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Design and Manufacturing of Smart Stand using 3D Printer

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ABSTRACT

This paper presents the design and development of a multipurpose smart stand using 3D printing technology. The smart stand is designed in an ergonomic way to handle daily requirements with smart features such as the display of a digital to-do list, hourly reminders for drinking water, and the monitoring of room temperature. The proposed work includes 3D modeling, material selection, and 3D printing with PLA materials along with basic electronics for automation. The designed prototype showcases an efficient combination of mechanical design and smart capabilities, serving as a useful and user-friendly solution for work environments. The proposed design showcases the capabilities of additive manufacturing for designing customized, functional, and innovative.

Keywords: - Products. Smart Stand, 3D Printing, Additive Manufacturing, Smart Reminder, Product Design

1. INTRODUCTION

The ever-increasing development of digital technology and portable electronics has brought about a dramatic change in contemporary work environments and learning spaces. The devices include smartphones, tablets, and microcontrollers. These devices have become indispensable tools for communication, productivity, and learning. Thus, there is a growing need for ergonomic, compact, and multifunctional desktop accessories that can safely hold these devices and enhance user comfort and productivity. The conventional device stand available in the market may have limited functionality, such as fixed-angle support, and may not be amenable to different usage scenarios. Furthermore, the commercially available device stands may not offer adequate structural integrity and flexibility to accommodate smart electronic components such as display, sensors, or embedded controllers

This is an obvious opportunity for the development of a smart stand that can be customized according to the needs of the user. Additive Manufacturing (AM), also known as Fused Deposition Modelling (FDM), has been identified as an effective manufacturing method for rapid prototyping and small-batch production of complex shapes. FDM enables designers to create light, cost-effective, and shape-optimized parts with reduced material usage. The use of Polylactic Acid (PLA) and similar materials has made AM more feasible due to ease of use, accuracy, and eco-friendliness.

The proposed work involves the design and development of a smart stand using FDM 3D printing technology. The primary objective of the proposed work is to design a mechanically stable and ergonomically adjustable structure that can be used to hold electronic devices and serve as a base for the integration of smart features in the future. The proposed work primarily involves the design optimization process, material selection, optimization of manufacturing parameters, and accuracy and load tests.

2.LITERATURE REVIEW

1) Jovanov, emil. (2016)

"SmartStuff: A Case Study of a Smart Water Bottle" – IEEE EMBC 2016

The research paper talks about the development of a smart water bottle named Smart Stuff. The smart water bottle contains sensors that track the consumption of water by the user. The smart water bottle is connected to a mobile application using wireless communication (Bluetooth). The smart water bottle tracks the daily water intake routine of the user and provides notifications to the user to improve the water intake routine. The primary objective of the research paper is to encourage healthy water intake practices using wearable technology and IoT.

2) Sun et al. (2018)

Design of Smart Mirror Based on Raspberry Pi – IEEE ICITBS 2018

The proposed paper involves the design of a smart mirror using Raspberry Pi. The smart mirror has the capability to display information such as time, weather, news, and traffic updates, in addition to functioning as a normal mirror. The proposed system will utilize a display screen, Raspberry Pi processor, and internet connectivity. The primary objective of the proposed paper is to provide valuable information in real-time in a smart environment.

3. METHODS AND MATERIAL

3.1 Design Methodology

The design and development of the smart stand were done using a systematic and interdisciplinary design approach to satisfy the needs of structural stability, ergonomic adjustability, manufacturability by additive manufacturing, and the integration of smart electronics. The design process started with conceptual designs that were developed based on functional requirements such as load support, adjustability for viewing, compactness, and the inclusion of smart electronics. The conceptual design was further developed into a detailed three-dimensional CAD design using the SolidWorks software. The design ensured that the integration of the electronic components such as the Raspberry Pi controller, sensors, and touch screen was done without affecting the mechanical strength of the structure. The internal space and provision for mounting was also designed to include the electronic components. The smart aspect of the stand seeks to integrate the functionality of the touch screen display to make it easier to interact and display information. The reminder function is also incorporated through software control, which sends notifications at predetermined intervals (every one hour) to remind the user to take water or short breaks, thus improving working habits. The temperature sensor is also incorporated to measure and display the room temperature in real time, thus improving the functionality of the stand as a smart desk accessory.Provision is also made for the development of a mobile application interface that will enable wireless communication with the stand. The interface will enable the user to set reminder intervals, displayIn addition to the integration of functional capabilities, the optimization of print time and durability was also an important design consideration. Geometries of the components were optimized to minimize material usage, eliminate unnecessary solid components, and provide uniform load distribution. Wall thickness, internal volumes, and fillets were also designed to optimize strength while reducing print time and material usage. The mechanical design was intended to withstand a minimum eccentric load of 1 kg with stability at various viewing angles from 0° to 90°. A hinged arm mechanism was also added to facilitate smooth angular movement and fixation through friction created by a mechanical fastener. The design limitations imposed by FDM printing, such as overhang angles, wall thickness, and interlayer adhesion, were taken into account during the modelling process.

