DESIGN AND STRUCTURAL LOAD ANALYSIS OF FTA FR-ABS BATTERY HANDLE

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Abstract: *In this work, a battery handle is designed and modified on the bases of existing model for a battery capacity of 12V-100Ah. The existing model is made-up of PPCP (polypropylene co-polymer) is made to analysis under load of 350 N and 700 N to identify the loop holes. Later based on the analysis data a 3D model is created by changing of material from PPCP to FR-ABS. Size optimization method is selected for making a better and safe design for working conditions.*

Key Words: Battery handle, FR-ABS material, 3D modelling, Size optimization method, Analysis.

1. INTRODUCTION

A battery handle, which is a device used to hold batteries securely in place and facilitate their installation and removal from electronic devices or equipment. The primary function of a battery handle is to provide a convenient way to insert and remove batteries from a device, making it easier for users to replace depleted batteries and ensuring reliable power supply. Additionally, battery handles may also offer ergonomic benefits, making it more comfortable for users to hold and operate devices that use batteries.

2. LITERATURE REVIEW

1) Carmen M. et al. provide a comprehensive review of polymers in additive manufacturing (AM) and 4D printing, emphasizing their role in fabricating complex objects with customized geometries, particularly in biomedical applications. They discuss the basic principles, advantages, and limitations of polymer AM technologies, as well as the development of materials and methodologies for 4D printed structures capable of changing over time.

2) Fariba et al. explore modifications and research potentials of acrylonitrile/butadiene/styrene (ABS) membranes, focusing on their application in 3D printing technology. They investigate the influence of selected fillers on the properties of ABS-based polymer composites, particularly in terms of rheological, mechanical, and physicochemical characteristics, aiming to enhance their performance for additive manufacturing.

3) Qian Zhang et al. conduct an investigation into particle emissions and aerosol dynamics from consumer fused deposition modeling (FDM) 3D printers. They propose a dynamic model to better understand particle formation mechanisms, emphasizing the impact of printer extruder temperature and filament material on particle emissions, with implications for environmental and health considerations.

4) Kaushik Kumar et al. undertake a comparative study of the mechanical and tribological behavior of thermoplastic-based composites, particularly focusing on ABS polymer matrix filled with micron-sized inorganic and natural/green fillers. Their research aims to elucidate the performance differences between composites with different filler compositions, providing insights for optimizing composite materials for various applications.

5) Tai Gyun Kim et al. discuss the hydrometallurgical recycling of surface-coated metals from automobile-discarded ABS plastic waste. They review the properties and applications of polymer nanocomposites, emphasizing their mechanical performance improvements through the incorporation of nanosized particles or fillers into the polymer matrix, with implications for sustainable waste management and material utilization.

6) Minji Jun et al. focus on the extraction of surface-coated metals from waste acrylonitrile butadiene styrene (ABS) plastics using an ammoniacal solution. They investigate the flotation separation of polycarbonate (PC) and ABS waste plastics combined with ammonia pretreatment, aiming to efficiently separate and recover pure PC and ABS plastics from mixed waste streams for recycling purposes.

7) Marzieh Hosseinabadi et al. study the morphological and rheological behavior of acrylonitrile-butadiene-styrene

(ABS)/thermoplastic polyurethane (TPU) blends for fused deposition modeling (FDM) printing. They optimize blend compositions and printing parameters to achieve 3D-printed objects with improved surface structure and minimized warpage, highlighting the potential of ABS/TPU blends for additive manufacturing applications.

8) B Hermawan et al. investigate the effect of oil palm empty fruit bunches (OPEFB) fibers on recycled acrylonitrile butadiene styrene (ABS) polymer matrix. They analyze the molecular and mechanical properties of ABS composites reinforced with OPEFB fibers of different sizes, aiming to understand the influence of fiber size on the material's capability to withstand external deformation, with implications for the development of sustainable and environmentally friendly composite materials.

3. METHODOLOGY

To thoroughly analyse an existing model, identify loopholes, optimize its size, and create a 3D model with FR-ABS material, a systematic approach is essential. First, the existing model undergoes detailed scrutiny using CAD software and simulations to assess its geometry, material properties, and structural integrity. Loopholes and weaknesses are pinpointed, considering factors like thermal stress and max stress. With the optimized design in place, a new 3D model is crafted using FR-ABS material, ensuring compliance with required specifications and performance criteria. Simulations validate the new model's performance, comparing it to the original design to gauge improvements. Any remaining issues are addressed through further iteration, resulting in an enhanced model ready for prototyping or production, demonstrating the efficacy of the systematic approach in refining and improving existing models.

