information and the result is a chart that describes the problem and or solutions in increasing detail.

3.1 Black Box Model of Functional Decomposition

A black box model depicts all input and output flows for the primary, high-level function of the design task. In the context of input-output modeling, a flow enters an operation or subfunction, is manipulated by the subfunction, and exits in a new state. A flow is a physical phenomenon (e.g. material, energy, or signal) that is intrinsic to a product operation or subfunction. In the context of input-output modeling, a flow enters an operation or subfunction, is manipulated by the subfunction, and exits in a new state.

There are generally three types of input and corresponding output in a black-box. They are:

- Energy flow
- Material flow
- Information flow

Figure 2 has shown the Black box diagram of the workstation.

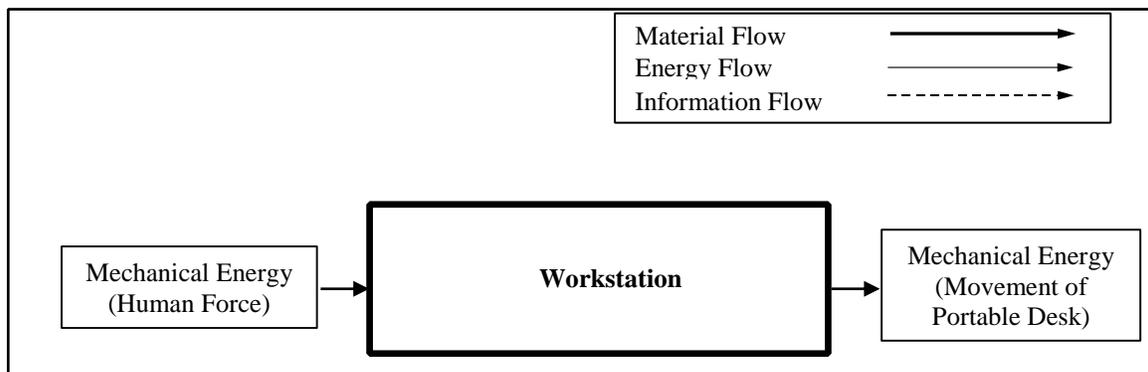


Figure 2: Black Box Model of workstation

3.2 Component Hierarchy

Functional decomposition takes something complicated and simplifies it. The individual elements of the process and their hierarchical relationship to each other are commonly displayed in a diagram called a functional decomposition diagram. The component hierarchy is a tree of components is shown in Figure 3.

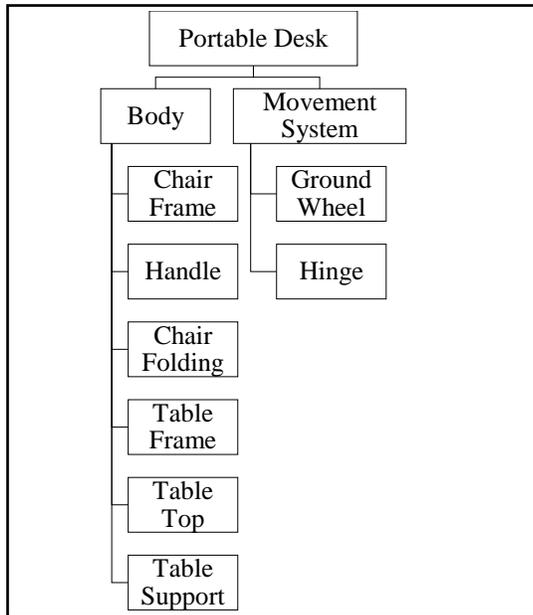


Figure 3: Component hierarchy of workstation with power supply

3.3 Cluster Function Structure

Cluster function structure represents the overall mechanisms of a product and shows the relationship among them. Figure 4 has shown the cluster function structure of the workstation.

