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DESIGN OF THROTTLE PEDAL WITH THE HELP OF 3D PRINTING AND ADDITIVE MANUFACTURING

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Abstract: *A system of focus within Quad torque involves the throttle assembly. The system is composed of a intricate pedal system and a less complex cable system to transmit the pedal motion to the engine throttle. Enough focus is given on the pedal assembly, but not enough on the cable assembly. In regular vehicles, the throttle pedals are heavy in weight and are made of alloy steel or aluminium. In this work, we optimise the weight of the pedal (weight reduction by 50%) keeping strength parameters unaffected, using topology modelling, 3D printing and additive manufacturing. The deformation point of throttle pedal is safer than traditional one when it is simulated with SolidWorks and checked with varying stress, strain and deformation. Since the aspects of the body and topology model is well designed, the stress, strain and displacement are in blue region respectively.*

Keywords: additive, topology, throttle

1 INTRODUCTION

Considering the working of the Internal Combustion engine, the throttle exercises a control over engine power by regulating the intake of fuel or air into the engine [1]. The throttle pedal, or an accelerator is used to modulate power in a motor vehicle. The power of an engine may be enhanced or decreased by restricting the input gases using a throttle. Through study on automobile and its engine, through the throttle body the flow of air flowing into the engine is regulated when the acceleration is given to the pedal in the primary.

In this paper, we are simulating the pedal component which is used to transfer the pedal motion to the engine throttle. The pedal is manufactured using 3D printing. 3D printing is an additive technology and uses the methodology of stacking and fusing of layers of material. It's quick and versatile technique. It is used quite often for prototyping of small parts and components [2-8].

2 MATERIAL AND METHODS

SolidWorks was used to model the pedals, and three finite element simulations were performed. Both *static* and *dynamic* tests were subjected on the pedal. We designed a 3D model, in SolidWorks, and the data is send to 3D Printer that creates the physical object. For 3D printing we used *Accucraft i250+*. We focused on *Alloy Steel* as our material for Throttle Pedal and for that we made the simulations for same. For the prototype we considered *ABS* material, which is the most suitable material in the class of polymers for 3D Printing.

2.1 Model Topology Using Solidworks

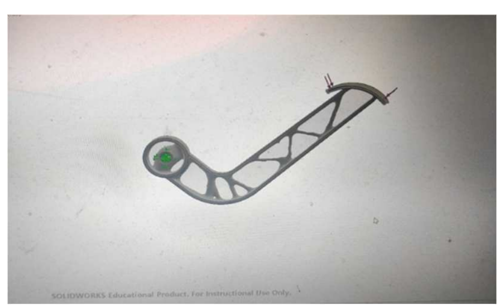

Figure 1: Topology Model

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3 RESULTS

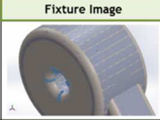
The solid body was chosen from two materials: *Alloy steel* and *ABS.* The simulation was done in SolidWorks (Fig 1 shows topology model, Fig 2 shows properties and Fig 3 shows loads and fixtures). Fig 5 and 6 show system for solid body – ABS and loads and fixtures respectively. Fig 8 and 9 show system for solid body – Alloy steel and loads and fixtures respectively. Stress, strain and displacement were simulated and checked for safe limits. Since the throttle body is well designed, the stress, strain and displacement are in *blue* region respectively (Fig 4a, b, c for alloy steel; Fig 7a, b, c for ABS).

The topology model was chosen from alloy steel. The simulation was done in *SolidWorks*. Stress, strain and displacement were simulated and checked for safe limits. Since the throttle body is well designed, the stress, strain and displacement are in *blue region* respectively (Fig 10a, b, c). *Weight reduction* and *manufacturability studies* have been carried out on additively manufactured parts such as engine mounts and brake pads [9-20].

