Analysis and 3D printing of TASER bands for women safety

V.V.D. *Sahithi*[1], *Sriram* Prayaga[2], *Jyothika* Priya Lakshmi[2], *Nityasri* P[2], B *Naveen Kumar*[2]

[1]Assistant Professor, VNR VJIET, Hyderabad, India.
[2]B. Tech Student, VNR VJIET, Hyderabad, India.

Abstract. Women's safety has always been an issue in the modern era. They endure lot of problems like sexual harassment, physical abuse and trafficking. These are the most alarming problems in society. All these problems show a very dangerous impact on women empowerment. So, to protect women from such assaults it is very important to find a solution. In this present research work, authors designed a women safety TARA wrist band, a self-defence device for women. TASER [Thomas A. Swift's Electric Rifle] system is used in this device. This paper deals with the materials which are used in the device, battery, mechanical, thermal and physical analysis of the device. From this analysis, operating temperatures and the load conditions are analysed to manufacture a perfect women safety wristband. Fused Deposition Modelling 3D Printing technique is used for development of the prototype.

1 Introduction

This device was developed to ensure the safety and confidence of every woman in a permissible manner. Our grail include a reduce in the spike of rape cases by providing a comfortable, elegant and perpetual device which is so authentic. The representational design of this safety device is distinguishable to a bracelet. It has a stretchy material that compliments the band[1-7]. So, the size of the band is common for all. The two pin projections represent the TASER pins. The TASER system is the fundamental and core part of the functioning of this device. Technical specifications include 2 TASER pins which conduct a maximum current of 25-60 mA. This causes minor respiratory paralysis and isn't fatal by any means. The tapered block consists of the electronics and the battery. This type of design is chosen to fit more of the electronics part and thereby, seamlessly moulds with the cross section of the band. This device consists of all rudimentary components.

*Corresponding author: sahithi_vvd@vnrvjiet.in

1.1 Selection of material

Silicone is having low heat conduction, insulation effects. Si is mostly resistant to chemicals, corrosive materials, oxygen, ozone and UV light around us. It also reveals low lethality. It inhibits a property to repel water and from watertight seals. Their firmness towards heat is 200°C. It doesn't even support bacteriological broadening [1]. Ni-Cr is defined as steel containing both nickel and chromium. It is in the ratio of 2 to 3 parts Ni to 1 part Cr. The 2:1 ratio gives good toughness. The Ni and Cr are deliberated to balance each other in physical effects. Hardness and toughness are the characteristics of these steels. Ni-Cr steel containing 1 to 1.5% Ni, 0.45 to 0.75% Cr and 0.38 to 0.80% Mn are used[2]. Stainless Steel is an alloy of iron, containing at least 11% Cr along with C. The other materials are involved according to the requirement for the device. It has magnificent corrosive resistance. Regarding its tensile strength, they are superior to materials such as Al, CuPbZn and soft steel. It has great fire resistance due to high strength. SS's are ductile and hence they can also be used for manufacturing jewellery[3]. Rubber is known for its elastic properties. In general, Silicon and Rubber are common strap materials used for any wristbands. In this project, we have included rubber parts to provide stretching ability to the band[4, 10-14].

2 Design and Analysis

2.1 3D Printing

3D printing of the device was accomplished by the authors using Flash forge Guider 2 3D Printer manufactured by Flashforge. The machine consists of a large build volume of 280 x 250 x 300 mm3. This works on the principle of Fused Deposition Modelling (FDM). Fused Deposition Modelling (FDM) is an additive manufacturing technique which involves the melting of a thermoplastic thread in the filament. The extruding nozzle selectively deposits the material layer by layer[9,15]. The input is given to the 3D printer after converting the .stl file into a .gx file. The G-Code file is then stored in a hardware storage device which is feeded to the 3D printer for digital input. The estimated time and the preview of the. gx file is displayed on the monitor of the 3D printer.

Fig. 1. (a) 3D Printing; (b) PLA Prototype.

