International Journal of Engineering Research and General Science Volume 5, Issue 4, July-August, 2017
ISSN 2091-2730

CASE STUDY ON WHITE BOARD DUSTER

Ashiq Mohamed M,

Student of SASTRA University,

Tirumalaisamudram,Thanjavur- 613401,

E mail: ashiqtaheer@gmail.com

Abstract- This case study is related to a white board duster (also called as marker board duster). In this case study, the usage of the existing white board duster and its pros and cons were studied and its design was analyzed. Then the better design that could overcome the limitations of the existing duster was prepared, analyzed and validated theoretically. Then the redesigned duster was fabricated by rapid prototyping process and tested manually. The material of both the existing duster and the redesigned duster was acrylonitrile butadiene styrene (ABS) and the software used for analysis was CATIA V5.

Keywords-White board duster, Impressions, Principal stress, Displacement, Von mises stress, Paint thinner or Water, Ultimate tensile strength, Maximum principal stress theory, 3 D printing.

INTRODUCTION-

In today's scenario though the science and technologies are updated, the use of marker boards in educational institutions, offices and in various other places are unavoidable. Though the automatic board erasing robots have been already developed, their installation and maintenance are uneconomical in certain places like government schools, public notice boards etc. In such cases, it is necessary to use manual duster for erasing purpose. In this case study one of the major problems of this duster was studied and the solution is depicted.

CASE PRESENTATION-

The actual existing white board dusters are shown below. Some organization even uses the black board duster for erasing the marker board.

(*Figure 1)*

(Figure 2)

Here the Omega manufacturer's duster (Figure1) is taken as a reference. Usually these duster is of plastic material (preferably ABS) which would cost about INR 35 to INR 50. Inevitably these duster are integrated with foam material for the ease of erasing. The foam employed is of hard type which has high resistance to water absorption compared with soft foam.

Apart from this certain marker board duster have pocket on its top surface in order to hold the marker. These are the secondary functions of the duster whereas, the primary intended function is to erase the impressions on the board. Below table shows the function analysis of the existing marker board duster as similar to the function analysis of the application taken from the reference paper [1].

PART NAME	QUANTITY	FUNCTION		PART	
		VERB	NOUN	PRIMARY	SECONDARY
Gripper (plastic)	1	Provide	Grip	X	
		Hold	Marker pen		X
Sponge (Hard foam)	1	Erase	Impressions	X	

(Table 1: Function analysis of marker board duster)

For the purpose of case study, the duster that incorporates only the primary function is considered.

METHODOLOGY-

The methodology behind analyzing the duster is that, the type and nature of the material of the duster is noted initially. Then the properties of the material are taken from standard books. Then the type of load that act on the duster upon erasing action is identified and its magnitude is approximated. Then the duster is designed and analyzed from the obtained datum. Depending upon the nature (ductile or brittle) of the material, the appropriate theory of failure is selected and the results obtained from the analysis are cross-checked according to the selected theory of failure in order to prove for a safer design.

DISCUSSION-

The main advantage of using these manual duster for erasing purpose is that, they are economical, portable and there is no maintenance cost. They are reliable maximum up to the period of 6 months. But there are also certain limitations such as they have to be replaced frequently once in 6 months, and could not effectively erase the impressions on the white board after 3 days. In such cases, additional liquid substance like paint thinner or water is applied on the board and then they are erased off.