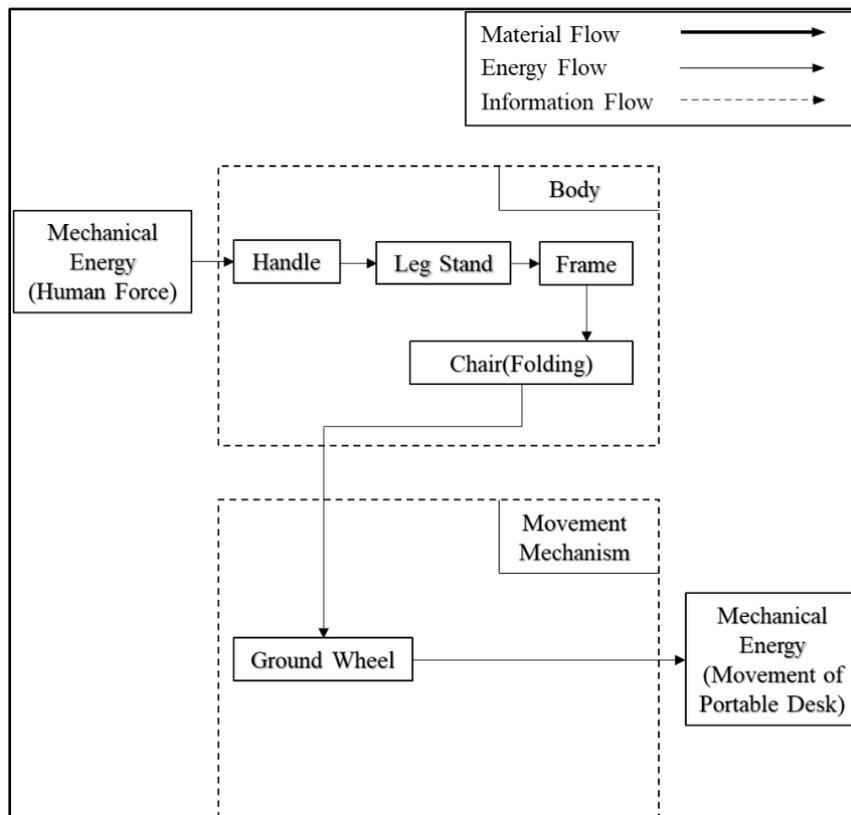


Figure 4: Cluster function structure for workstation

Through this Functional Decomposition procedure, we developed the complete design of our product in a descriptive way. In black box model we showed the major functions of our product which is energy flow. Again, a component-based dissection was shown in the component hierarchy. At last we constructed a cluster function to represent the energy flow with detail working procedure and how they relate to each other.

4. Design Analysis of Workstation

According to (Silva & Chang, 2002), Design changes are frequently encountered in the product development process. Both parts and assembly must be regenerated for a physically valid product model, at the same time, the regenerated product model must meet the designer's expectations. If the product solid model is not parameterized properly, the changes in geometry often lead to invalid parts or assembly. At the part level, the changes may yield a solid model with invalid geometric features if it is not properly parameterized. In this case, the entire product assembly is in vain. Even when individual parts of the product are regenerated correctly, parts may still penetrate to their neighboring parts or leave excessive gaps among them, if the solid model is not properly parameterized at the assembly level.

Design analysis is a powerful software technology for simulating physical behavior on the computer. Design analysis can minimize or even eliminate the need for physical prototyping and testing. In the field of production engineering, design analysis can solve a wide range of product development problems. Engineers can use a design analysis to predict the physical behavior of just about any part or assembly under any loading conditions. Figure 5, 6, 7 represent the parts and assemblies of the workstation and Figure 8 shows the folding states of the product.