3.1 Simulation of Solid Body (Material – Alloy Steel)

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Yield strength: 6.20422e+08 N/m^2 Tensile strength: 7.23826e+08 N/m^2 Elastic modulus: 2.1e+11 N/m^2 Poisson's ratio: 0.28 Mass density: 7,700 kg/m^3 Shear modulus: 7.9e+10 N/m^2 Thermal expansion coefficient: 1.3e-05 /Kelvin	SolidBody 1(Imported1)(Part1), SolidBody 3(Fillet3)(Part1)

Figure 2: Properties of Solid Body – Material- Alloy Steel

Fixture name	Fixture Image	Fixture Details
Fixed-1		Entities: 1 edge(s), 2 face(s) Type: Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	315.687	858.478	-0.323781	914.682
Reaction Moment(N.m)	0	0	0	0

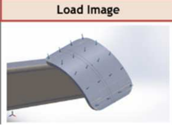
Load name	Load Image	Load Details
Force-1		Entities: 1 face(s) Type: Apply normal force Value: 1,000 N

Figure 3: Loads and Fixtures

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 1	1.958e+08N/m^2 Node: 443647

Figure 4a. **Stress**

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 1	1.958e+08N/m^2 Node: 443647

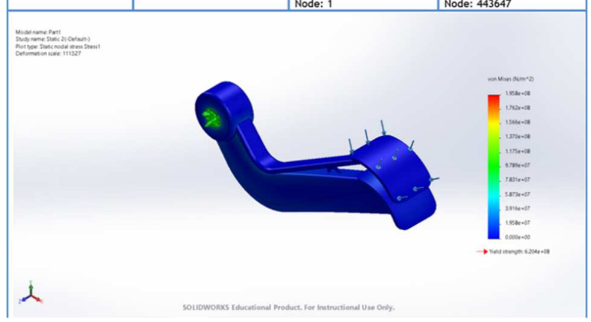


Figure 4b. **Strain**

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 1	2.523e-01mm Node: 450436

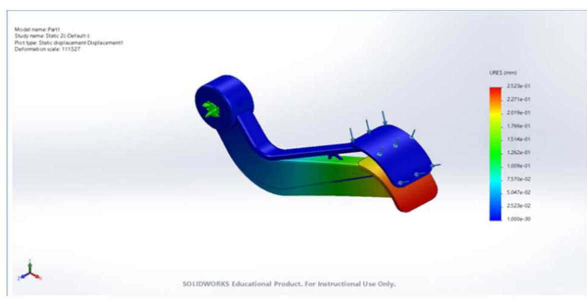


Figure 4c **Displacement**

3.2 Simulation of Solid Body (Material – ABS)

Model Reference	Properties	Components
Name:	ABS	
Model type:	Linear Elastic Isotropic	
Default failure criterion:	Unknown	
Tensile strength:	3e+07 N/m^2	
Elastic modulus:	2e+09 N/m^2	
Poisson's ratio:	0.394	
Mass density:	1,020 kg/m^3	
Shear modulus:	3.189e+08 N/m^2	SolidBody 1(Imported1)(throttlepedle final), SolidBody 2(Fillet3)(throttelpedle final)

Fixture name	Fixture Image	Fixture Details		
Fixed-1				
Entities:	1 vertex(s), 6 edge(s), 5 face(s)			
Type:	Fixed Geometry			
Resultant Forces				
Components	X	Y	Z	Resultant
Reaction force(N)	3.16037	8.57981	-0.00235654	9.14337
Reaction Moment(N.m)	0	0	0	0

Figure 5: Properties of Solid Body – Material- ABS

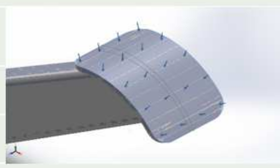
Load name	Load Image	Load Details
Force-1		
Entities:	1 face(s)	
Type:	Apply normal force	
Value:	10 N	

Figure 6: Loads and Fixtures

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 1	1.916e+06N/m^2 Node: 451617

