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Design and Analysis of 3D Printed Vent Splitter Using Pla Anti-Bacterial Material by FDM Machine

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Abstract

The manufacturing process is an important phase and it's become the major concern in manufacturing industries. Many industries use the traditional manufacturing process for product development which is time-consuming, expensive and it requires skilled labor which in turn leads to a huge investment for the development of a product. These are the problems that originate due to the use of the current conventional methods. So, keeping all these inobservances, additive manufacturing (3D Printing) Process is utilized to print the vent splitter which is useful in medical applications and helpful in pandemic situations 3D printed Vent splitter is prototyped in a fused deposition modeling machine. This FDM technology is widely used in the Additive manufacturing industry. The two-way vent splitter is printed by using Polylactic Acid (PLA) material. A normal splitter can use only once for a single patient. To overcome this, a vent splitter was designed to use up to 4 times simultaneously for two patients. Numerical analysis can perform a PLA material prototype to predict the behavior of the specimen. During epidemics or pandemics affecting the respiratory systems, hospital equipment such as ventilators may become insufficient and different solutions can be considered. In fast-spreading respiratory illnesses such as COVID-19 due to the rapidly increasing number of patients, ventilator machine insufficiencies may appear. It may be considered to use one hospital ventilator for more than one patient by dividing the airway of the machine with a specially designed splitter. This study aimed to determine when the ventilator can be modified to provide ventilation of two or more patients simultaneously by using 3D-designed and manufactured splitters. A two-port and four-port splitter were designed in a computer program and manufactured by 3D printed. Two sets of splitters were used to adapt to the ventilator during the trial process: one for aspiratory and one for expiratory outputs. Two intensive care specialists voluntarily tried this study on themselves. It was concluded from the study that 3D designed and manufactured two-port splitter can be used to separate the way of a single ventilator to multiple patients within a very limited indication and time-interval.

Key Words: 3DPrinting, FDM, Printing Parameters, Numerical analysis, PLA.

1 Introduction

In the present scenario, as the number of patients in critical condition grows, mechanical ventilation is required to provide sufficient oxygen into the lungs and body. Ventilator machines are limited in supply, and hospitals can run out of machines faster than they can order new devices. Adding an adapter to one ventilation system to be used with more than one patient may help expand capacity. These adapters could allow for two, three, or four patients with similar needs and conditions to potentially use one ventilator. To [1] ventilate two patients on one ventilator, place one splitter on the inspiratory limb and one on the expiratory limb as shown. To ventilate four patients, you need a total of 6 splitters arranged such that each of the splitters in the "Two Patient" scenario has an additional splitter on each limb. Under normal protocols, these two numbers are the same. One ventilator device is dedicated to one patient. Now, it turns out that the ability to use a splitter shown in Fig. 1. to route the air pumping capacity of a ventilator to multiple patients [2,3]has been studied in lungs emulators, animal studies, and used in the field all successfully.

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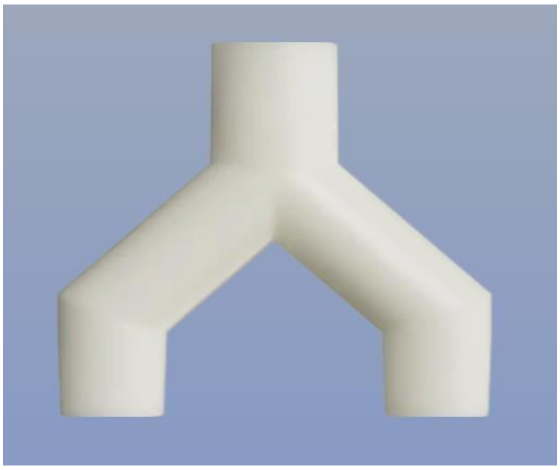