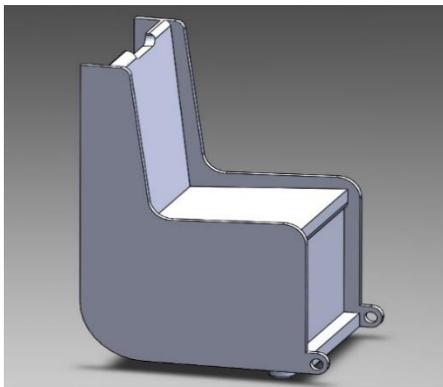


Figure 5: Chair

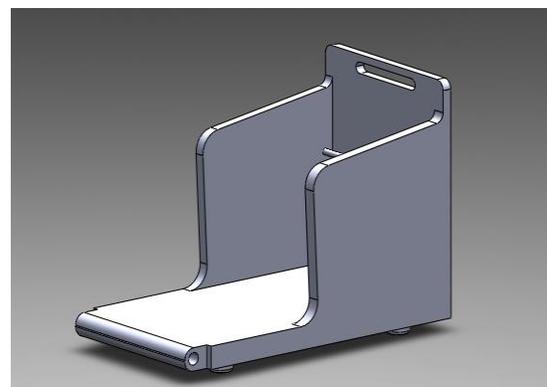


Figure 6: Table holder

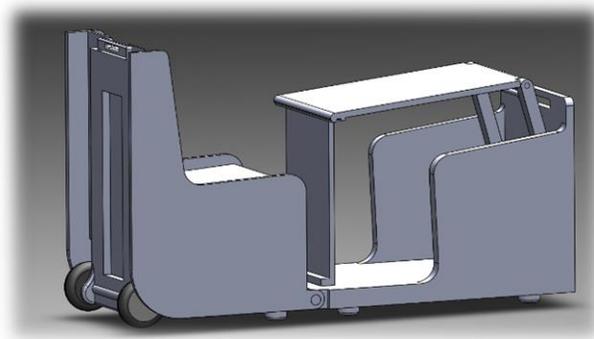


Figure7: Assemble of workstation

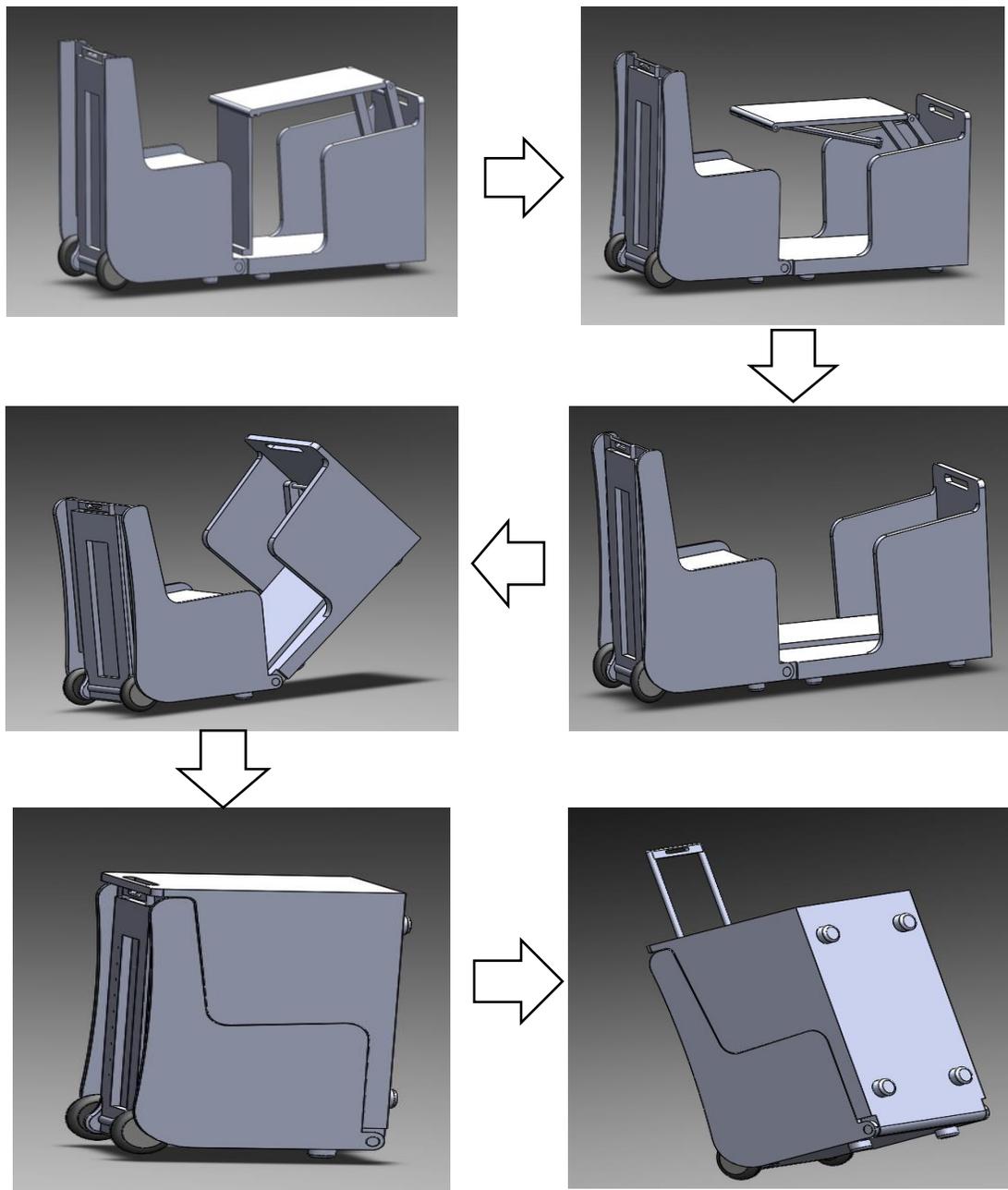


Figure 8: Working procedures of workstation

4.1 Stress Analysis

In engineering, stress analysis is often a tool rather than a goal in itself; the goal being the design of structures and artifacts that can withstand a specified load, using the minimum amount of material or that satisfies some other optimality criterion. This analysis has given the idea of how reliable the product is to bear variable ranges of the load.

