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Design and Analysis of Fused Deposition Modeling 3d Printer Nozzle in Different Materials

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ABSTRACT

In Fused Deposition Modelling have led to the creation of inexpensive desktop based Rapid Prototypes such as the Replicating Rapid-Prototype (Rep Rap) allowing the individual the freedom to fabricate three dimensional parts of their own, however print resolutions of the parts are not on the same level as commercially based systems. It has been observed that adjusting the certain parameters on the polymer melt extruder such as the extruder nozzle diameter, nozzle angle, and liquefier length ultimately affects the extruded melt flow behaviour. These parameters are important factors to consider for an improved design. This thesis presents the results of the computational and experimental work that shows this effect taking the original specifications of the RepRap extruder and aims to show how reducing nozzle exit diameter and varying nozzle angle has resulting effects on pressure drop and the flow behaviour of the melt. The results show that optimization of the flow rate can have signification effects on the extruded melt and it also shows limitations on how small the nozzle exit diameter can be before the resulting pressure drop becomes too large such that the motor cannot provide enough torque to drive the flow. Ultimately, the proposed redesign suggests that the RepRap's extruder with specific nozzle diameter and angle which will decrease the diameter of the extruded melt contributing to better resolutions.

KEYWORDS

Nozzle, Clogging Error, Materials of Nozzle.

Introduction

Fused deposition (FDM) type 3D printing technology is a kind of efficient solid molding technology, the basic working principle of this type of printer is after slicing the computer data, in a relatively short period of time, encoding by computer generated 3D model on the real thing are processed and analyzed. After slicing into a two-dimensional planar graph, namely solid planar contour, using the general layer increasing material-cooling technology, When the wire feeding mechanism will print raw materials delivered to the nozzle and the high temperature of the melt, namely printer nozzle print, print steps will need objects directly in the print reference surface layer printing manufacturing. It also because the layered printing of the model is based on the cooling of the upper layer, and whether the printing of the next layer can be completed smoothly depends on whether the printing of the upper layer meets the requirements.

Structure and Function of Nozzles

The nozzle is the core components of the printer to complete the fused deposition modeling, according to the requirements of the different printing can choose single or double spray nozzle, the nozzle is a common problem, so the choice of single nozzle are analyzed and explained, the nozzle structure of FDM type rapid prototyping equipment generally includes structure control device, a feeding mechanism, throat cooling unit, cooling device, pipe assembly and nozzle hot end components.

3D printer, solid material wire nozzle in the interior of the whole working process is: first, control device to control the signal feeding mechanism, refrigeration equipment and hot end components, solid material into the wire feeding mechanism and feeding mechanism is the molten material from the feed inlet to the transmission cylinder and the materials in accordance with the feed rate into the pipe cooling module set, pipe cooling assembly for cooling pipe assembly, then pipework components hot end components and the nozzle throat cooling component is connected with the thread structure, and the structure and function of nozzle hot end components is that will print the heating materials, the material from solid wire as the molten state.

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Nozzle Problem Analysis and Design Improvement

Model Collapse, Cracking and Solutions. The model of FDM type 3D printed on the printer, by way of the printed layer by layer model, when the cross-sectional area changes too quickly, or when a part of the cross-sectional area is too small, especially the cross section of the bottom of the model is too small, so it is very easy to cause the collapse of print model. The collapse phenomenon appeared in the process of printing, This paper proposes the following solutions: making models before the first control action program of printer was improved, the main improvement is the pre-processing software program, the first to set up a model of maximum slope value and minimum cross-sectional area values, when the computer in the setting of the unilateral range, generating section after the printing process when reaching the critical range, to generate the actual processing path in programming, will free model dynamic adding auxiliary plane. The auxiliary plane added in the model in external, will not affect the results of the original model of the print, so in the production model, by the following layer printing a layer contains two parts, namely the model part and the auxiliary part, the two part of the production is completed, has reached a stable cooling model in the upper layer, stable printing, deformation and collapse will improve the model to a large extent, these problems are obviously improved compared to the past. For the model of cracking, the actual printing, the volume of the model is too large or a direction of length is too long, the model may crack during the printing process. This is because the FDM type printer to realize solid liquid - solid change process in the accumulation layer when the solid model. The key problem lies in the liquid in the nozzle is extruded, depends on the cooling conditions in a layered printing solidified into a solid, and accumulated as the three-dimensional model of the shape of some. At this time due to material affected by the physical factors of expansion and contraction, so it is easy to produce a certain degree of deformation of the solid model from the liquid cooled, and the solution is for printing products with different shrinkage optimal material ratio is low, try to avoid the occurrence of large deformation model, to prevent serious problems when model reaches the limit bearing capacity when the degree of rupture.

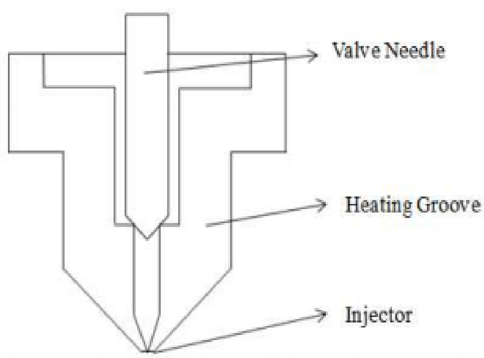

Fig. 1. Improvement of two dimensional sprinkler nozzle

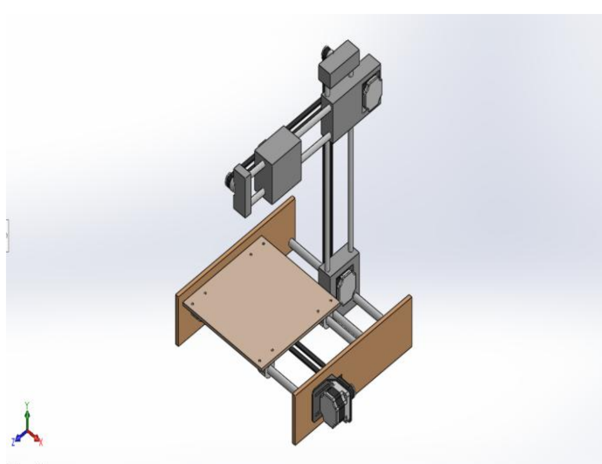

Fig. 2. Assembled model of 3d printer

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The Optimized Structure of Nozzles