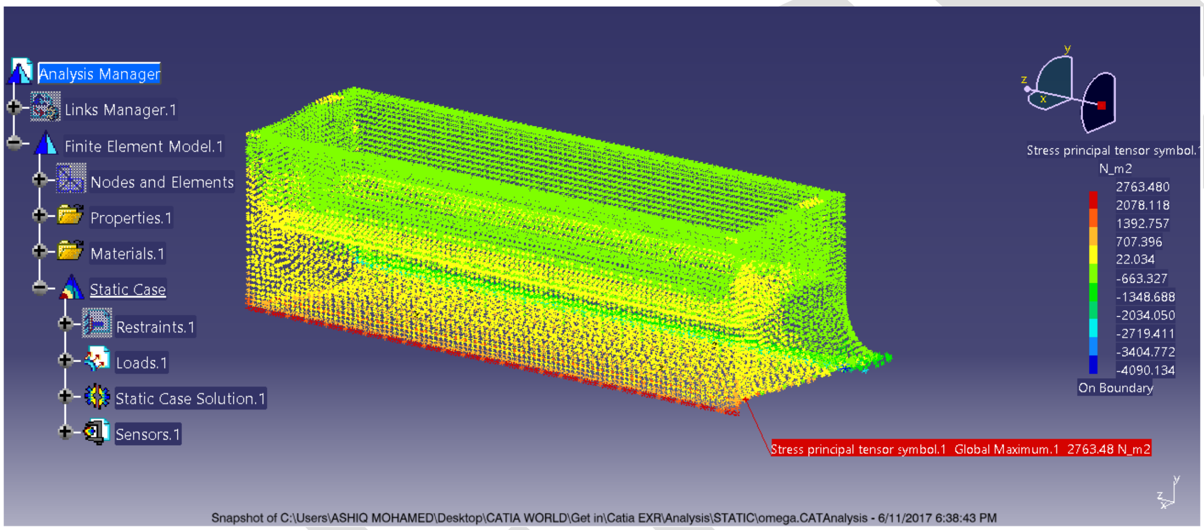
The reference plastic duster (ABS material) is approximated to design by Reverse Engineering process in CATIA V5. Reverse Engineering is a very important tool and this technique has been widely recognized as an important step toward developing improved products as well as reducing time and costs in order to achieve profitable production of the new product [2].

After the design is made the static analysis is performed on the design, which predicts the maximum normal stress that could be withstand by the duster, von mises stress and the deflection of the duster under loading condition. Usually the type of load, that acts upon the duster while erasing off the impressions on the board, is of shear type loading. The overall dimension of the duster (only plastic part) exist up to 10x3x3 cm with hallow surface on its top (as shown in figure 1) and the shear force of 1N is assumed to act upon the duster while erasing relatively with the board. The properties of the ABS material are given in the table below.

PROPERTY	VALUE
Technical Name	Acrylonitrile Butadiene Styrene
Softening Temperature	128 °C
Tensile Strength	55.2 MPa
Yield Strength	51 MPa
Specific Gravity	1.06
Typical Injection Moulding Temperature	204 – 238 °C
Shrink Rate	0.5 – 0.7 %

(Table 2: Material properties)

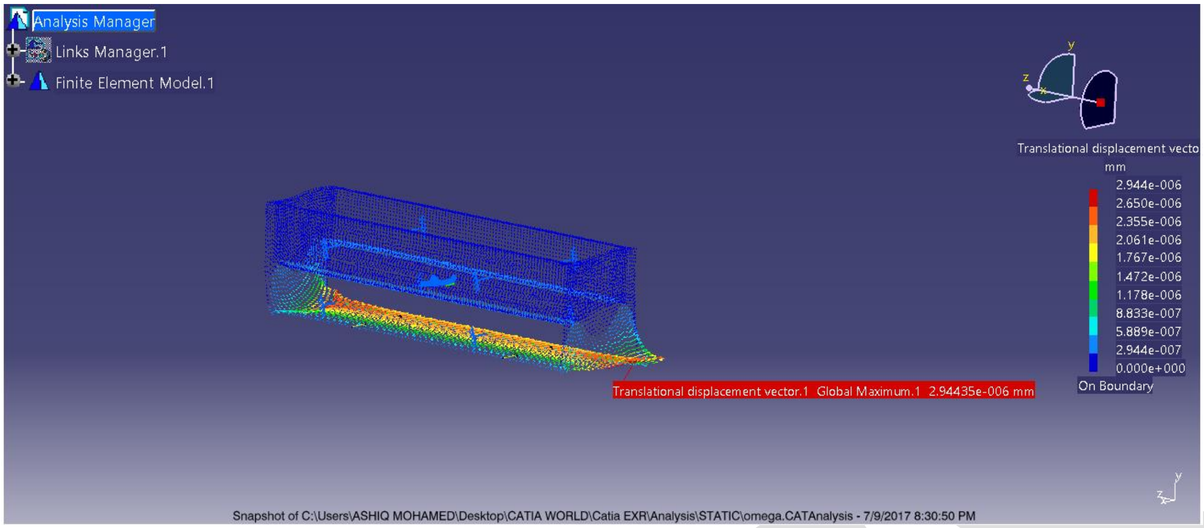
ABS resins are thermoplastic resins composed of three kinds of monomers- acrylonitrile, butadiene, and styrene[3]. The design is analyzed and the principal stress induced in the duster is shown below in figure 3. The principal stress that could be withstand by the duster is 2763.48 N/m^2 and it is constant irrespective of the magnitude of the load.