4.2 Stress Analysis of Back of the Chair

The back part is used for leaning. Hence the load applied would be lesser compared to the seat. Here, we have applied 8 N force for analyzing the stress on it.

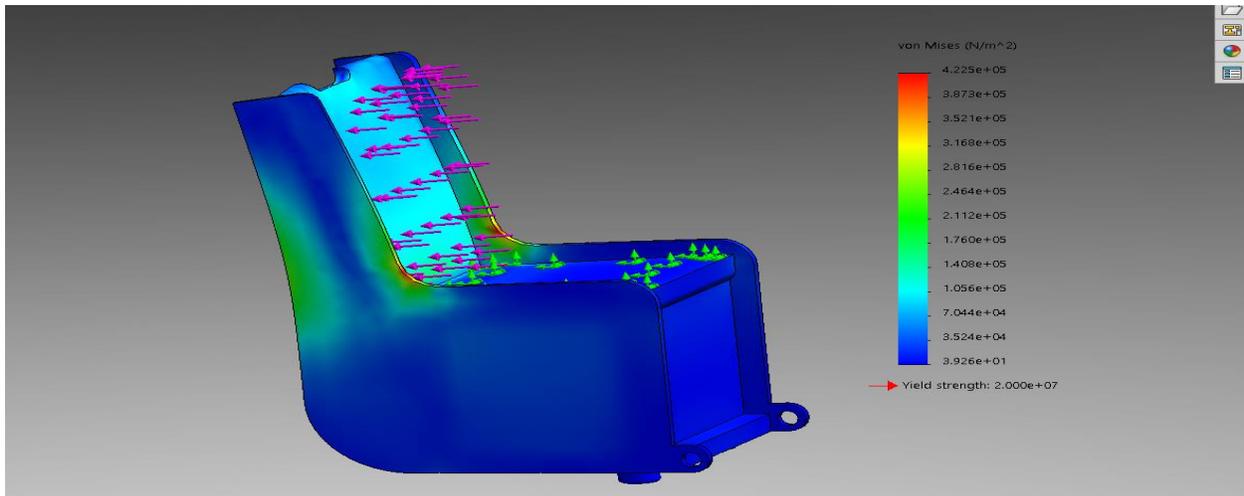


Fig. 9: 8 N load applied on the back part for leaning back

4.3 Stress Analysis of Wheel

There are a total of 2 wheels in our design for carrying the load. Due to symmetry, any load will be equally distributed between the wheels. We have assumed that each wheel will bear a load of 590 N (60 KG each). Figure 6 shows the effect of this load.