Fig. 1. Vent Splitter

The 3D printing method is widely investigated in processing thermoplastic i.e., PLA due to the good characteristics of strong operation, low cost, and no need for tooling or mold. The printing techniques of polymer materials mainly include the [4,5] Stereo Lithography Apparatus (SLA) and Fused Deposition Modeling (FDM). The fused deposition modeling with low costs of the printing device and thermoplastic materials is a better choice for industrial production. Various devices and parts have been printed by the FDM to investigate the mechanical strengths and anisotropic material properties of FDM manufactured parts. Carbon fiber powder reinforced composites with the microstructures and mechanical performances being tested. The continuous fiber-reinforced composites could be fabricated by 3D printing and the technique has the potential to become the next-generation composite fabrication methodology. The printed a sandwich structure with carbon fibers placed between lower and upper plastic plates and heated after 3D printing to bond the carbon fibers with the plastics. These printing methods mention above can manufacture continuous carbon-fiber-reinforced thermoplastic composites. However, the curved printing path can be printed, and the weak infiltration between fiber and resin reduced the performance [6,7] of printed composites. These techniques were still very much in their infancy, with many obstacles to be overcome before RM could be considered a realistic manufacturing method. The laser's heat fuses the particles at their boundaries. Once each layer is complete, more powder is scattered over it and the process is repeated until a complete artifact is produced. the accuracy can be enhanced, especially on rounded or tubular designs, which also benefits from reduced processing time before the build process starts. the [8,9] reinforced specimens fabricated from vacuum casting exhibit improved mechanical properties implemented successfully and tested, where typical measured build time was reduced by approximately 50% without reducing overall surface accuracy. This is required to enable 'Design for Rapid Manufacture'. The most comprehensive analysis to date of three new materials aimed for end-use part manufacture at differing ages [10,11] humidifies, and temperatures are presented. Plywood has been used in engine mountings keeping in mind the strength. Balsa wood has been used in the fabrication of fixed tail fins and elevens since these are light and easy to fabricate. The thermosetting resins readily impregnate fibers and help in the [12,13] manufacturing of complex-shaped parts. Epoxies are the most common thermosets used in the application of UAVs. Based on compression testing, the proposed inflatable wing design will combine the advantages of compliant [14,15] mechanisms and deployable structures to maximize the flexibilities of movement in UAV design and development. [16,17] The elastic properties were evaluated over several weeks of accelerated artificial aging. The stiffness degradation of the samples subjected to [17,18] aforementioned aging protocols is statistically described by a nonlinear multi-factorial model inspired by the Design of Experiments (DoE) theory.

1.1 STL File

The standard file format for rapid-prototyping is called STL (Standard Triangulation Language), where the shape of the object is defined by a mesh of tiny triangles laid over the surface. The triangles must meet up exactly with each other, without gaps or overlaps, if the object is to be built successfully. The "slice files" which are used to build each layer are calculated from the STL file, and if there are any gaps between the triangles, then the edges of the slices are not properly defined.STL is a standard output format from most CAD (computeraided design) software, and the number of triangles used can be user-defined. Commonly the translation from the modeling format to STL leaves a few flaws, and so the integrity of STL files is usually checked using special software before the files are used to build an object. Small errors can be corrected automatically, but big faults or ambiguities may need "repairing" by an engineer. Fig. 2 shows a sliced model using STL. When creating an STL file from CAD, the resolution (also known as Tolerance, Chord Height, or Facet Deviation) can be specified. Under-facetedSTLfileswillaffecttheaccuracy and may affect the appearance of the part. Over-faceted STL files will increase the time it takes to prepare the part, without improving the quality. There is there for an optimum resolution for the STL file to give the best accuracy in the smallest file. Their solution is best set between 0.01 mm and 0.05 mm and the overall binary file size should not normally be more than 5M bytes.