4. Existing model

The design of the handle is to be made in such a way that it should fit inside the cover of the battery without any extra projection or space. The rest position of the handle is to be inside the cover of the battery such that it is to be transported easily without occupying extra space and it should be fit correctly in according to the container.

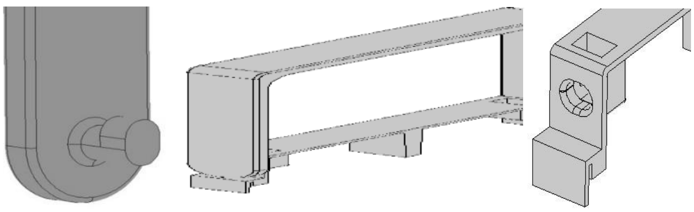

Fig: Battery handle design

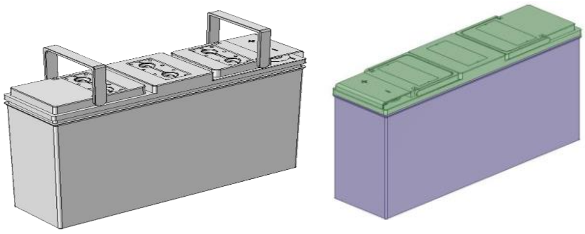

Fig: Assembled battery

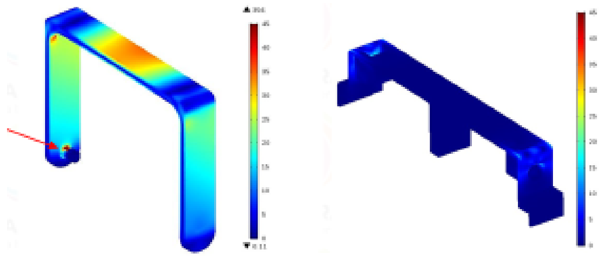

Fig Case(1a): Current design for 350 N

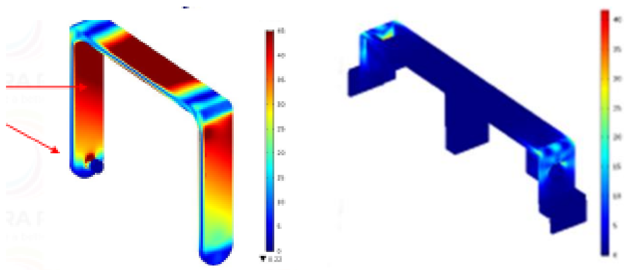

Fig Case(1b): Current design for 700 N

- Load on each handle 350N, cover bottom displacement constrained
- Von Moises stress 356MPa
- In the above image the handle is bearing to its break point

Table 1: critical segment of existing design

Case	Load (N)	Handle Thickness (mm)	Handle Width (mm)	Pin Dia (mm)	Pin Length (mm)	Pin Max Von mises stress (MPa)	Handle Max Von mises Stress (MPa)
1(a)	350	5	17.5	5	5	356	125

- Load on each handle 700N, cover bottom displacement constrained
- Von Moises stress 711MPa
- In the below image the handle is bearing to its break point

Table 2: critical segment of existing design

Case	Load (N)	Handle Thickness (mm)	Handle Width (mm)	Pin Dia (mm)	Pin Length (mm)	Pin Max Von mises stress (MPa)	Handle Max Von mises Stress (MPa)
1(b)	700	5	17.5	5	3	711	200

5.1 PROBLEM IDENTIFICATION

In the above case the handle of the battery is about to break due to the load of the battery. Need some changes to handle to with stand to the load of the battery. We can observe in the above image that the max stress in the handle has been exceeded to the break point.

5.2 DESIGN MODIFICATION

The new design demission are modifications of existing design. For new design a new material FR-ABS is used for the increase of stiffness and strength of the material. In design 1 pin length is increased to 10 mm. In design 2 the complete handle thickness and width is increased to 7 mm and 21mm respectively and pin diameter is increased to 9 mm for designing with the high factor of safety.