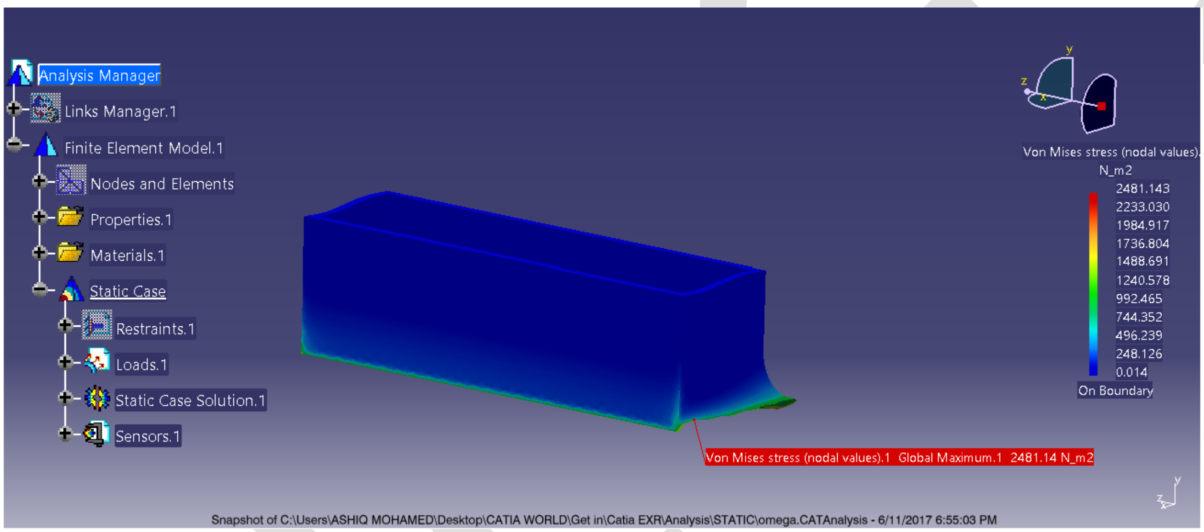
(Figure 3 : Principal stress)

From the table (2), it could be noted that the softening temperature is 128 °C [4], up to which the ABS material will behave as a brittle material. The appropriate theory of failure for brittle material is maximum principal stress theory which states that the material fails, when the principal stress induced in a material under complex loading condition exceeds the ultimate tensile strength of the material [5,6]. The obtained value of principal stress is lesser than ultimate tensile stress of the ABS material which is 55.2 Mpa (i.e. 5.5 x 10^7 N/m^2). So the design is safe according to maximum principal stress theory.

The maximum displacement of the duster, shown in figure 4, when acted upon by a force of 1N, under constrained condition is found to be 0.00000294 mm which is negligible. And the von mises stress due to the application of load is found to be 2481.14 N/m^2 which is shown in the figure 5. Since ABS is a brittle material, it is sufficient to validate only the maximum principal stress theory in order to prove for a safe design.



(Figure 4 : Displacement)