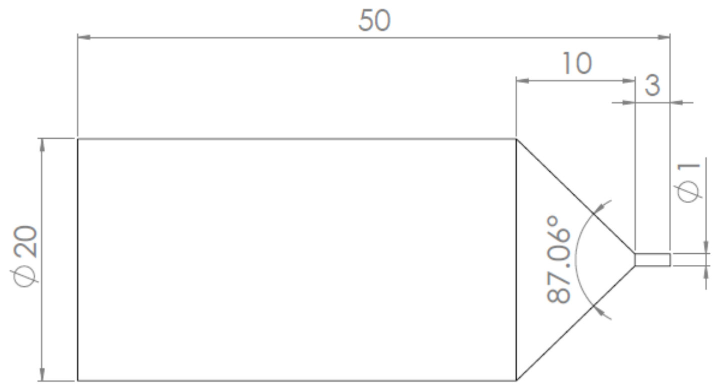

Fig. 3. Shortest Angle Profile

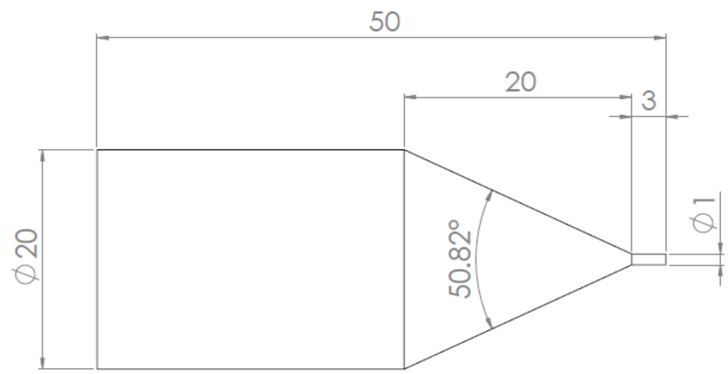

Fig. 4. Longest Angle Profile

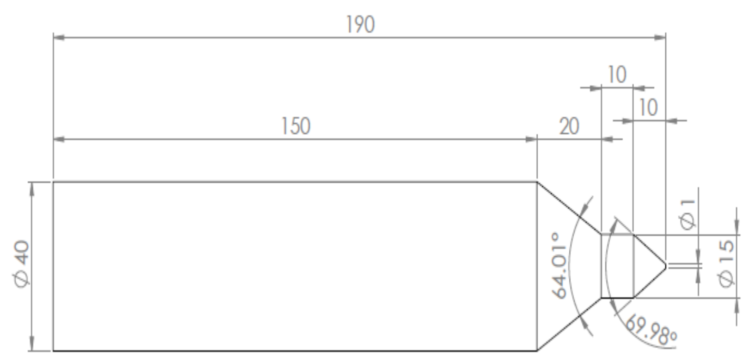

Fig. 5. Dual Bell Profile

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Result of Shortest Nozzle Aluminium