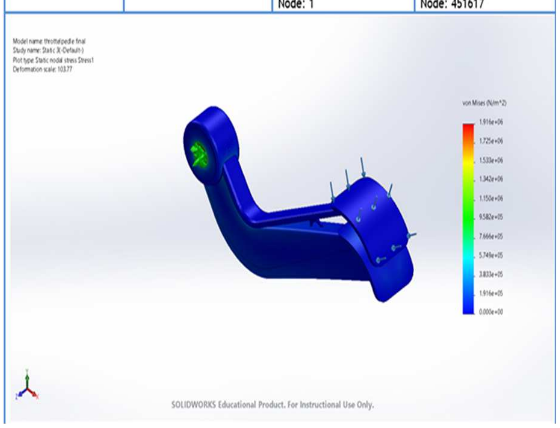


Figure 7a. **Stress**

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0.000e+00 Element: 1	7.377e-04 Element: 289202

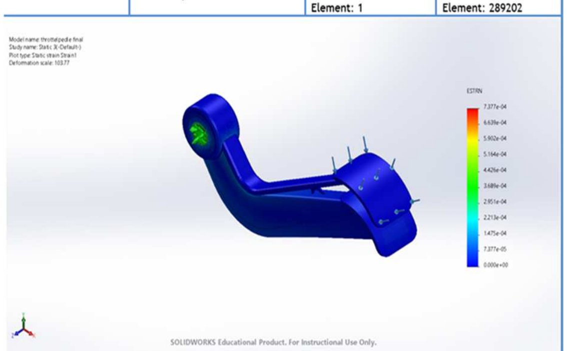


Figure 7b. Strain

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 1	2.710e-01mm Node: 447207

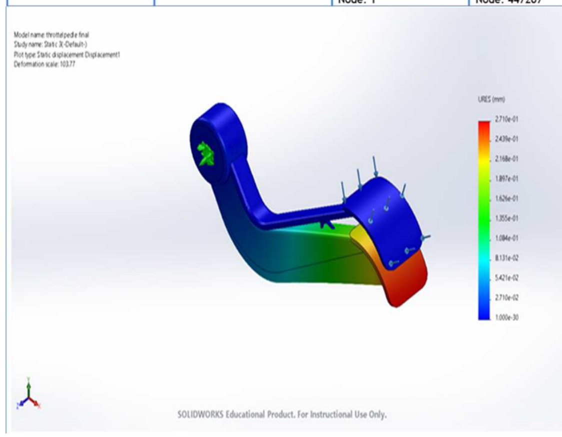


Figure 7c. Displacement

Figure 7: a, b, c shows stress, strain and displacement profiles

3.3 Simulation of Topology Model (Material – Alloy Steel)

Document Name and Reference	Treated As	Volumetric Properties
Imported3 	Solid Body	Mass:0.754335 kg Volume:9.79655e-05 m^3 Density:7,700 kg/m^3 Weight:7.39248 N

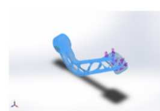
Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Yield strength: 6.20422e+08 N/m^2 Tensile strength: 7.23826e+08 N/m^2 Elastic modulus: 2.1e+11 N/m^2 Poisson's ratio: 0.28 Mass density: 7,700 kg/m^3 Shear modulus: 7.9e+10 N/m^2 Thermal expansion coefficient: 1.3e-05 /Kelvin	SolidBody 1(Imported3)(throttelpedle final)

Figure 8: Properties of Topology Model – Material- Alloy Steel

Fixture name	Fixture Image	Fixture Details		
Fixed-1		Entities: 1 vertex(s), 17 edge(s), 21 face(s) Type: Fixed Geometry		
Resultant Forces				
Components	X	Y	Z	Resultant
Reaction force(N)	4,253	10,402.7	13.5452	11,238.5
Reaction Moment(N.m)	0	0	0	0

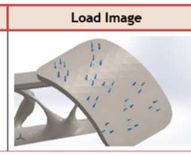
Load name	Load Image	Load Details
Force-1		Entities: 12 face(s) Type: Apply normal force Value: 1,000 N