2.2 ANSYS Workbench R22

A general-purpose finite-element modelling tool called ANSYS is used to numerically solve a wide range of mechanical issues. These issues range from acoustic and electromagnetic problems to static/dynamic, structural analysis, heat transport, and fluid mechanics [16-20].

2.1.1 Geometry Creation Using Space Claim

The geometry of the TASER system is created using Space Claim Modelling built into ANSYS 2022. By using the dimensions in millimetres, the reference TASER model is constructed and imported as the geometry for static structural analysis. Under material properties, the pin segments are assigned to Nickel Chromium steel and the block component is assigned to structural steel.

2.1.2 Fixed Support

Before running the test cases, the basement or fixed support has to be assigned in order to apply the load on the constrained pins. In order to constraint the pins, the base of the block component is selected as the fixed support under the AS tab. It is represented in purple colour.

2.1.3 Force Test

The second test case includes a normal force applied on the pins structure which can be caused due to accidental bumps when hit by a wall or hard object. Under the AS tab, a ramped force of 100N is added in the Z direction and the geometry selected is the pin structure.

2.1.4 Total Deformation

After performing force tests, a total deformation test is performed by selecting the option “total deformation” under the solution tab. In the below figure, various colours represent the various deformations which occur until the fatigueness is achieved. In this case, the base block component is dark blue since it is fixed and constrained. The colours change from light blue to yellow and the most deformable area is coined as red.

2.1.5 Damage

The design life divided by the available life is the definition of fatigue damage. This test exhibits the characteristics of the nickel chromium alloy pins and the effect when cycles of load are applied on them. The red colour indicates maximum possibility of damage while the blue colour indicates least chance of damage.

2.1.6 Equivalent Stress

Since it is simpler to see, the Von Mises stress is the greatest way to describe the primary coordinate system. With ductile materials, equivalent stress is frequently employed to characterize a material's condition.

2.1.7 Normal Elastic Strain

When an item stretches in response to a regular stress, this is known as normal strain (i.e. perpendicular to a surface). Tensile strains and compressive strains are the two categories of normal strains. when an item stretches or lengthens as a result of the applied force. Simply described, it is the axial deformation to initial member length ratio.

2.1.8 Temperature Analysis

An object with thermal loads that don't change over time can have its temperature distributions determined using steady state thermal analysis. In a steady state thermal analysis, heat is transferred through conduction, convection, and radiation. In order to analyse the heat transfer in the TASER block, temperature analysis is performed.

2.1.9 Heat Flux

The heat flow rate in heat transfer is referred to as the energy per unit time. A physical definition of heat flux is the rate of heat flow divided by the area. Heat flux is thus defined as heat flow on a unit area in a unit of time.

