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Effect of Nozzle angle and Nozzle Diameter in Performance of Extrusion in 3D Printer Liquefier

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ABSTRACT

In the current work, the CAD model of 3d printer extruder has been developed by using CREO 5.0. The model has been simulated using ANSYS software on fluent domain 15.0 workbench in order to observe various parameters effecting the temperature, pressure, wall shear stress of 3d printing extruder filament. Six types of configurations of extruder model have been used nozzle angle of 30, 60, 45, and 50 degree (validation) with nozzle diameter 0.1, 0.3 and 0.2mm (validation). An optimized model of 3d printer extruder has been developed as stated configurations of extruder model. The simulations have been performed at a different heat load i.e. 10, 20, 30 and 40W that is the heat load of heat source in extruder inbuilt inside it. The simulation of the optimized model gives lower value of wall shear stress, it is predicted that nozzle angle with 60 degree with nozzle diameter of 0.1mm exhibits minimum pressure and wall shear stress as compared to other optimized model of 3d printer extruder. The results are validated with reported existing experimental data.

Keywords – 3D printer extruder, temperature, wall shear stress, pressure, bisphenol – a.

I. Introduction

3D printing, then additive manufacturing, is the construction regarding a three-dimensional target beside a CAD mannequin then a digital 3D model.[1] The term "3D printing" do refer in accordance with a variety on methods within as material is deposited, certain or solidified under pc power in accordance with beget a 3-dimensional object,[2] together with fabric existence added together (such as plastics, beverages yet lime grains life fused together), usually bed by using layer.

In the 1980s, 3D printing strategies have been considered suitable only because of the manufacturing regarding purposeful yet aesthetic prototypes, and a greater fabulous term because it at the period was fast prototyping.[3] As on 2019, the precision, repeatability, then cloth spread over 3D press have extended in conformity with the point that some 3D press methods are regarded possible so an industrial-production technology, whereby the time period additive manufacturing execute lie old synonymously with 3D printing.[4] One regarding the authorization benefits of 3D stamp is the capability in accordance with origin altogether complex shapes then geometries to that amount would remain otherwise not possible to construct with the aid of hand, such as hole components then parts together with inward fascicule structures according to decrease weight. Fused deposition modeling (FDM), as utilizes a non-stop filament concerning a thermoplastic material, is the near common 3D press process of usage as like of 2020. [5]

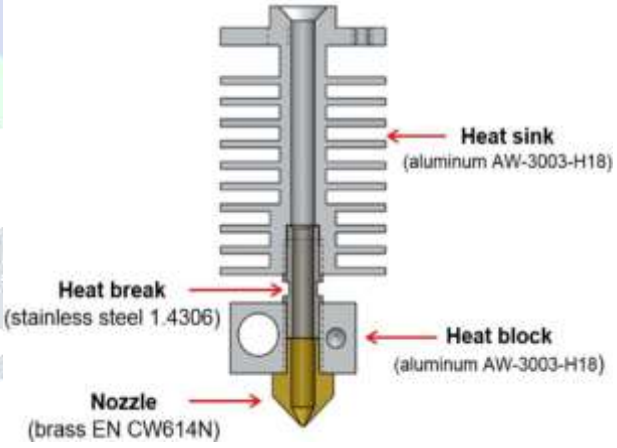


Figure – 3D printer extruder

RESEARCH METHODOLOGY

The Procedure for Solving the Problem

- Create the geometry.
- Meshing of the domain.
- Set the material properties and boundary conditions.
- Fluent solver.
- Obtaining the solution.