Table 3: modified design measurement

Case	Handle Thickness (mm)	Handle Width (mm)	Pin Dia (mm)	Pin Length (mm)
Design 1	5	17.5	5	10
Design 2	7	21	9	10

5.3 MATERIAL PORPERTY

FR-ABS, or Flame-Retardant Acrylonitrile Butadiene Styrene, is a thermoplastic material known for its blend of properties suitable for diverse applications. Its primary feature is its flame retardancy, making it resistant to combustion and limiting the spread of flames, which is crucial for applications requiring fire safety.

Additionally, FR-ABS exhibits good mechanical strength, including high impact resistance and toughness, ensuring durability against impacts and stresses. It also offers moderate heat resistance and dimensional stability over a range of temperatures, along with resistance to various chemicals, oils, and solvents, enhancing its versatility in different environments.

Furthermore, it provides good electrical insulation properties, contributing to its use in applications requiring electrical safety.

6. RESULT AND DISSCUSSION

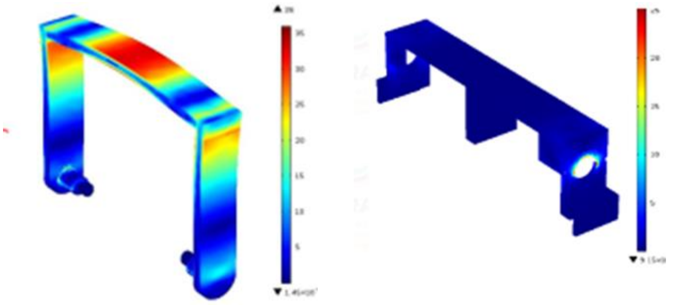

Fig Case(2a): Design 1 for 350 N

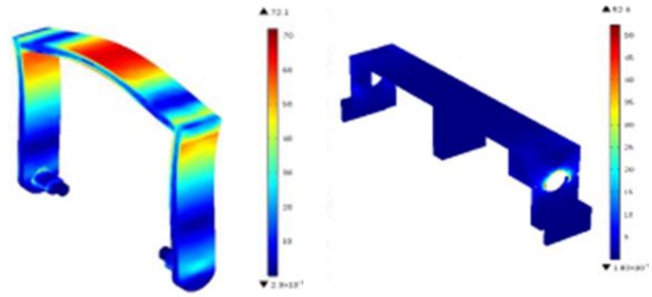

Fig Case(2b): Design 1 for 700 N

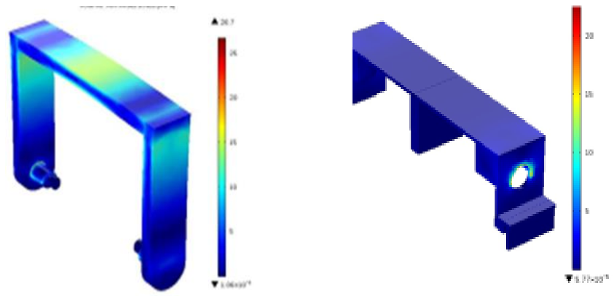

Fig Case(3a): Design 2 for 350 N

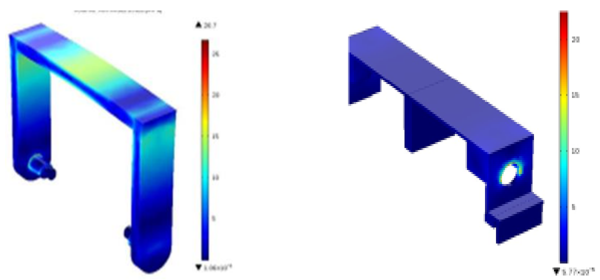

Fig Case(3b): Design 2 for 700 N

Table 4: Summary of All Results

Case	Load (N)	Handle Thickness (mm)	Handle width (mm)	Pin Día (mm)	Pin Length (mm)	Pin Max Stress (MPa)	Handle Max Stress (MPa)
1a	350	5	17.5	5	3	356	125
1b	700	5	17.5	5	3	711	200
2a	350	5	17.5	9	10	25	36
2b	700	5	17.5	9	10	35	72.1
3a	350	7	21	9	10	17.5	26.7
3b	700	7	21	9	10	22	53.5

From the above analysis modules, it is clearly evident that case 3 has more advantages in terms of strength, ability to withstand load rather than the above 2 cases and it is safer while carrying the battery.