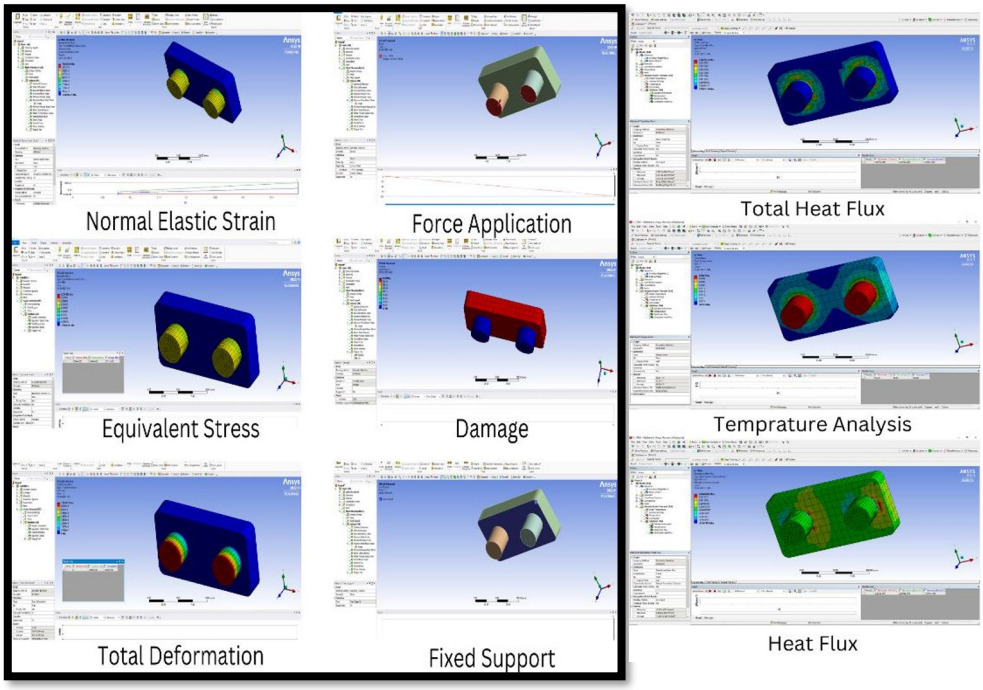

Fig. 2. (a) Static Structural Analysis; (b) Steady State-Thermal Analysis.

3 Results and Discussions

This paper emphasizes the design and analysis of women safety device. The design of this equipment contains a TASER system which can be used by the user for protection in unfavorable conditions. The design was developed using AutoCAD 2020 3D, Autodesk Netfabb Premium and FlashPrint v5.0 softwares. The simulation and the engineering analysis was performed using ANSYS R22 Student Version. From the ANSYS results performed on the TASER system, the maximum deformation occurring at the top cross section of the pins is 2.95 x 10^{-5} m. While the equivalent stress acting in terms of minimum, average and maximum values is represented as follows: (Min: 3.896 x $10^{0.013}$ N/mm^2 , Avg: 2.991 x $10^{0.02}$ N/mm^2, Max: 5.6459 x $10^{0.02}$ N/mm^2). The maximum normal strain acting is 7.6669 x 10^{-8} . When it comes to deformation, the maximum deformation possible is 7.6669 x 10^{-6}mm. In case of thermal analysis, the maximum heat flux generated during temperature analysis of 50^0C is 2.8972 x 10^{-2} W/mm^2.

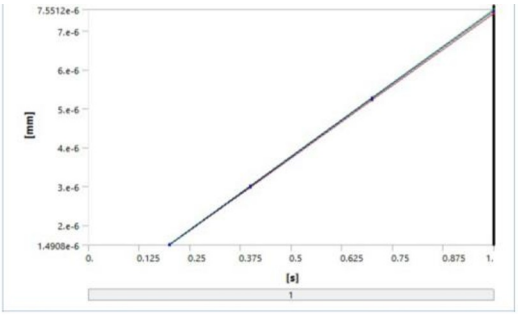

TABLE 20
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
0.2	1.4908e-006	1.5102e-006	1.5009e-006
0.4	2.9816e-006	3.0205e-006	3.0019e-006
0.7	5.2179e-006	5.2858e-006	5.2533e-006
1.	7.4541e-006	7.5512e-006	7.5047e-006

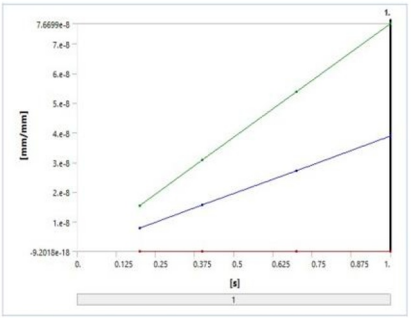

TABLE 28
Model (A4) > Static Structural (A5) > Solution (A6) > Normal Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
0.2	-9.2018e-018	1.534e-008	7.7674e-009
0.4	-6.08e-025	3.068e-008	1.5535e-008
0.7	-7.3117e-025	5.369e-008	2.7186e-008
1.	-6.4629e-025	7.6699e-008	3.8837e-008

Fig. 3. (a) Total Deformation; (b) Normal Elastic Strain

4 Conclusions

From the tests and results obtained from ANSYS, the maximum operating temperature of TARA wrist band is 50°C, which is suitable for the climatic conditions in India. The pin structure cavity is designed in such a way that it can take 200N on daily wear and tear conditions and can even function when deformed. This device is quite reasonable for ladies to hope to complete their everyday exercises without the apprehension about attack or misuse. This gadget can likewise be utilized for the assurance of youngsters. The essential point is to give a solid, cost-proficient gadget which utilizes the most recent innovation, and gives security to the client.