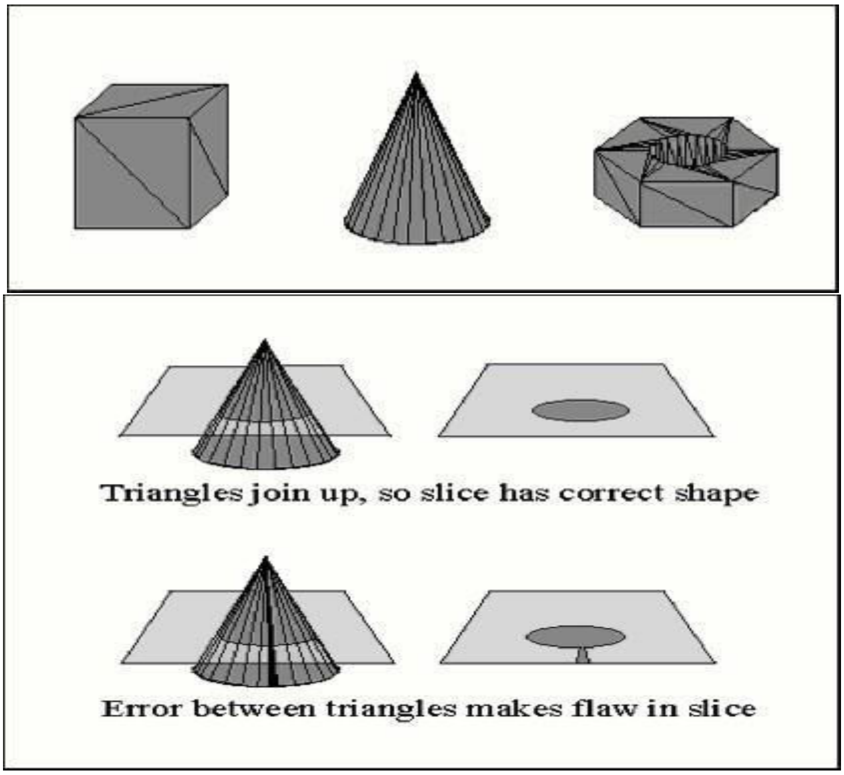

Fig. 2. A sliced model using STL

Improvements in rapid prototyping technology allow very accurate slice thicknesses, as low as 50microns, to be achieved. As layers are finite thickness, small degrees of errors can be tolerated within the Z-axis. The final build process requires the merging of multiple STL files to produce the final build file and the building of the component can begin.

1.2 Specific shortcomings

In FDM processing, Layered Manufacturing (LM) technology, which uses STL format files as its input data, is employed where a part is built by stacking multiple flat layers of materials. LM technology not only brings advantages to the FDM process but also unavoidable shortcomings. The “Stair-step” effect is the main shortcoming of all the RP processes, particularly in FDM. It is caused by the LM technology using horizontal flat layers and the part orientation during the deposition. The faceted STL model is sliced with certain horizontal planes, and the contour of each layer is generated. The RP machine tool, no matter whether they use a laser or a deposition head, traces the slicing pattern and builds the physical part in thin layers, which exhibit a stair-step effect, as shown in Fig. 3, and such effect becomes more obvious on curved surfaces and particularly when using the thicker layers.

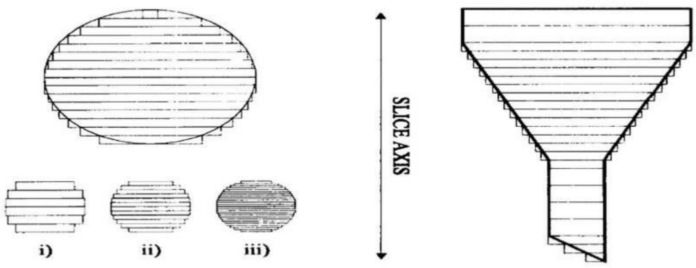

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Fig. 3. Stair-Step effect phenomenon

Too many layers and high time consumption to process are other shortcomings of FDM. More accuracy and higher resolution are always one of the important requirements of the RP part. To achieve the required accuracy and resolution, more layers are needed. To build the part more accurately, the number of layers needs to be increased, whereas the thickness is reduced as shown in Fig 4. However, this solution also increases the part build time, often to an unacceptable level.

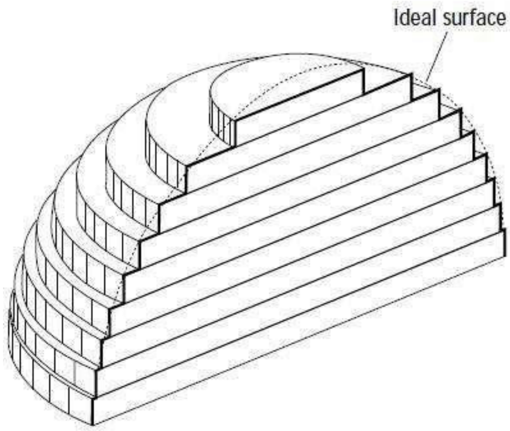

Fig. 4. Thin build Layers better complex surface

The anisotropy property of the final part also is a shortcoming of FDM. The strength of FDM parts suffers from anisotropy and adhesive strength between layers or across filaments is weaker than the strength of continuous filaments. The air gap and raster orientation affect the tensile strength of FDM parts dramatically. In some particular cases, for example, the thin shell components, the discontinuing filament deteriorates the anisotropy phenomenon, which causes part failure as shown Fig. 5.