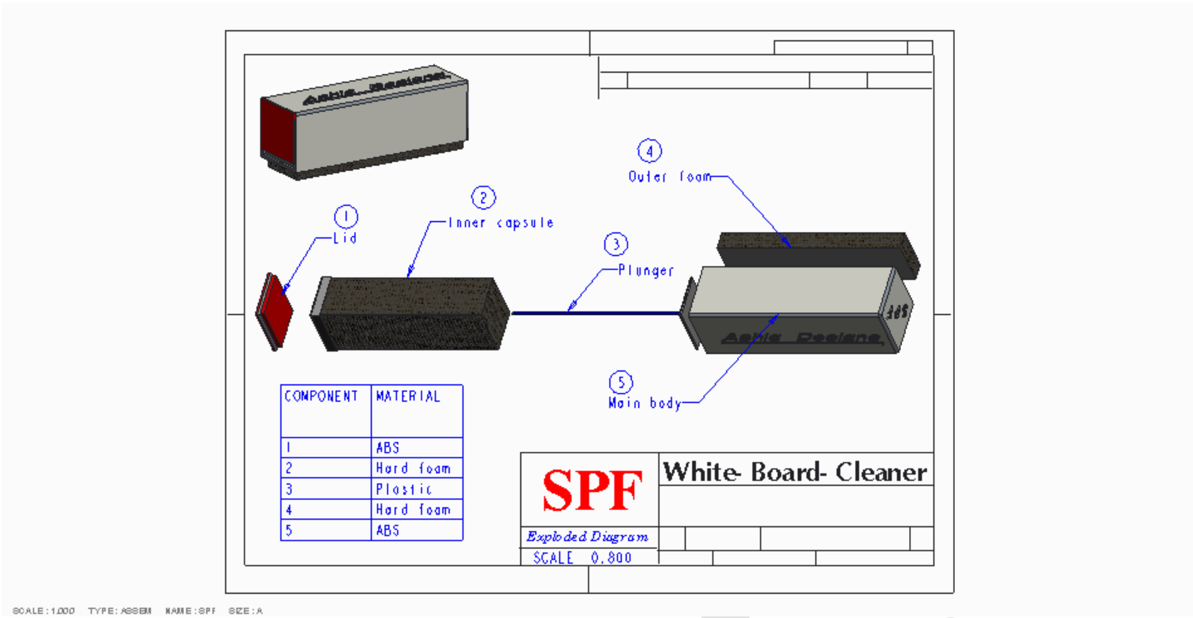


(Figure 5 : Von mises stress)

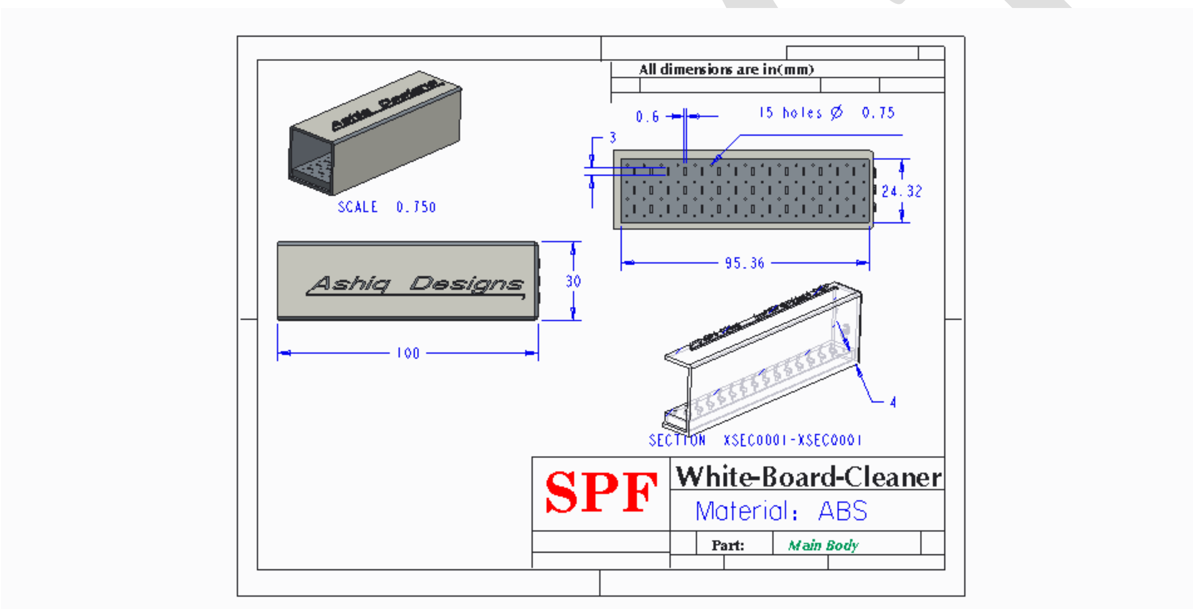
After such analysis, the modified design which could overcome the limitation of the existing duster is made and its drafting diagram is shown in figure 6. The final step of designing a part or assembly is communicating it in a medium other than the computer monitor's display. For some operations this means plotting out design drawings [7,8].

The dimensional details of the main body is given below in figure 7. Here the inner capsule which is a foam material is dipped in the liquid (water or paint thinner) used for cleaning, and then it is placed inside the main body along with the plunger. The lid is used to close these arrangements. Outer surface of the main body consist of dry foam. This duster can be used as a default duster while erasing the impressions instantaneously after writing it in the marker board.