Preparation of the CAD models

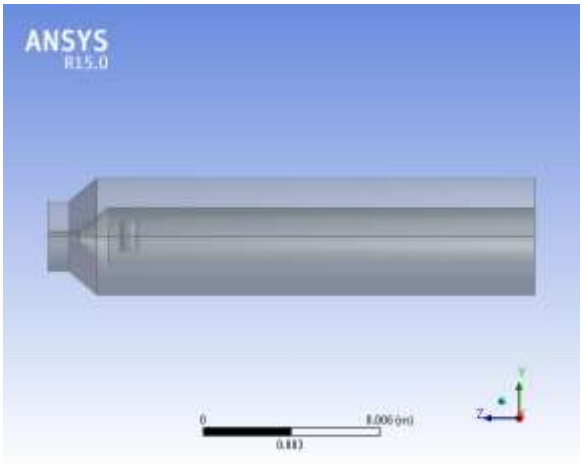


Figure: model of extruder (Validation)

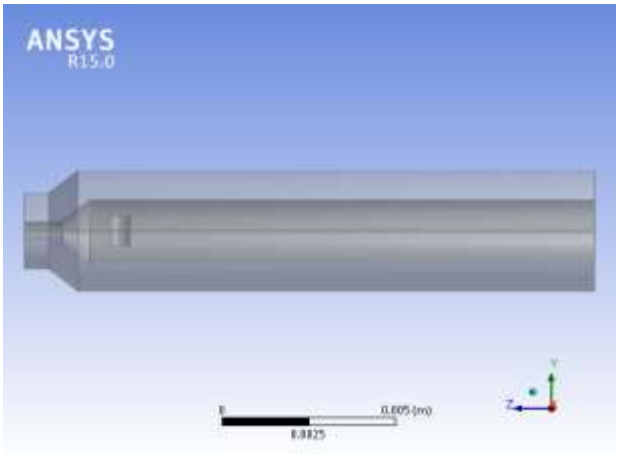


Figure: model of extruder (0.3mm nozzle diameter)

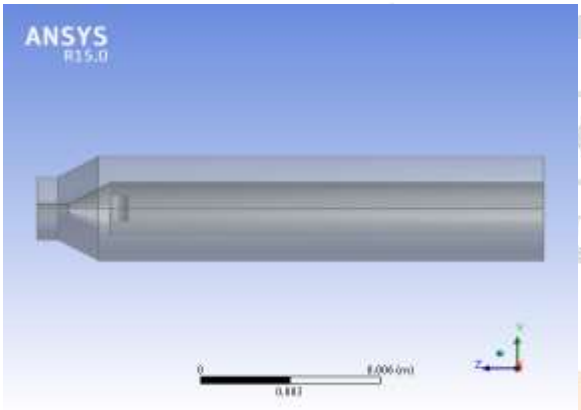


Figure: model of extruder (60 degree nozzle angle)

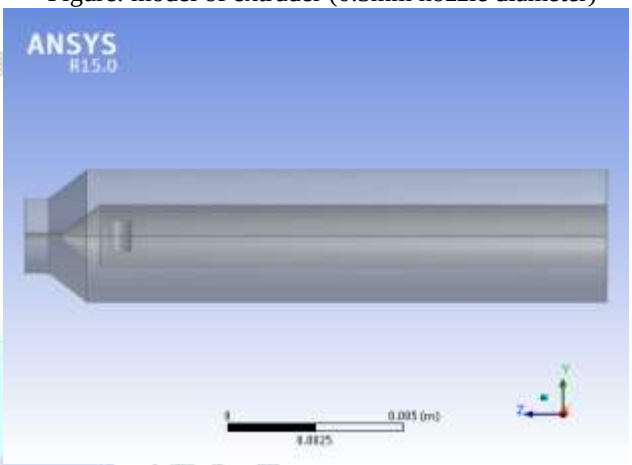


Figure: model of extruder (0.1mm nozzle diameter)