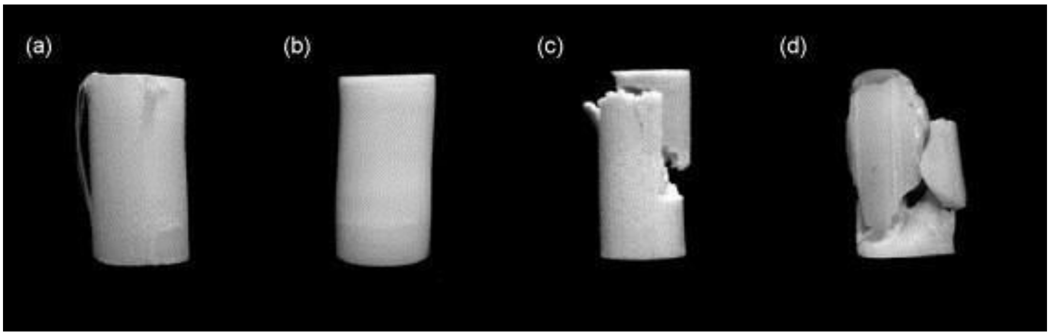

Fig. 5. Failure modes of the specimens: (a) FDM-axial (b) FDM-transverse (c) 3D printer-axial (d) NCDS-axial

These are some of the drawbacks that typical FDM parts suffer from. There has been researching effort in different directions, attempting improvements in materials as well as deposition techniques. The strength of the fused deposition modeling process lies in its ability to reproduce parts with close tolerance and higher

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resolutions. However the properties of the rapid prototypes tend to degrade with time, so, therefore, electroplating these prototypes eliminates the adverse effects of water absorption, exposure to UV lights on the prototypes.

2 Designs for 3D Printing

The first step in generating an FDM part is to create a three-dimensional solid model. This can be accomplished in many of the commonly available CAD packages. The model is then exported to the slicer software via the stereolithography (STL) format. This format reduces the part to a set of triangles by tessellating it. The advantage of the STL format is that most CAD systems support it, and it simplifies the part geometry by reducing it to its most basic components. These sections represent the two-dimensional contours that the FDM process will generate which, when stacked upon one another, will closely resemble the original three-dimensional part. This sectioning approach is common to all currently available RP processes. Obviously, the thinner the sections, the more accurate the part. The software then uses this information to generate the process plan that controls the FDM machine's hardware shown in Fig. 6.

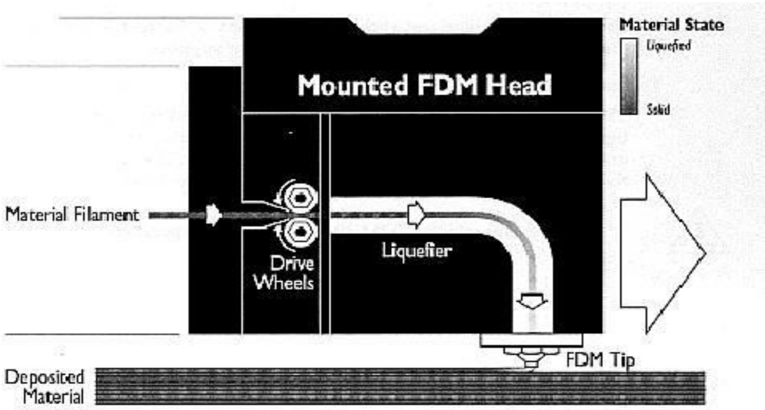

Fig. 6. FDM Machine Hardware

Be sure to calibrate the 3D printer before using it, it is essential to ensure that the part sticks properly to the build plate. If it does not, at some point the part may come loose and ruin the entire print job. Some thought should be given to the orientation of the part since some printers are more precise on the X and Y axes than the Z-axis.