If there is a need to erase the impressions after few days, here comes the use of liquid inevitable. In such cases the lid has to be opened, then the plunger has to be pulled out. Due to this action, the wet inner capsule will be compressed due to which the liquid from this inner capsule travels to the dry foam through the capillary holes present in the main body. Now the impressions can be easily erased off without taking effort separately as such in usual existing dusters.



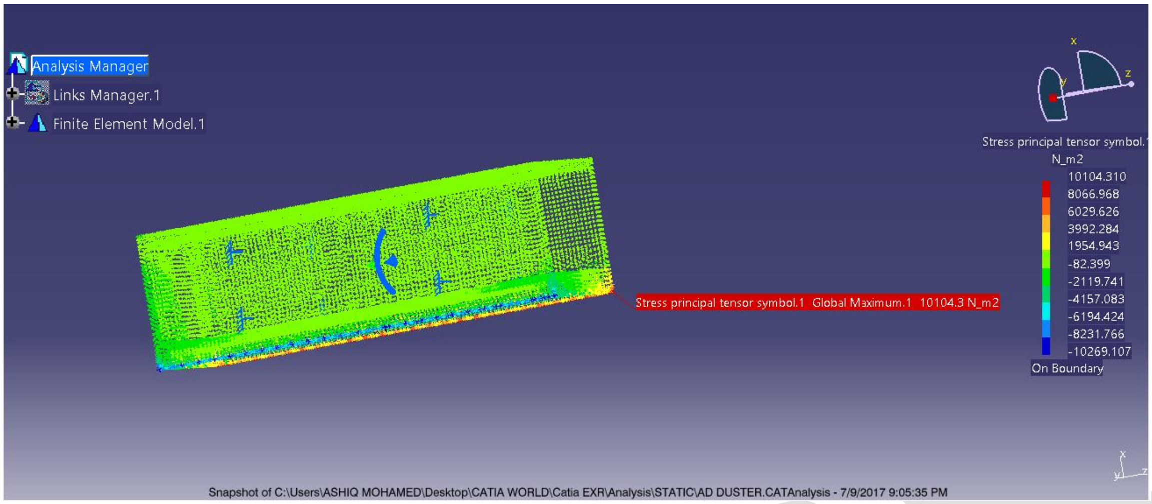
(Figure 6 : Exploded view of redesigned duster)



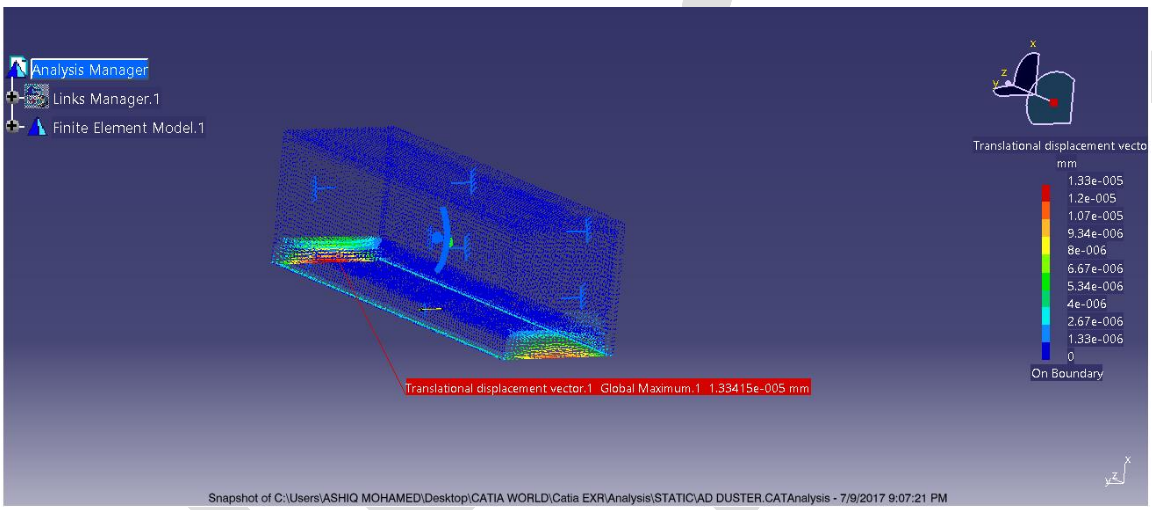
(Figure 7 : Dimensional details of main body)

The modified design is also proved to be safe according to maximum principal stress theory of failure for brittle materials [5,6]. The principal stress, when acted upon by the same shear load of 1N was found to be 10104.3 N/m^2 and it is lesser than ultimate tensile strength of ABS material.