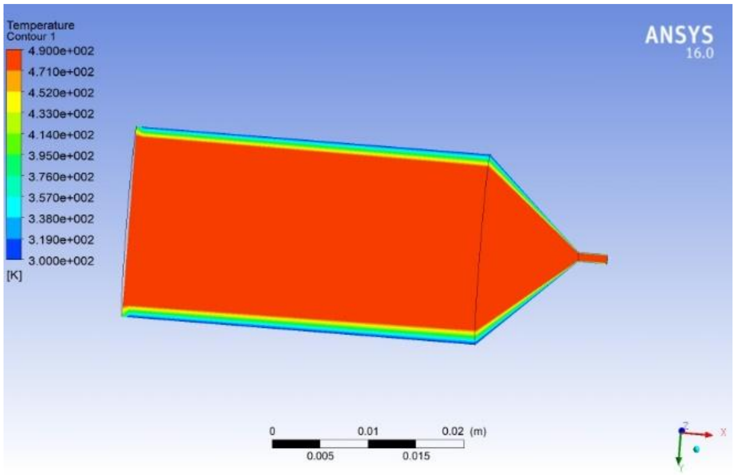

Fig. 6. Temperature

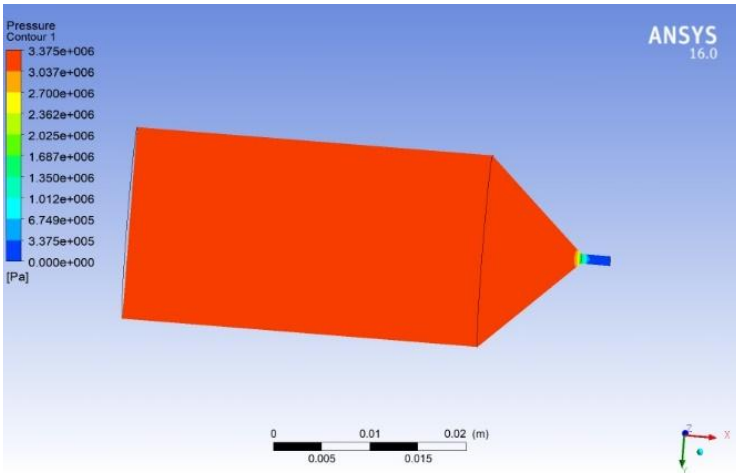

Fig. 7. Pressure

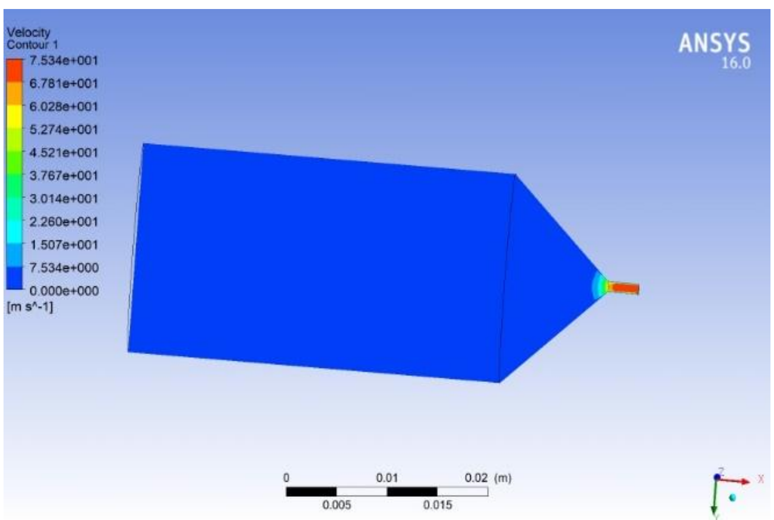

Fig. 8. Velocity

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Result of Shortest Nozzle Nickel

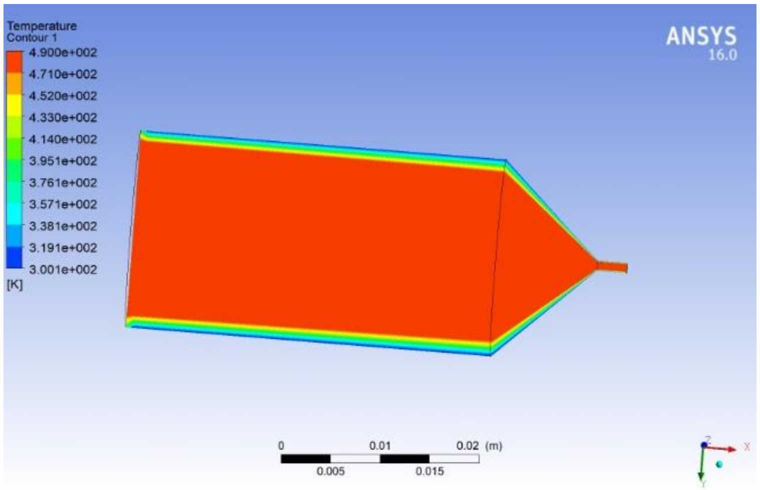

Fig. 9. Temperature

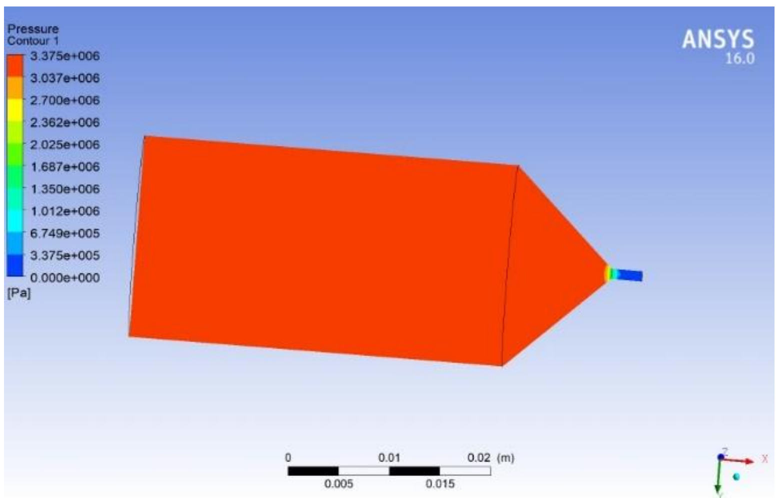

Fig. 10. Pressure

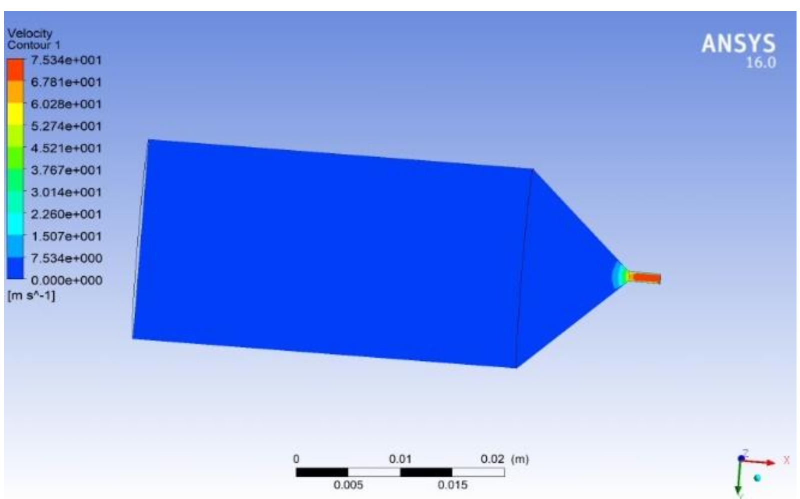

Fig. 11. Velocity

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Result of Shortest Nozzle Steel