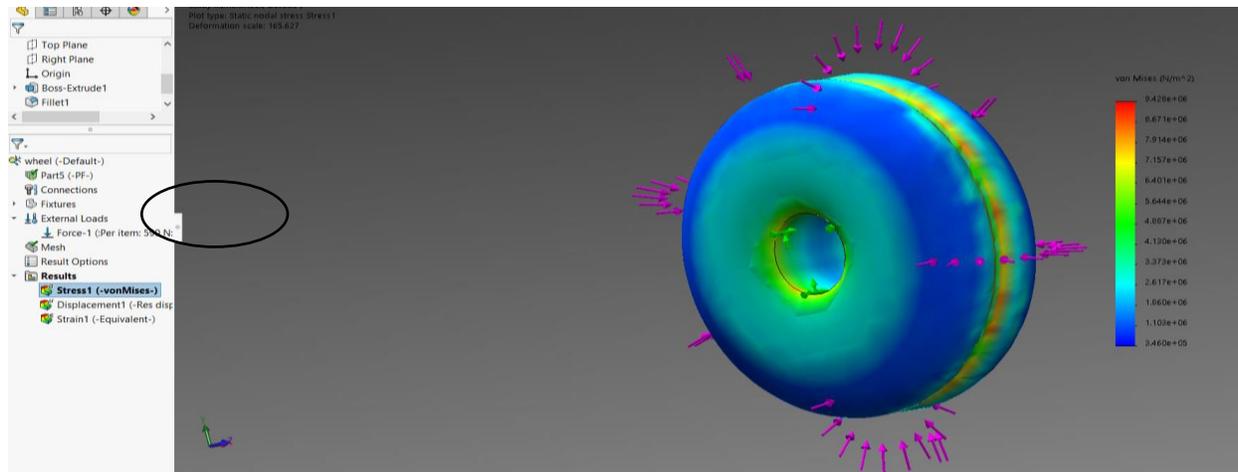


Fig. 10: 590 N load applied on the wheel.

4.4 Stress Analysis of Seat

After adding the storage system, the seat could take more load than without support. It is also evident from figures 5 & 6. The loads applied are 9800 N (1000 KG) & 800 N (81 KG) sequentially.

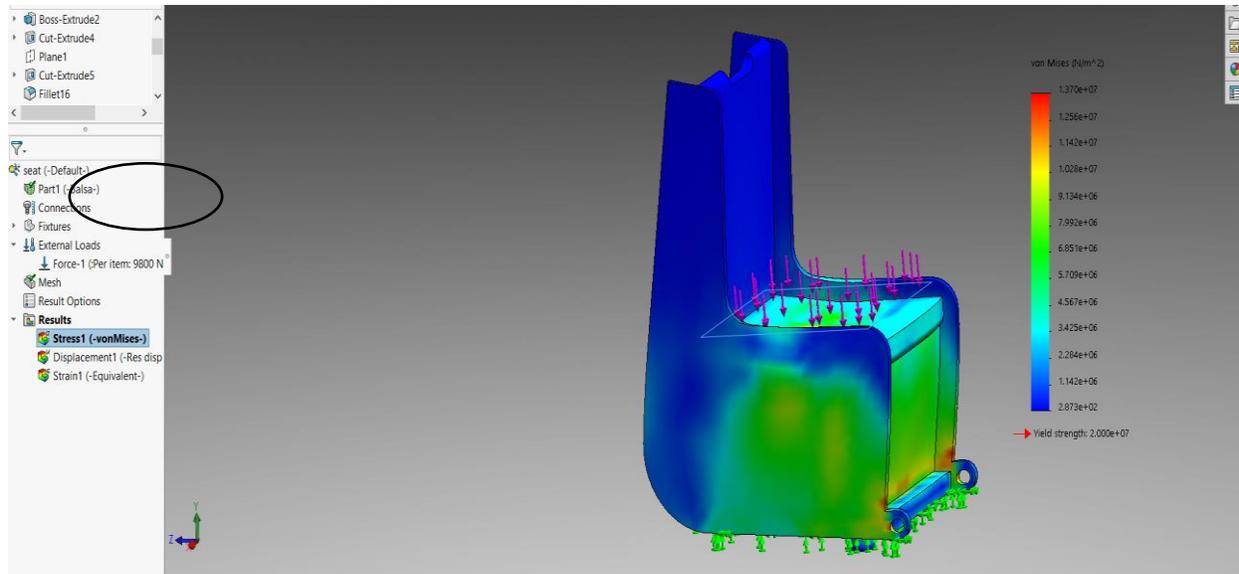


Fig. 11: 9800 N load applied on the seat while there was inner support underneath

4.6 Table Support

Stress is analyzed of the joint where the support meets the lower part of the body-frame. A load of 1 N is applied to the joint for supporting the table.