References

1. Shit, Subhas C., and Pathik Shah. "A review on silicone rubber." National academy science letters 36.4 (2013): 355-365.
2. Gonnelli, Cristina, and Giancarlo Renella. "Chromium and nickel." Heavy metals in soils: trace metals and metalloids in soils and their bioavailability (2013): 313-333.
3. Lula, Remus A. "Stainless steel." (1985): 1986-12-23

4. Mark, James E., Burak Erman, and Mike Roland, eds. The science and technology of rubber. Academic press, 2013.
5. Parikh, Dhruvil, et al. "IoT based Wearable Safety Device for Women." Int. J. Eng. Res. 9.05 (2020): 1086-1089.
6. Paradkar, Abhijit, and Deepak Sharma. "All in one intelligent safety system for women's security." International journal of computer applications 130.11 (2015): 33-40.
7. Chougula, Basavaraj, et al. ``Smart girls security system." International Journal of Application or Innovation in Engineering & Management 3.4 (2014): ISSN 2319 - 4847
8. Chennakesava, P., and Y. Shivraj Narayan. "Fused deposition modeling-insights." Proceedings of the international conference on advances in design and manufacturing ICAD&M. Vol. 14. 2014.
9. Islam, Muhammad Nazrul, et al. "Safeband: A wearable device for the safety of women in bangladesh." Proceedings of the 16th International Conference on Advances in Mobile Computing and Multimedia. 2018
10. Zhou, Lu-Yu, Jianzhong Fu, and Yong He. "A review of 3D printing technologies for soft polymer materials." Advanced Functional Materials 30.28 (2020): 2000187.
11. Lee, Huei-Huang. Finite Element Simulations with ANSYS Workbench 2022: Theory, Applications, Case Studies. SDC publications, 2022.
12. Prakash, N., et al. "GSM-based design and implementation of women safety devices using Internet of Things." Intelligence in Big Data Technologies—Beyond the Hype. Springer, Singapore, 2021. 169-176.
13. Bhardwaj, Nishant, and Nitish Aggarwal. "Design and development of “Suraksha”-a women safety device." International Journal of Information & Computational Technology 4.8 (2014): 787-792.
14. Monisha, D. G., et al. "Women safety device and application-FEMME." Indian Journal of Science and Technology 9.10 (2016): 1-6.
15. Puneet Kumar and Mahadev Satyanarayanan. Flexible and safe resolution of file conflicts. In Proceedings of the USENIX Technical Conference, pages 95–106. USENIX, January 1995.
16. Jensen, Gary F., and Maryaltani Karpos. "Managing rape: Exploratory research on the behavior of rape statistics." Criminology 31.3 (1993): 363-385.
17. Von Hofer, H. (2000). Crime statistics as constructs: The case of Swedish rape statistics. Eur. J. on Crim. Pol'y & Rsch., 8, 77.
18. Gager, Nancy, and Cathleen Schurr. Sexual assault: Confronting rape in America. New York: Grosset & Dunlap, 1976.
19. Stolarski, Tadeusz, Yuji Nakasone, and Shigeka Yoshimoto. Engineering analysis with ANSYS software. Butterworth-Heinemann, 2018: https://doi.org/10.1016/C2016-0-01966-6.
20. Raafat, Eyad, et al. "Fatigue and thermal stress analysis of submerged steel pipes using ANSYS software." Ocean Engineering 193 (2019): 106574.