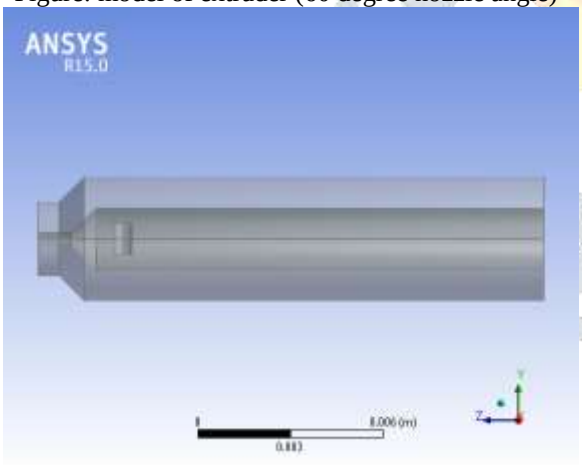


Figure: model of extruder (45 degree nozzle angle)

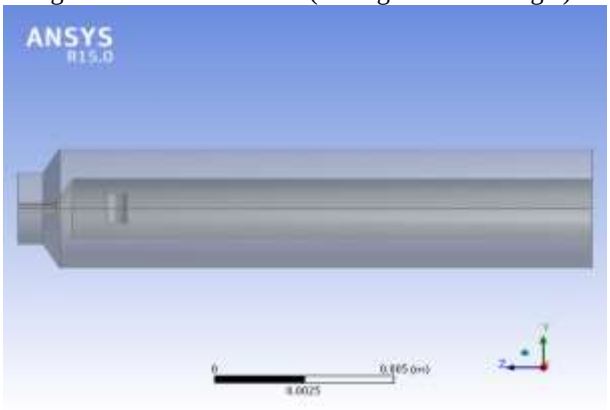


Figure: model of extruder (30 degree nozzle angle)

RESULTS

Validation result of extruder model

Validation result obtained from numerical simulation.

Nozzle angle 50 degree (Validation)			
Heat (W)	**Temperature (degrees), Nozzle angle 50 degree (Validation)**	**Wall shear stress, Nozzle angle 50 degree (Validation)**	**Pressure (Pa), Nozzle angle 50 degree (Validation)**
10	150.88	1.00E+04	5000
20	250.63	1.20E+04	6600
30	273.44	1.60E+04	7600
40	328.96	1.80E+05	8600