3 Results and Discussions

3.1 Static Temperature

The static temperature flows are shown in Fig. 7. Shows the condition according to the above contour plot, the maximum temperature at inlet and outlet of the boundaries, because the applying the boundary conditions at the inlet of the vent splitter and minimum temperature at inside the vent splitter. According to the above contour plot, the maximum temperature is 3.000e+002 and the minimum temperature is 3.000e+002. The temperature is constant.

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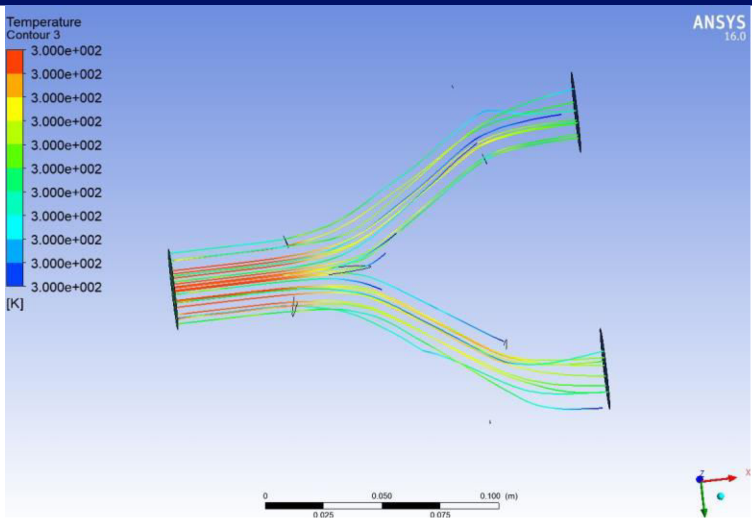

Fig. 7. The flow of Temperature Measurement

3.2 Velocity

The velocity temperature shows in Fig. 8. Gives the best results according to the below contour plot, the maximum velocity magnitude of the at inlet and outlet of the boundaries, because the applying the boundary conditions at the inlet of the vent splitter and minimum velocity magnitude at inside the vent splitter. According to the above contour plot, the maximum velocity is 2.121e+001m/s and the minimum velocity is zero.

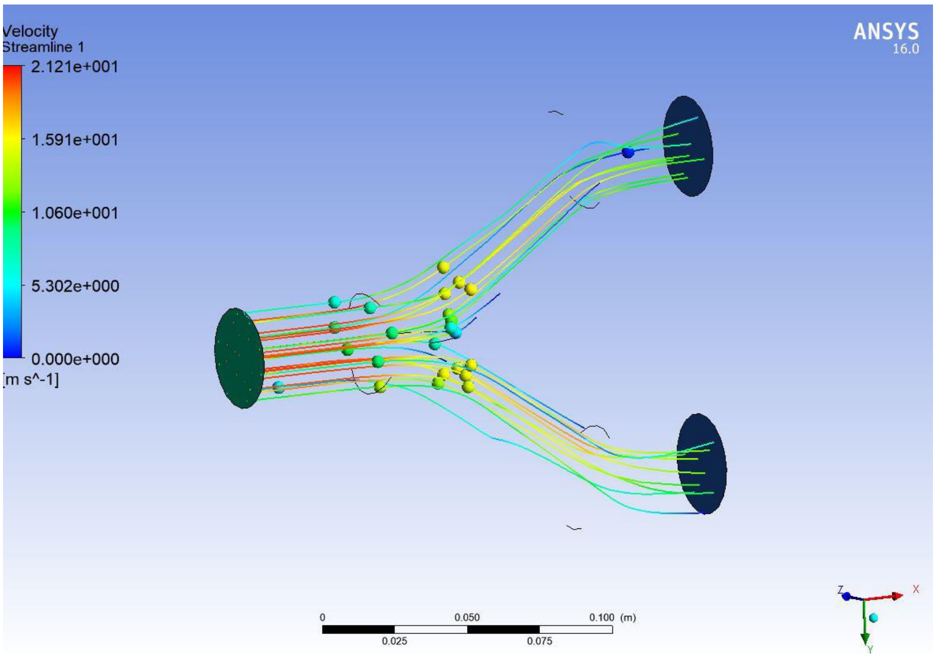

Fig. 8. The flow of Velocity Measurement

4 Cura Version

The cura version 15.04 gives the first time you open Cura for Type a Machines, the program will be in Quick Print mode. This mode uses print resolution and material settings optimized to produce high-quality results for general printing needs. To prepare a 3D model for printing, you first load it into Cura for Type A Machines by clicking the Load button near the upper left corner of the window. Cura for Type A Machines works with STL, the 3D industry standard file format, as well as OBJ, DAE, and AMF files. The first time you open Cura for

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Type A Machines, a test 3D model called First Print Cone will be loaded automatically for use as your test print.