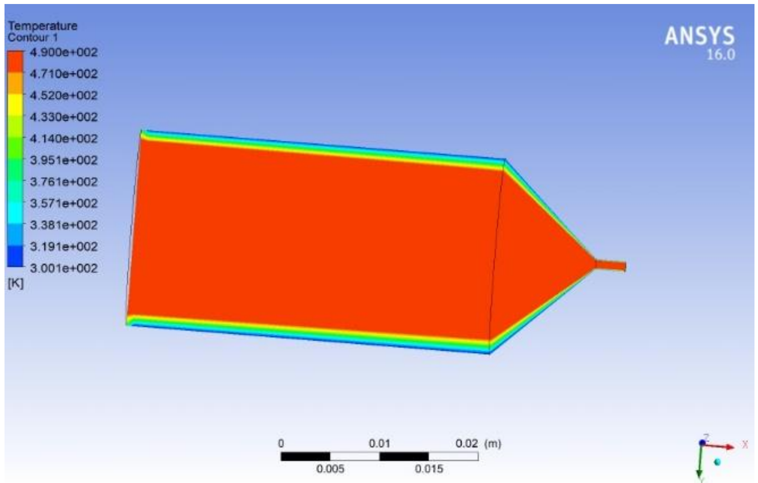

Fig. 12. Temperature

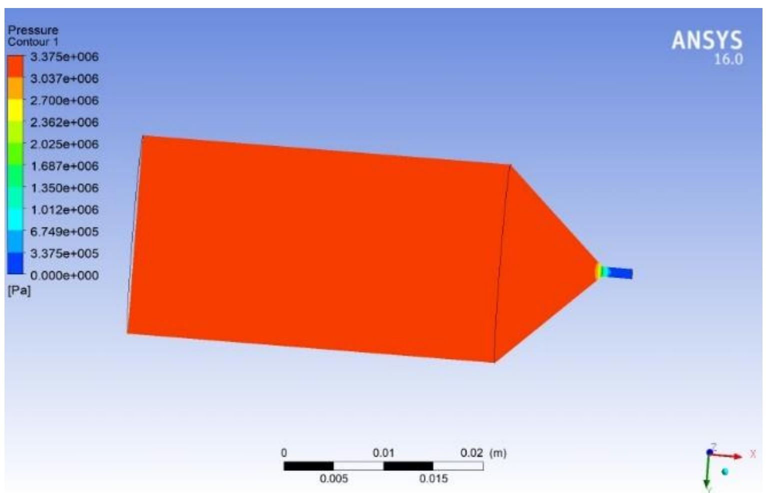

Fig. 13. Pressure

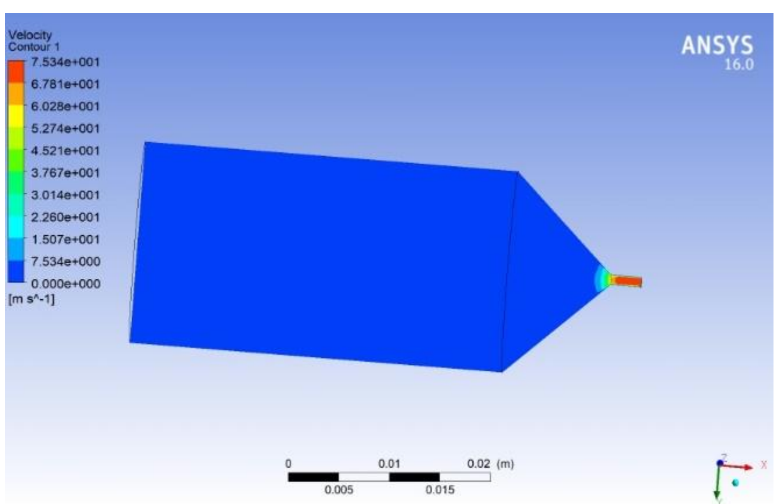

Fig. 14. Velocity

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Result of Longest Nozzle Aluminium