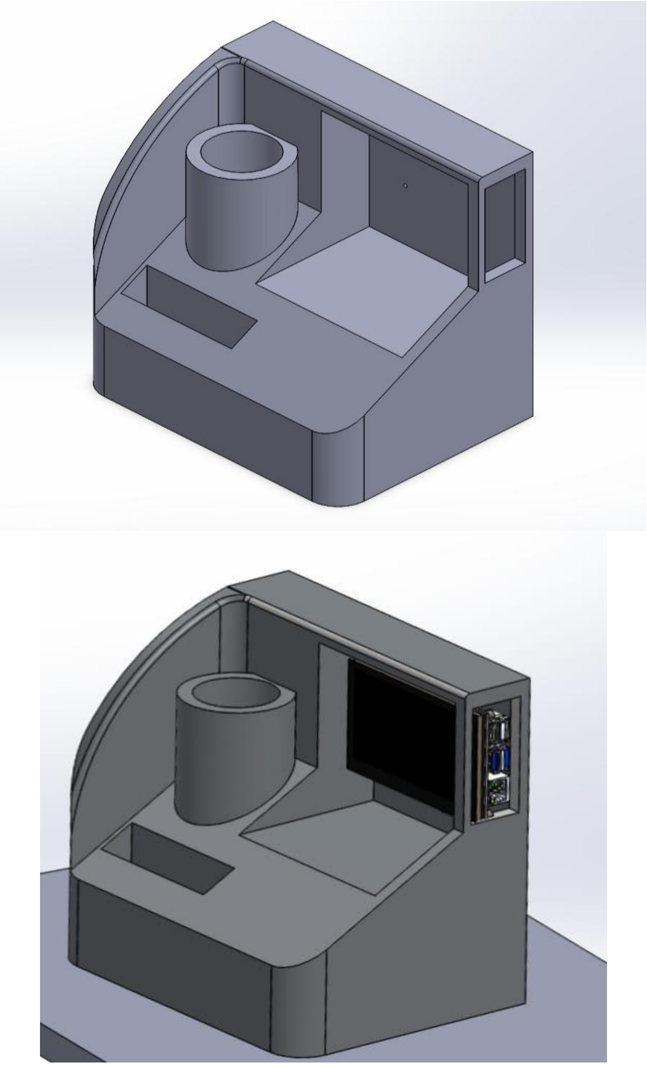


Fig actual component .

3.2 CAD Modelling and Structural Design

The CAD model of the smart stand was designed as a modular assembly with three main components: a base plate, a support arm, and a device mounting plate. The justification for the use of the modular design approach for the smart stand was to make the manufacturing process simpler and avoid complex support structures. The base plate was designed with a large footprint to provide overall stability and have internal cavities for the housing of electronic components like Raspberry Pi, a power bank, and sensors. The support arm was the main load-bearing part and was designed with internal channels for cable organization, providing a safe path for the wiring of electronic modules. The device mounting plate had anti-slip grooves and a recess to provide for the integration of a touch screen or charging module.

Fillets and chamfers were included on all edges to enhance the ergonomics and aesthetics of the design. The dimensional tolerances of approximately 0.2 mm were included in the critical mating components to provide for material shrinkage and size variations typical of FDM printed parts

3.3 Material Selection

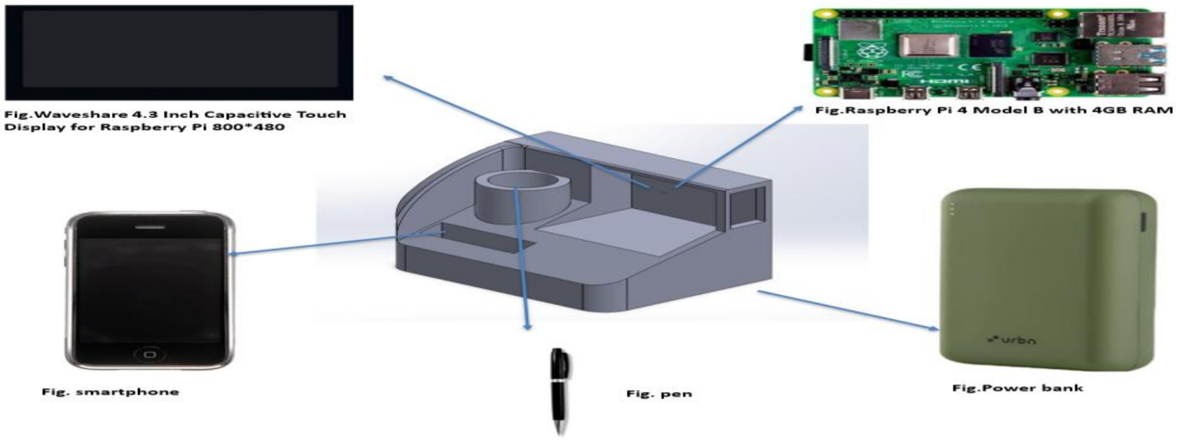
Material selection was an important aspect in the achievement of the desired mechanical properties, size accuracy, and surface finish. The materials short-listed for the fabrication process included Polylactic Acid (PLA), Acrylonitrile Butadiene Styrene (ABS), and Polyethylene Terephthalate Glycol (PETG). PLA was chosen as the material of choice owing to its superior printability, low warping, high dimensional accuracy, and adequate stiffness for the applied loads. Even though ABS and PETG have superior heat resistance and impact resistance properties, their high printability complexity, warping, and requirement for proper printing conditions during the fabrication process made them less desirable for rapid prototyping.