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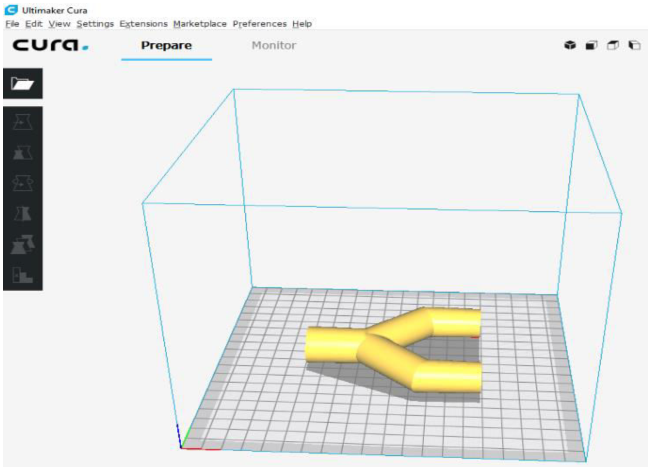

Fig. 9. Model Inserted Into Cura Software

The cura model as per dimensions solid view shows in Fig. 10 after every change, you will notice a progress bar in the upper left corner. This is the slice progress. When it's done, your model is ready to be sent to the printer. For large and complicated models, a slice may take a few minutes to complete. When a slice is completed, it will tell you the estimated print time, as well as the amount of material the print will consume. If you are happy with the selected settings, click the 'Save' Icon to save the G-Code, which will run on the printer. This saved file in G-CODE format is what you will upload to the Series 1 Web Interface.

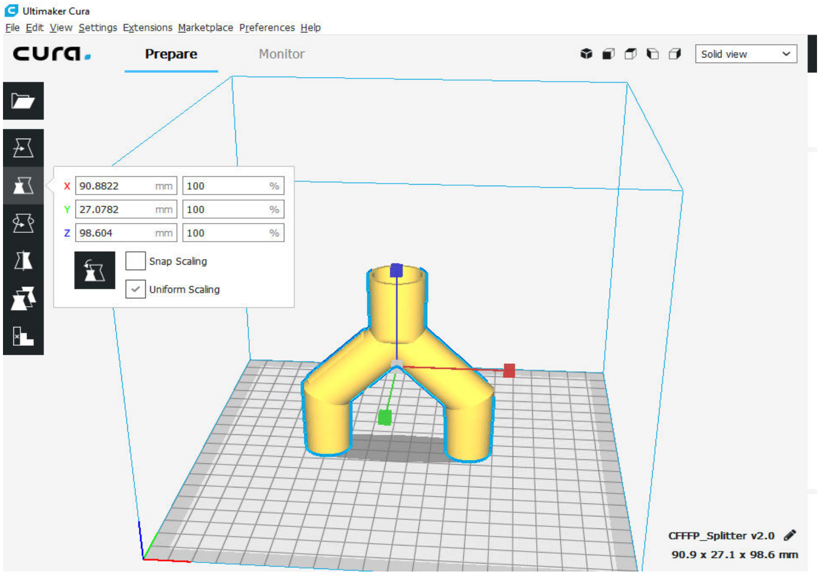

Fig. 10. Model Inserted Into Cura Software

5 Conclusions

In this research, filaments were directly available in the form of PLA composite in which it can also be prepared from extrusion processes. Materials with a high strength-to-weight ratio are used to manufacture lightweight parts which can be used to prototype the splitters and also to replace some parts in other beneficiary industries. Numerical analysis is carried out on PLA are used to predict the behavior of specimen and resulted that there is no loss rate in the flow of air in the vent splitter specimen which is helpful to continue the use of specimen in the medical applications and this work will use to further investigation of the specimen with different materials. This work is useful as a reference for further proceeding research on the anti-bacterial material.

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