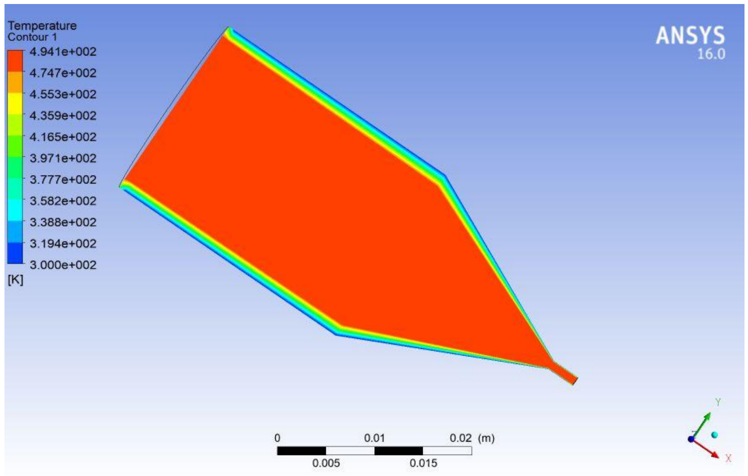

Fig. 15. Temperature

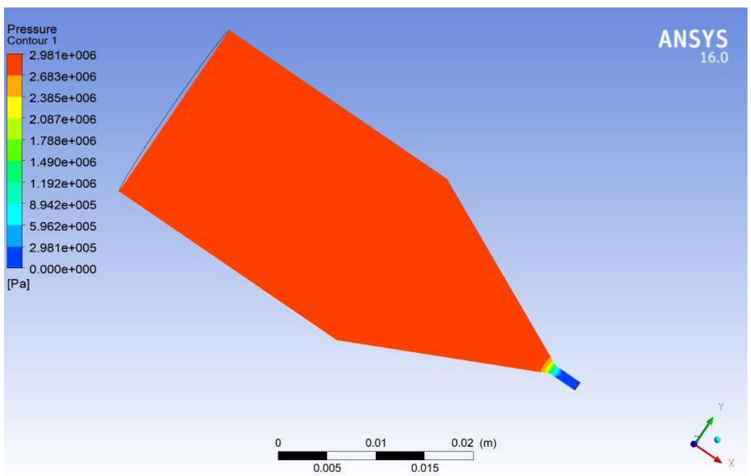

Fig. 16. Pressure

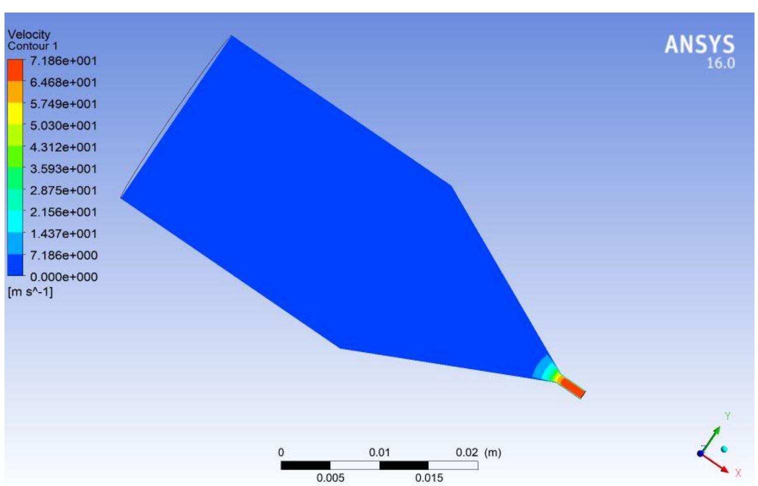

Fig. 17. Velocity

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Result of Longest Nozzle Nickel

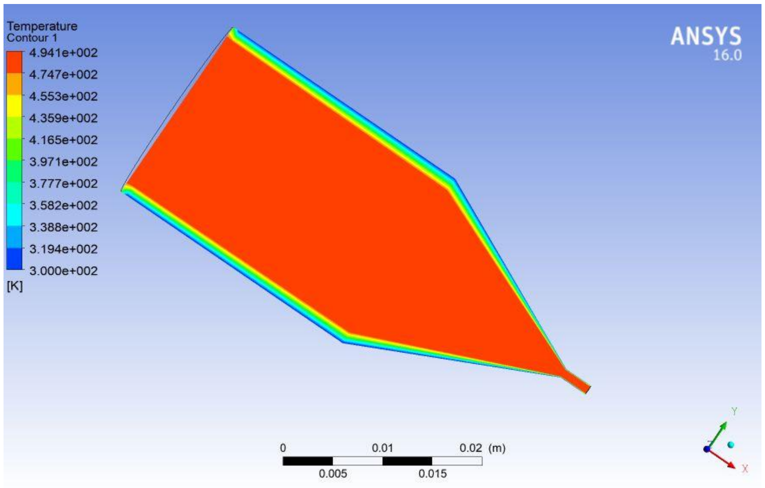

FIG. 18. Temperature

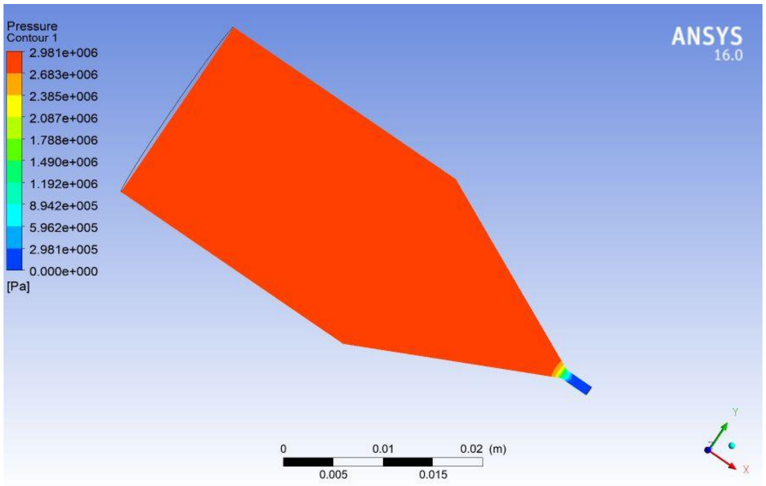

Fig. 19. Pressure

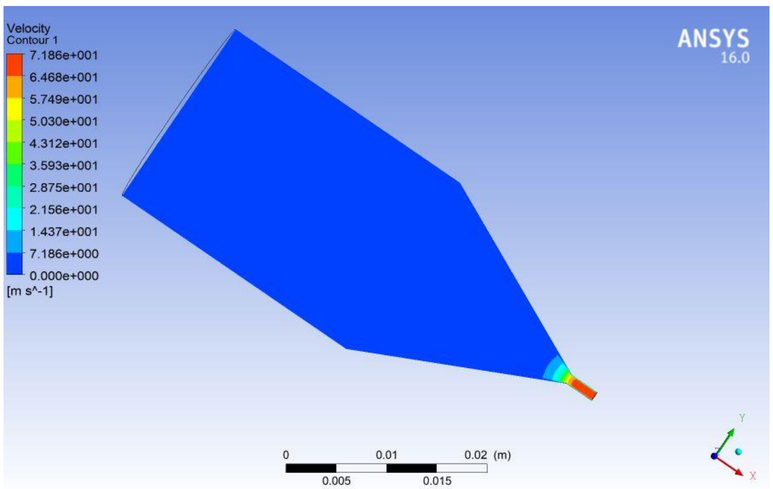

Fig. 20. Velocity

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Result of Longest Nozzle Steel