3.4 3D Printing Process Parameters

The components of the smart stand were designed using the Fused Deposition Modeling method on a desktop 3D printer with a nozzle size of 0.4mm. The CAD files were stored in STL format and sliced into machine code. The layer thickness of 0.2mm was selected to offer the best possible compromise between surface finish, strength of the component, and printing speed. The infill patterns for the components were designed to maximize the strength of the internal components with the least amount of material and printing time. The positioning of the components on the build plate was determined to maximize interlayer adhesion in the high load paths and minimize the use of support structures, thus maximizing component strength and printing speed

3.5 Post-Processing and Assembly

The post-processing techniques included the strategic removal of support material, minimal surface sanding to improve the surface finish, and reaming of hinge holes to enable precise engagement of fastening components. The individual components were assembled with a mechanical fastener to develop a friction hinge system, which enables smooth angular movement and precise engagement of loads.The design and fabrication strategy employed ensured the successful development of a functional mechanical prototype that is strong, aesthetically pleasing, and ready for testing and subsequent integration of smart electronic components.



4. RESULTS AND DISCUSSION

A. Dimensional Accuracy and Manufacturing Quality

Dimensional accuracy is a key aspect to verify the viability of FDM-based additive manufacturing. After the manufacturing process, the critical dimensions of the smart stand components were measured using a digital vernier calliper and verified with respect to the corresponding values in the CAD model.

The variation in the manufactured parts was found to be an average of 0.35 mm, which is well within the acceptable tolerance levels for PLA FDM manufacturing. The important interfacing details such as hinge hole locations, mating surfaces, electronic cavities, and mounting slots were found to be correct, which helped in the smooth assembly of the parts without the need for heavy machining. The small variations observed in some regions were mainly due to the thermal shrinkage of PLA and layer deposition in FDM.

B. Structural Performance and Load Testing

In an attempt to determine the mechanical strength of the smart stand, a static loading test was performed under the worst possible conditions. The stand was placed at its maximum extension angle of 90°, and the gradually increasing load was applied to the device mounting plate

The stand was capable of supporting a weight of 1.5 kg for an extended period of one hour without any signs of deformation, breakage, or slippage of the hinges. This is 50% above the original design specification of 1 kg, thus ensuring a sufficient factor of safety. The friction hinge system performed well in supporting the required angle, thus ensuring that the mechanical design is sufficient.

C. Print Optimization and Surface Finish

The structure was able to withstand a weight of 1.5 kg for a period of one hour without any deformation, breakage, or slippage of the hinges. This is well above the original design specification of 1 kg by 50%, thus ensuring a factor of safety. The friction hinge system was able to sustain the required angle, thus ensuring that the mechanical design is sufficient.

D. Smart Feature Integration and Functional Discussion

The results have confirmed that the application of PLA in the FDM-based additive manufacturing process is a feasible and economical approach for designing smart stand structures that are mechanically strong and adaptable. The precision of the structure, the carrying capacity of the structure, and the incorporation of the electronic facilities have been successfully validated. Though some minor printing defects were observed, they can be overcome in future developments.

5. CONCLUSION

This paper has dealt with the design, development, and testing of a smart stand designed using Fused Deposition Modelling (FDM) based 3D printing technology. The main aim was to create a mechanically stable and ergonomically adjustable design that can support electronic devices and help to integrate smart functionality.

The prototype design has been able to provide a good level of accuracy with an average deviation of 0.35 mm and has been able to withstand a static load of 1.5 kg, which is 50% higher than the design requirement. This clearly indicates that the design is mechanically stable and the friction hinge mechanism is working properly.

The CAD design assisted in efficient manufacturing, and the design was compatible with electronic components like Raspberry Pi, touch screen, temperature sensor, and reminder system. The printing settings assisted in printing with less material, and the surface finish was acceptable with improved durability.

The relevance of the research work is the application of additive manufacturing in rapid prototyping and designing intelligent desk accessories. Future studies will include the integration of the electronic system, design of a mobile app, advanced sensors, and designs for mass production with new materials and improved thermal resistance

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