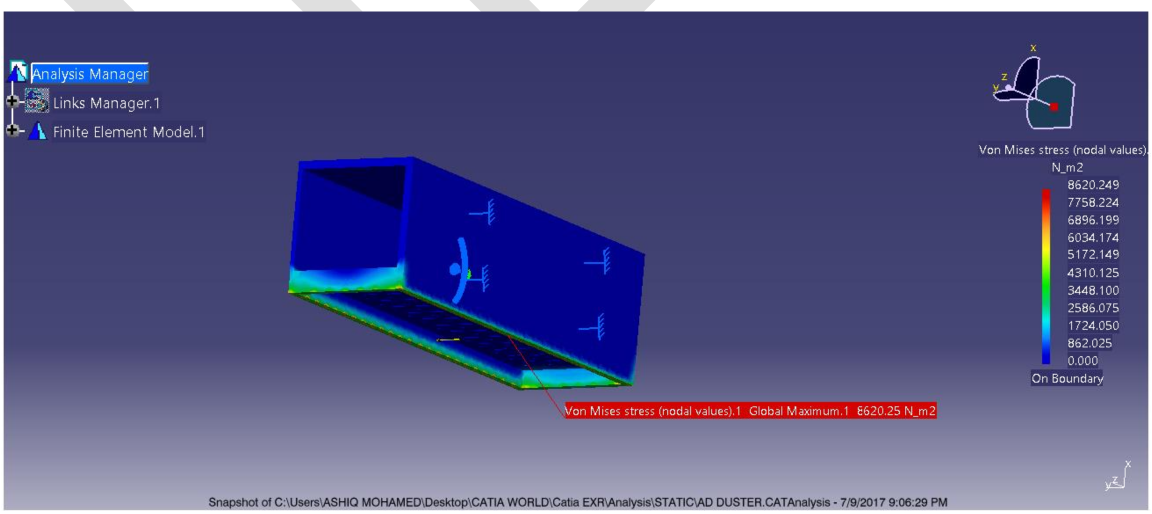
The displacement of the redesigned duster was found to be 0.0000133 mm which is negligible and von mises stress was found to be 8620.25 N/m^2. And they are shown below in the corresponding figures below.



(Figure 8 : Principal stress of redesigned duster)

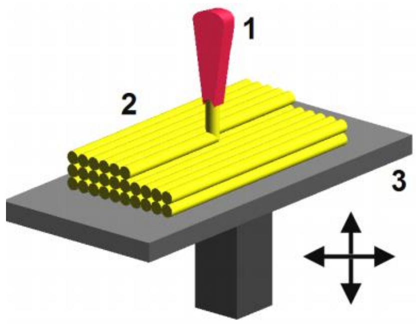


(Figure 9 : Displacement of redesigned duster)



(Figure 10 : Von mises stress of redesigned duster)

This design was prototyped with the help of 3D printing by employing FDM method. In Fused Deposition Modeling method, the parts are build layer-by layer from the bottom to top by heating and extruding thermoplastic filament. Initially the build-assistance software like Cura, slices the 3D CAD file and predicts a path to extrude thermoplastic Then the 3D printer heats the thermoplastic and deposits it along the extrusion path [9,10].



(Figure 11 : FDM principle. 1-nozzle, 2-building material, 3-moving table) [11]

Thus obtained duster was tested manually by erasing the impressions that were made few days before on the marker board and better improvements were noted. The details of the prototype is given below.

PARTICULARS	VALUE
Layer Thickness	200 microns
Infill Percentage	25 %
Shell	3

(Table 3 : Prototype details)

Infill refers to the amount of plastic to be used for the bulk of the object, it goes normally from 0% (hollow objects) to 50% (solid, very strong parts) [12].