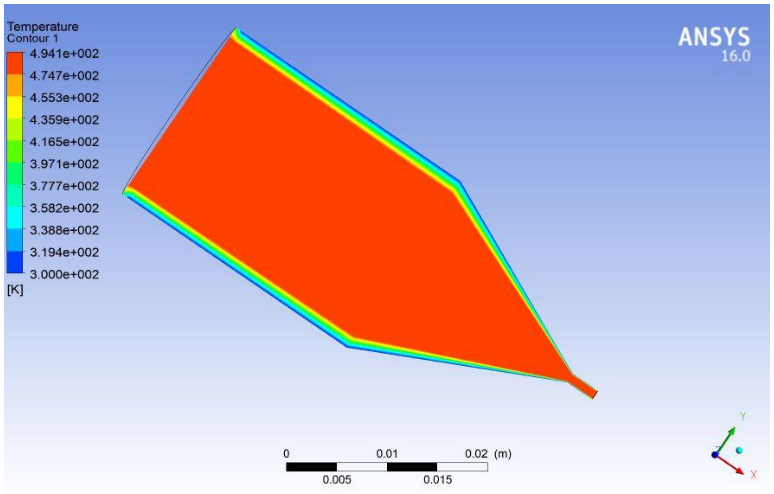

Fig. 21. Temperature

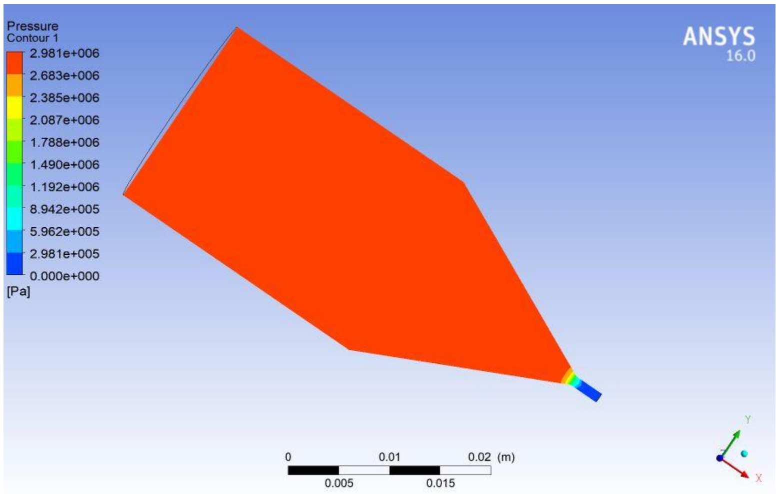

Fig. 22. Pressure

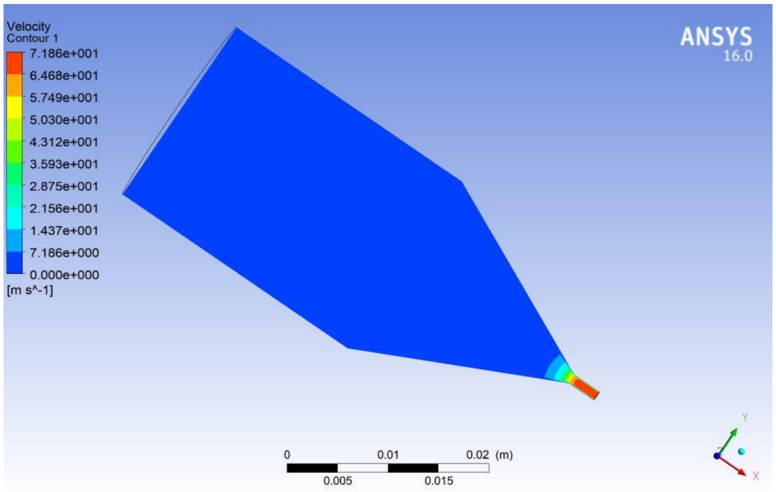

Fig. 23. Velocity

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Result of Dual Bell Nozzle Aluminium