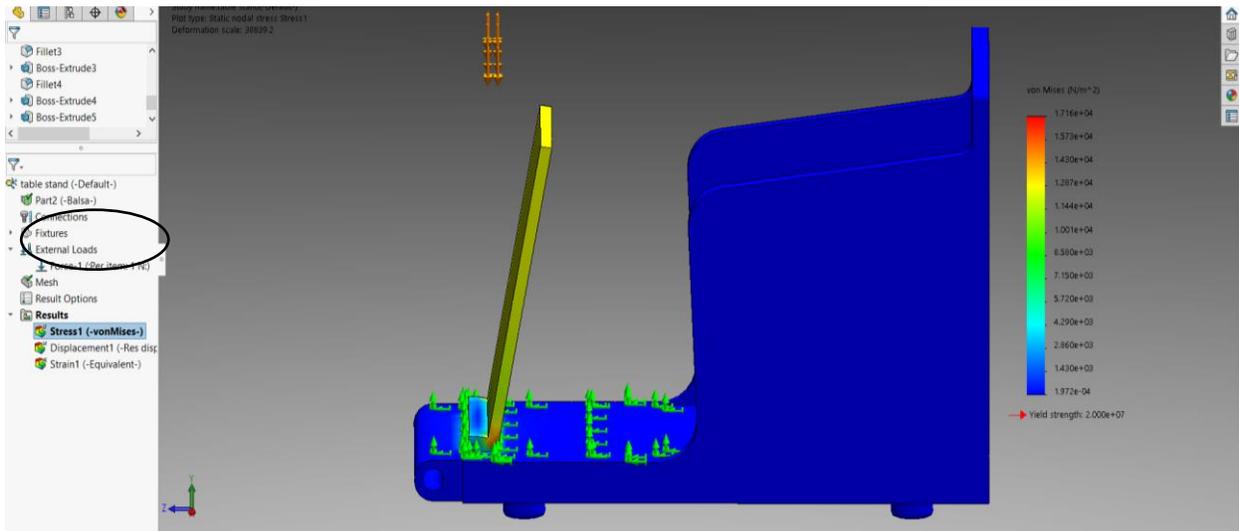


Fig. 12: 1 N load applied on the table support

5. Conclusion

In recent times emphasize must be given towards smart design which is more personalized and multifunctional. Most importantly to keep pace with the first moving world, product design and development should be happening according to the choice of customers. The aim of our paper to reflect both customers' desires while developing a product and reduce material and space consumption. The design parameters were selected from the views of customers which makes the product more acceptable for the customers. This design can further be modified by applying ergonomic analysis on the workstation and by adding more feature to improvise its usability and functionality.

Reference

- Ljungberg, L. (2007). Materials selection and design for the development of sustainable products. *Material and design*, 28, 466-479.
- Čiarnienė, R., & Vienažindienė, M. (2012). Lean manufacturing: Theory and Practice. *Economics and Management*, 17(2), 726-732.
- Govers, C. (1996). What and how about quality function deployment (QFD). *International Journal of Production Economics*, 46-47, 575-585.
- Hauser, J., & Clausing, D. (1988). The house of quality. *Harvard Business Review*, 66, 63-73.
- Karsak E., S. S. (2002). Product planning in quality function deployment using a combined analytic network process and goal programming approach. *Computer & Industrial Engineering*, 44, 171-190.
- Kulkarni, P., Kashire, S., & Chandratre, K. (2014). Productivity improvement through lean deployment and work study methods. *International Journal of Research in Engineering and Technology*, 3(2), 429-434.
- Pailhès, J., Sallaou, M., Nadeau, J.-P., & M. Fadel, G. (2011). Energy based functional decomposition in preliminary design. *Journal of Mechanical Design*, 133(5), 1-10.
- Silva, J., & Chang, K. (2002). Design parameterization for concurrent design and manufacturing of mechanical system. *Concurrent Engineering*, 10(1), 3-14.
- Ullman, D. (2003). *The Mechanical Design Process*. Boston: McGraw-Hill.

Biographies

Nadia Tanzeem is a Lecturer of the Department of Industrial and Production Engineering at Military Institute of Science and Technology, Mirpur, Dhaka, Bangladesh. She received her B.Sc. in Industrial & Production Engineering at Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh and continuing her masters at Bangladesh University of Science and Technology, Dhaka, Bangladesh. Her research interests include Product Design Process, Statistical Analysis, Optimization and modeling

Nafisa Ali Anika is an undergraduate student in the Department of Industrial and Production Engineering at Military Institute of Science and Technology, Dhaka, Bangladesh. Her research interests include Sustainable Manufacturing, Product Design and Development, and Additive Manufacturing.

Zareen Tasnim Safa is an undergraduate student in the Department of Industrial and Production Engineering at Military Institute of Science and Technology, Mirpur Dhaka, Bangladesh. Her research interests include machining processes, the design of experiments and optimization.

Ibrahim Hossain is an undergraduate student in the Department of Industrial and Production Engineering at Military Institute of Science and Technology, Dhaka, Bangladesh. His research interests include Product design process, micro-manufacturing, and Chatter control

Maliha Huq is an undergraduate student in the Department of Industrial and Production Engineering at Military Institute of Science and Technology, Dhaka, Bangladesh. Her research interests include the design of experiments, multivariate statistics, and optimization methods.