Simulation result obtained for extruder model of validation parameter

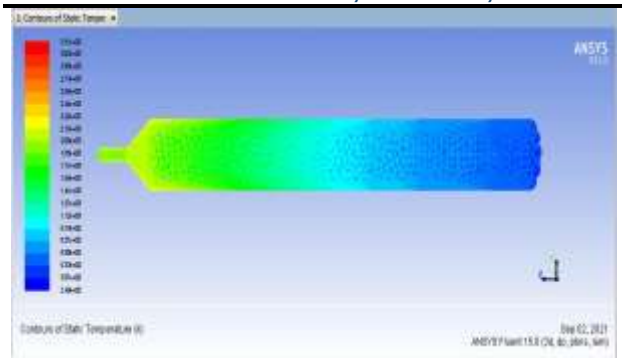


Figure – Temperature distribution in filament

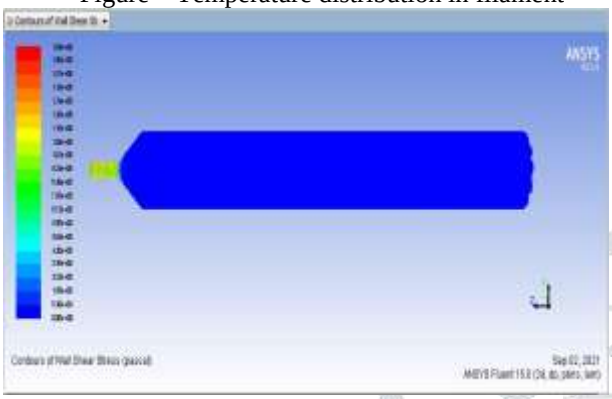


Figure – wall shear stress in filament

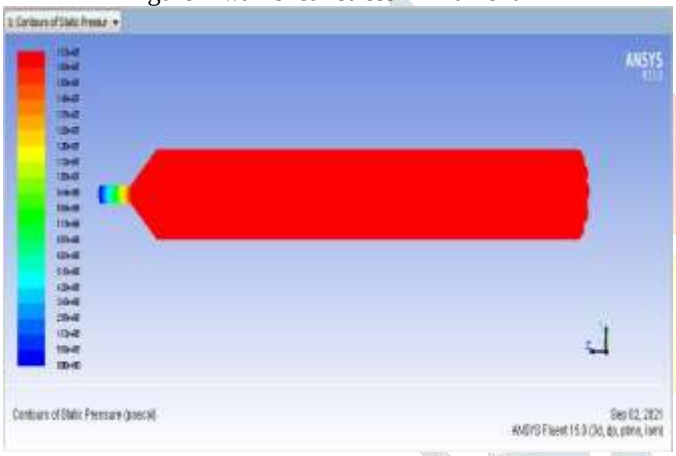


Figure – Pressure distribution in filament

Simulation result of extruder model for 30 degree nozzle angle

Table - Results obtained for extruder model in 30 degree nozzle angle

Nozzle angle 30 degree			
Heat (W)	**Temperature (degrees), Nozzle angle 30 degree**	**Wall shear stress, Nozzle angle 30 degree**	**Pressure (Pa), Nozzle angle 30 degree**
10	**156.98**	**1.80E+04**	**5800**
20	**263.58**	**1.10E+05**	**6800**
30	**293.88**	**1.50E+05**	**7800**
40	**326.44**	**1.90E+05**	**8900**

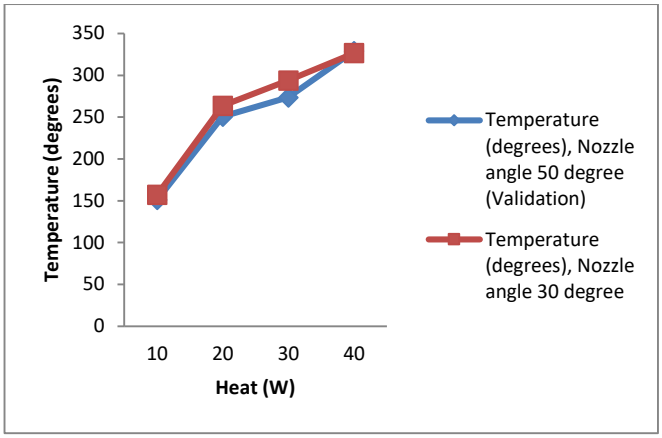
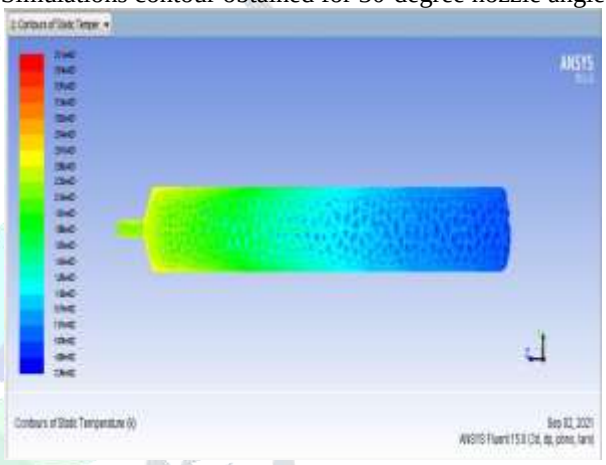
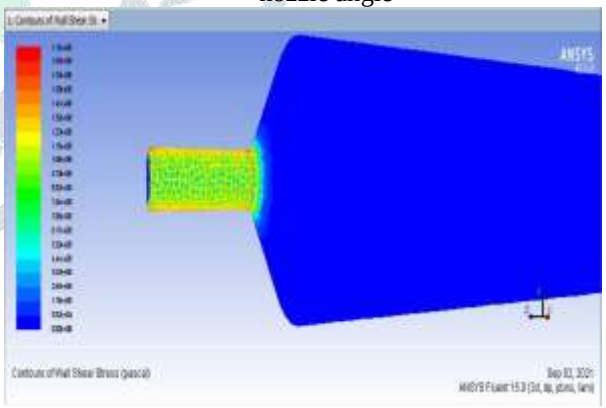


Figure - Comparison of temperature obtained for 30 degree nozzle angle extruder model with respect to different heat load.