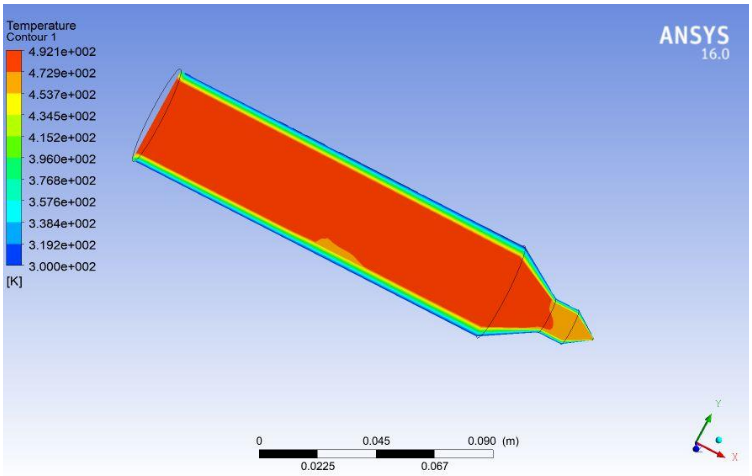

Fig. 24. Temperature

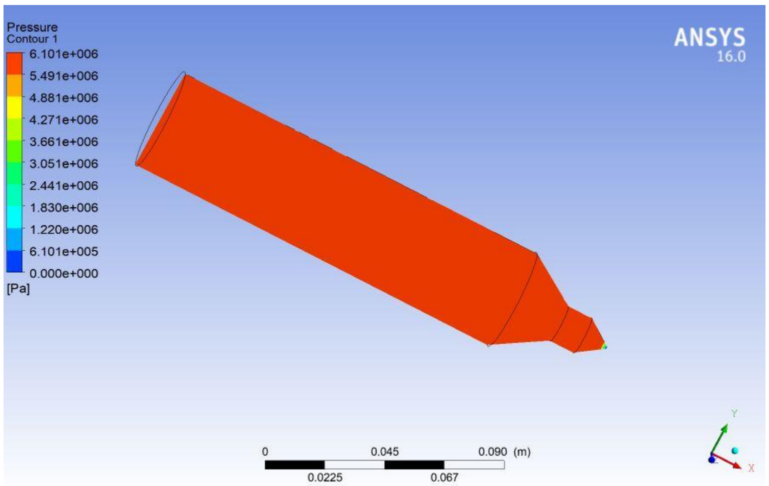

Fig. 25. Pressure

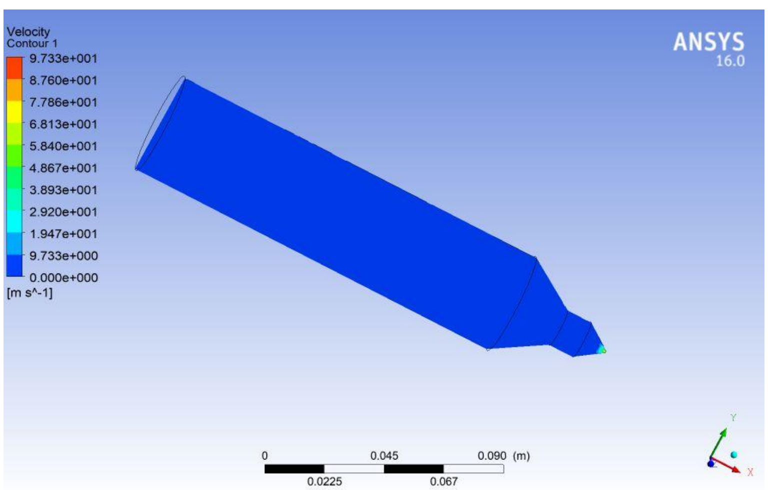

Fig. 26. Velocity

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Result of Dual Bell Nozzle Nickel

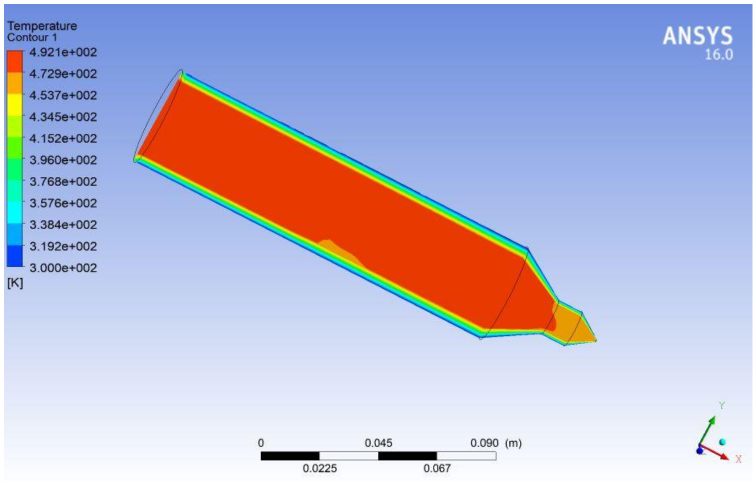

Fig. 27. Temperature

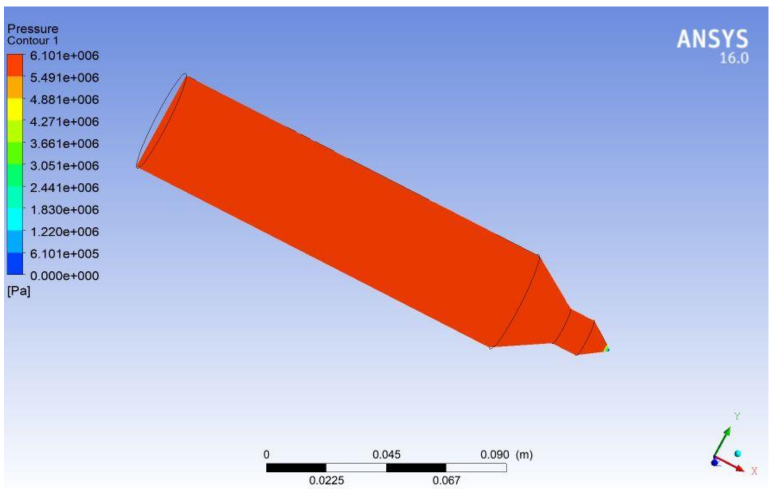

Fig. 28. Pressure

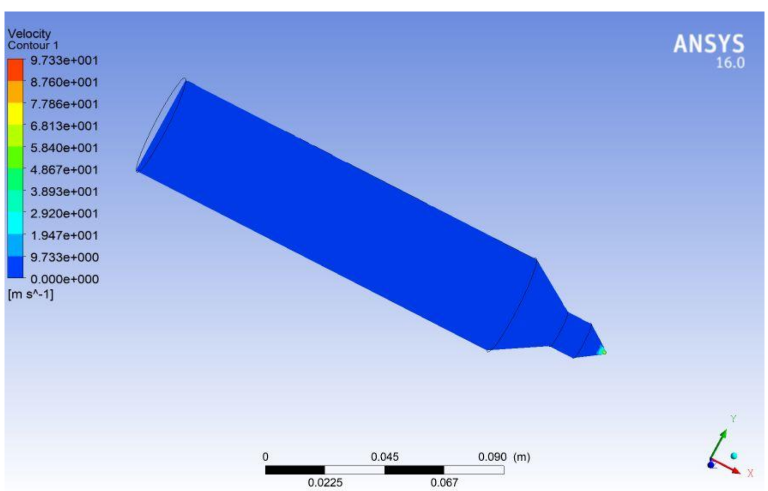

Fig. 29. Velocity

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Result of Dual Bell Nozzle Steel