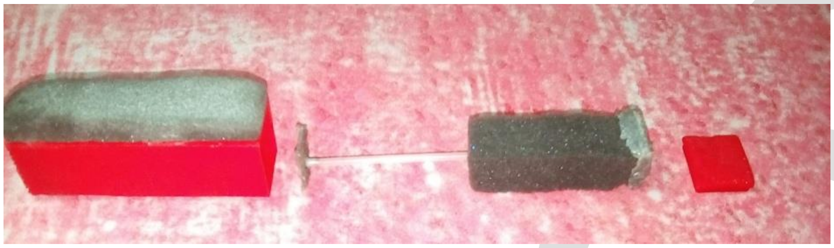
The below table shows the function analysis of the redesigned marker board duster.

PART	FUNCTION	PRIMARY FUNCTION	SECONDARY FUNCTION
Main body	1. Grip for holding 2. supports lid and encloses plunger and wet foam	1	2
Lid	1. Covers the plunger and wet foam and gives aesthetic value		1
Dry foam	1. Erase the marking on the board 2. Absorbs the water/ paint thinner for better erasing of impressions	1	2

Plunger	1. Compress the wet foam		1
Wet foam	1. Used for holding the liquid.		1

(Table 4 : Function analysis of redesigned duster)

The image of the exact prototype of the redesigned white board duster is shown below in an exploded view. It consist of the main body attached to the dry foam, plunger and wet foam arrangement and finally a lid to enclose these parts



(Figure 12 : Prototype image)

CONCLUSION-

Thus this case study illustrated the major demerits of the existing marker board duster and its necessity to be redesigned. Also from the above discussion, we can conclude that the usual existing duster could be effectively replaced by this modified duster in order to make the erasing purpose easier and with the surface roughness of 200 microns which facilitates for good ergonomical effect to use the duster. This modified design of the duster has better significant than the existing design of the usual duster and it is theoretically proved to be safe from the following key aspects.

- Material of the duster is brittle in nature, so the maximum principal stress theory has to be validated in order to prove for a safer design.
- The principal stress in the duster under loading condition is lesser than the ultimate tensile strength of the material.
- The displacement of the duster under constrained condition is negligible.

So it is suggested to switch over from the existing marker board duster to this redesigned duster in order to make the erasing process in an ease approach.

REFERENCES:

[1] Chougule Mahadeo Annappa, “Application of Value Engineering for Cost Reduction of Household Furniture Product - A Case Study”, International Journal of Innovative Research in Science, Engineering and Technology, volume 3, issue 4, 2014.

[2] Alexandru C. Telea, “Reverse Engineering – Recent Advances and Applications”,ISBN 978-953-51-0158-1, 2012.

[3]James M. Margolis, ”Engineering Plastics Handbook”, Acrylonitrile-Butadiene-Styrene (ABS) Resin Chapter (McGraw-Hill Professional, 2006), Access Engineering

[4]Cambridge University Engineering Department, “Materials Data Book”, 2003, http://www-mdp.eng.cam.ac.uk/web/library/enginfo/cueddatabooks/materials.pdf

[5]Dr. R K Bansal, “A textbook of strength of materials”, Laxmi publications (p) ltd, 2009, https://docs.google.com/file/d/0B0U1_eNEi1r-bG1MMFVWckRiTk0/edit

[6] Er. R K Rajput, “Strength of material (Mechanics of solid)”, S. Chand Publishing, ISBN 9789385401367, 2015.

[7] P Radhakrishnan, S Subramanyan, V Raju, "CAD/CAM/CIM", New Age International (P) Ltd., Publishers, Third edition, ISBN (13) : 978-81-224-2711-0, 2008.

[8] P N Rao, " CAD/CAM Principles and Applications", Tata McGraw Hill Education Pvt. Ltd, ISBN(10) 0-07-068193-7, 2010.

[9] Vinod G. Surange, Punit V. Gharat, " 3D Printing Process Using Fused Deposition Modelling (FDM)", International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 03, March 2016.

[10] Deepa yagnik, " Fused Deposition Modeling – A Rapid Prototyping technique for Product Cycle Time Reduction cost effectively in Aerospace Applications", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), International Conference on Advances in Engineering & Technology – 2014

[11] Ludmila Novakova-Marcincinova, Ivan Kuric, " Basic and Advanced Materials for Fused Deposition Modeling Rapid Prototyping Technology", Manuf. and Ind. Eng., 11(1), 2012, ISSN 1338-6549

[12] Enrique Canessa, Carlo Fonda and Marco Zennaro, "Low-cost 3D Printing for Science, Education & Sustainable Development", ISBN 92-95003-48-9, May 2013.