7. CONCULSION

The current model, composed of PPCP material, undergoes analysis subjected to loads of 350 N and 700 N for loophole identification. However, PPCP exhibits inadequate properties. In the redesigned iteration, FRABS plastic replaces PPCP, mitigating identified weaknesses. FRABS offers superior properties relative to PPCP. Furthermore, the redesign includes modifications to the handle and pin dimensions, which likely enhance the overall structural integrity and functionality of the product. These adjustments are crucial for ensuring optimal performance under diverse operating conditions. Overall, the transition to FRABS plastic, coupled with adjustments to the handle and pin dimensions, represents a comprehensive approach to enhancing the design's reliability and longevity.

8. FUTURE SCOPE

1) Dimensions can be changed according to load of the battery
2) There will be a chance to use another plastic to prepare handles

9. REFERNCE

1) Carmen M. González-Henríquez, Mauricio A. Sarabia-Vallejos and Juan Rodriguez-Hernandez, Polymers for additive manufacturing and 4D-printing: materials, methodologies, and biomedical applications, Progress in Polymer Science, 10.1016/j.progpolymsci.2019.03.001, (2019).

2) Fariba Sadat Kamelian, Ehsan Saljoughi, ParizadShojaeeNasirabadi and Seyed Mahmoud Mousavi, Modifications and research potentials of acrylonitrile/butadiene/styrene (ABS) membranes: A review, Polymer Composites, 39, 8, (2835-2846), (2017).

3) Qian Zhang, Girish Sharma, Jenny P. S. Wong, Aika Y. Davis, Marilyn S. Black, Pratim Biswas and Rodney J. Weber, investigating particle emissions and aerosol dynamics from a consumer fused deposition modeling 3D printer with a lognormal moment aerosol model, Aerosol Science and Technology, 10.1080/02786826.2018.1464115, 52, 10, (1099-1111), (2018).

4) Kaushik Kumar and J. Paulo Davim, Comparative Study of Mechanical and Tribological Behaviour of Thermoplast-Based Composites, Emergent Research on Polymeric and Composite Materials, 10.4018/978-1-5225-3023-7.ch003, (78-98)

5) Tai Gyun Kim, Rajiv R. Srivastava, Minji Jun, Min-seuk Kim and Jae-chun Lee, Hydrometallurgical recycling of surface-coated metals from automobile-discarded ABS plastic waste, Waste Management, 10.1016/j.wasman.2018.09.037, 80, (414-422), (2018).

6) Minji Jun, Tae Gyun Kim, Jae-chun Lee, Rajiv R. Srivastava and Min-seuk Kim, Extraction of the Surface-Coated Metals from Waste Acrylonitrile Butadiene Styrene Plastics in an Ammoniacal Solution, Extraction 2018, 10.1007/978-3-319-95022-8_144, (1743-1751), (2018).

7) Marzieh Hosseinabadi, Milad Ghetmiri, Alireza ShojaeiDindarloo and Yousef Jahani, Polyacetal/Acrylonitrile-Butadiene-Styrene/Thermoplastic Polyurethane Blends and Their Nanocomposites Morphological and Rheological Behavior as a Tertiary Blend, Polymer Science, Series A, 10.1134/S0965545X18070039, 60, 6, (816-827), (2019).

8) B Hermawan, S Nikmatin, Sudaryanto, H Alatas and S G Sukaryo, Effect of oil palm empty fruit bunches fibers reinforced polymer recycled, IOP Conference Series: Materials Science and Engineering.

9) Qian Zhang, Jenny P. S. Wong, Aika Y. Davis, Marilyn S. Black and Rodney J. Weber, Characterization of particle emissions from consumer fused deposition modeling 3D printers, Aerosol Science and Technology, 51, 11, (1275), (2017).

10) Szymon Wojtyła, Piotr Klama and Tomasz Baran, Is 3D printing safe? Analysis of the thermal treatment of thermoplastics: ABS, PLA, PET, and nylon, Journal of Occupational and Environmental Hygiene, 14, 6, (D80), (2017).

11) Chee Kai Chua, Chee How Wong and Wai Yee Yeong, Benchmarking for Additive Manufacturing, Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing, 10.1016/B978-0-12-813489-4.00008-8, (181-212), (2017).

12) NguyenThi Thanh Truc and Byeong-Kyu Lee, Selective separation of ABS/PC containing BFRs from ABSs mixture of WEEE by developing hydrophilicity with ZnO coating under microwave treatment, Journal of Hazardous Materials, 329, (84), (2017).