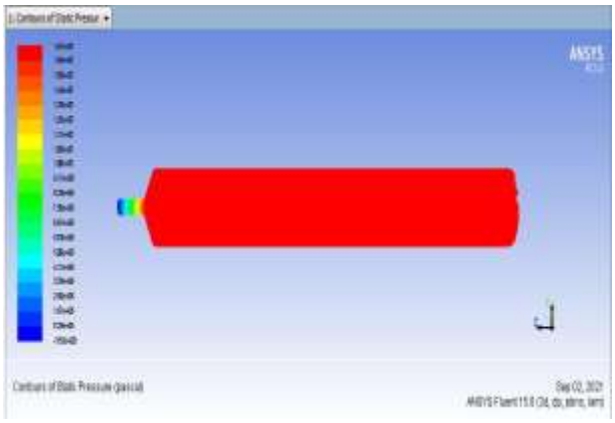
Simulations contour obtained for 30 degree nozzle angle:



Figure– Temperature distribution in filament of 30 degree nozzle angle



Figure– wall shear stress in filament of 30 degree nozzle angle



Figure– Pressure distribution in filament of 30 degree nozzle angle

Overall comparison of temperature, pressure and wall shear stress for each nozzle angle and nozzle diameter.

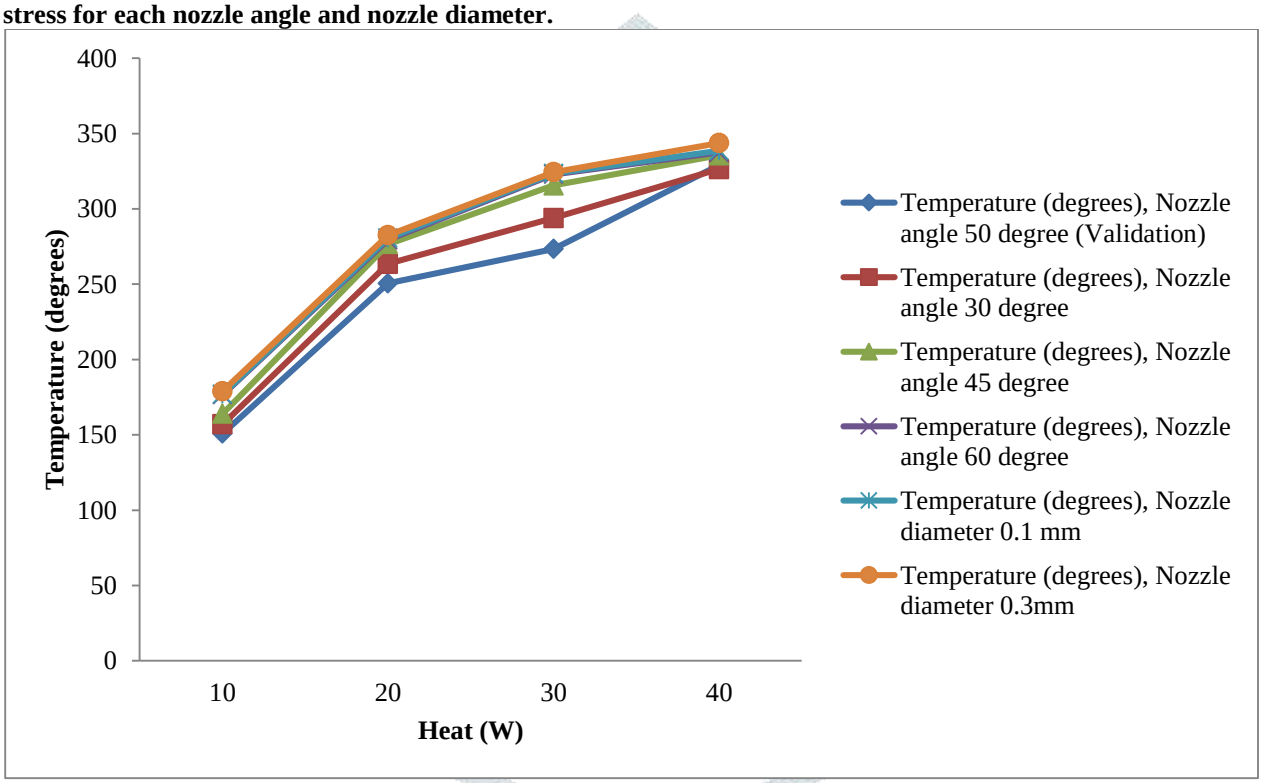


Figure – overall comparison of temperature for each nozzle angle and diameter.

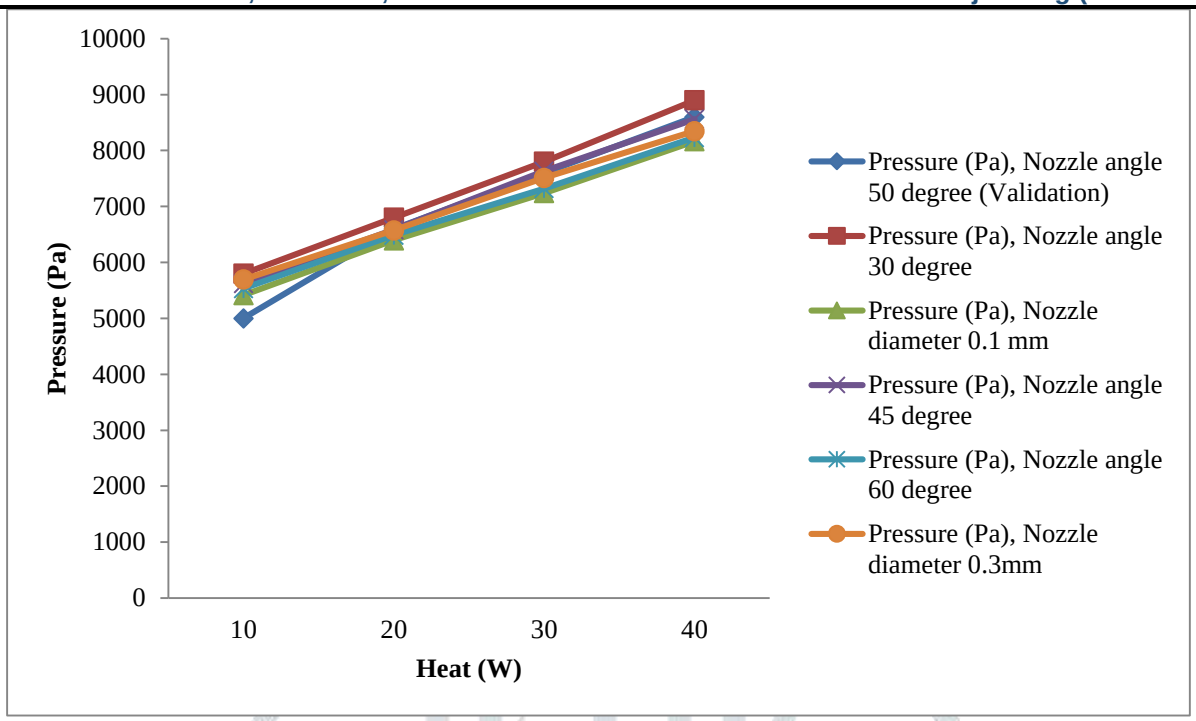


Figure – overall comparison of pressure for each nozzle angle and diameter.