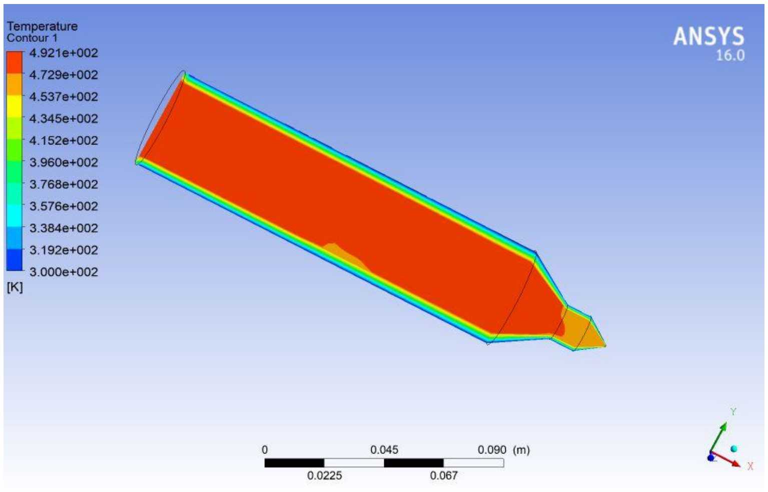

Fig. 30. Temperature

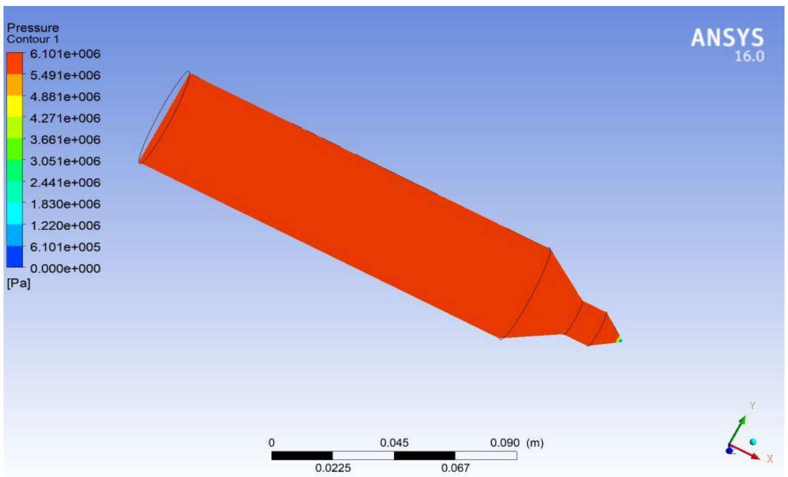

Fig. 31. Pressure

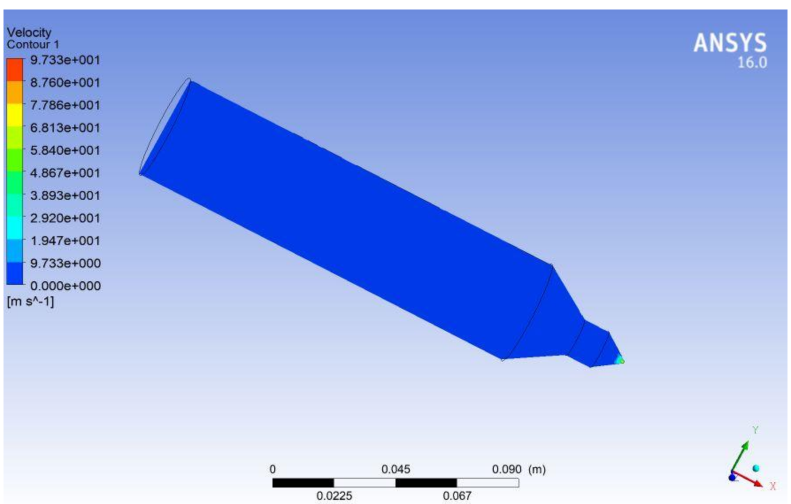

Fig. 32. Velocity

Conclusion

As a kind of mature rapid prototyping technology, fused deposition modeling has been a new production method in the 21st century. In this paper, the CAD model of 3D printer nozzle device is established by Solidworks software; meanwhile, the flow channel part of the whole device is extracted and simplified. The CAD model and the finite element model are established by Solidworks and ansys workbench, respectively, and then the flow field is simulated by Fluent software. According to the simulation of three variable nozzle profiles, the structure of dual bell nozzle profile gives a better results. After the above research, the conclusions are as follows.

The flow field of the simplified flow channel of the nozzle device is simulated by using the Fluent software. The results are, the flow condition of the molten filament is complex, and the control of the temperature field is the key factor. The suitable temperature of the nozzle at constant extrusion speeds is obtained, and the reason for the blockage of filament material at the intersection of the heating block is due to reduced pressure and velocity experienced inside the nozzle body. The proposed dual bell nozzle gives comparatively high pressure on the molten material during the flow and also it experiences normal flow velocity which allows the filament to flow without any deviations which avoids risk of blockage.

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