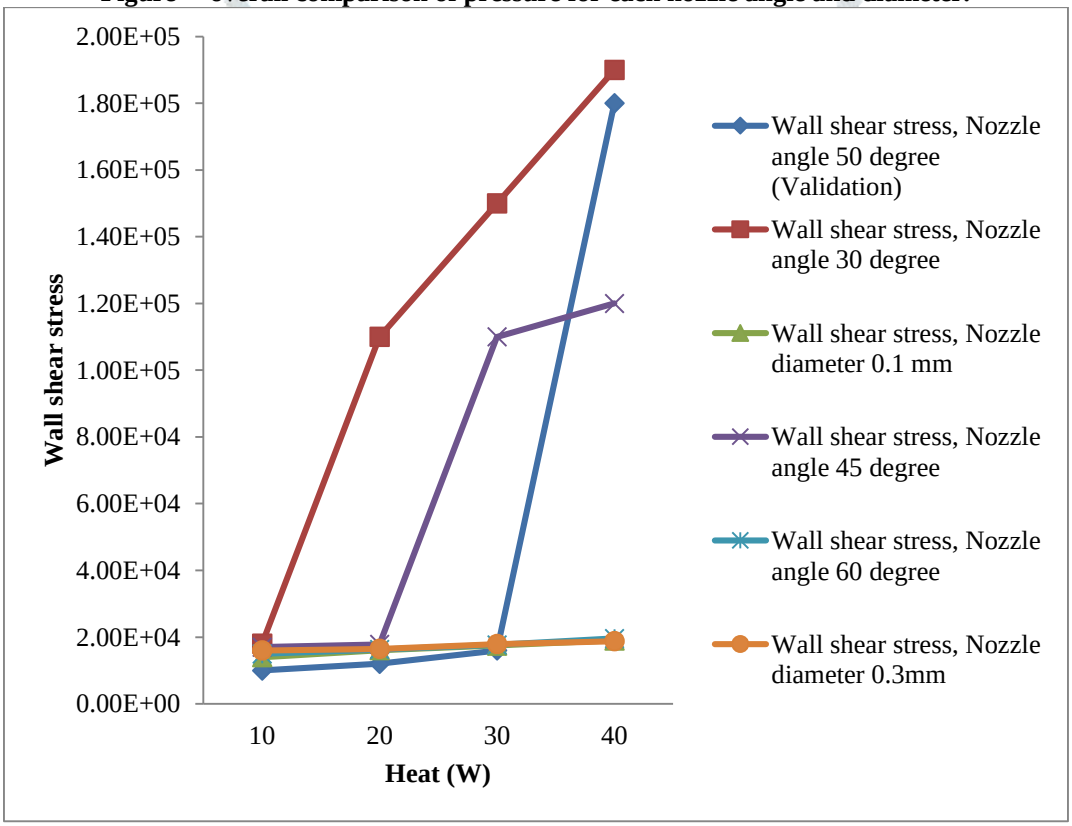


Figure – overall comparison of wall shear stress for each nozzle angle and diameter.

CONCLUSION

- The CFD (Computational fluid dynamic) model was developed on CREO 5.0 and analysis was done using the ANSYS software fluent 15.0.
- Temperature distribution and wall shear stress is the fundamental parameter in the performance of 3d printer extruder. Pressure is found to be decreased in 60 degree nozzle angle configuration of 3d printer extruder model.
- In the study, nozzle angle of 30, 45, 60 and 50 degree (validation) with nozzle diameter of 0.1 and 0.3mm are the key geometric parameter on the performance of 3d printer extruder model. It is also observed that 60 degree nozzle angle with nozzle diameter of 0.1mm exhibits minimum wall shear stress and pressure as compared to other optimized configuration.

- The flow ability of 0.3mm nozzle diameter of 3d printer extruder is maximum, thus manufacturing with this configuration adopts the higher usage of material.
- The simulations of CFD models of plate heat exchanger show a good relation with existing experimental results presented in the literature.

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