Figure 9: Load and Fixtures

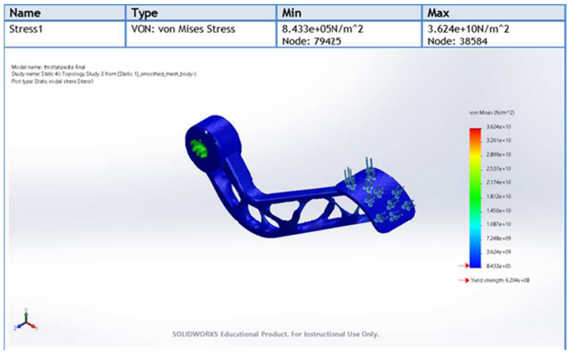


Figure 10a. Stress

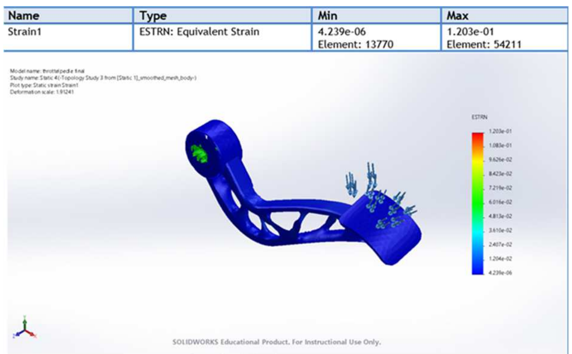


Figure 10b. Strain

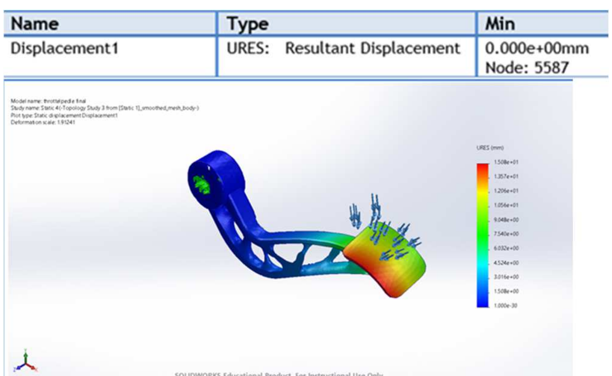


Figure 10c. Displacement

Figure 10: a, b, c shows stress, strain and displacement profiles

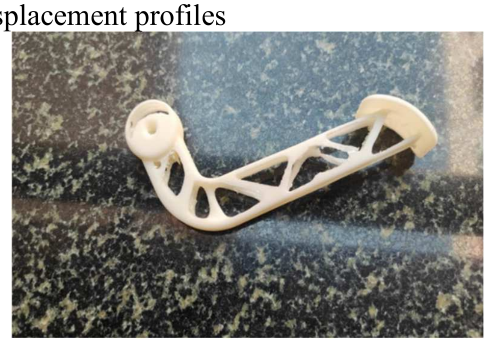


Figure 11: Prototype AM throttle pedal part made of ABS

With a particular interest in the printing of critical parts, we made a *prototype* (Fig 11) of the Throttle Pedal by additive manufacturing using *ABS material*.

4 CONCLUSION

We have demonstrated good results of 3D printing with significant weight reduction. In this paper, we briefly presented both the simulation of Solid Body as well as Topology Model using both material- Alloy Steel and ABS. Since the throttle body is well designed, the stress, strain and displacement are in blue region respectively.

With a particular interest in the printing of critical parts, we made a prototype of the Throttle Pedal by additive manufacturing using ABS material. The work demonstrated substantial weight reduction of the manufactured parts.

For automobile industry, the applicability of this work is on brake pedals, one of the crucial parts in the automotive industry that demand a number of high quality standards, can be produced using AM technologies.

The weight reduction of various parts other than throttle pedal can imply further reduction of energy consumption of the automotive industry, including enhancing the range of EVs and, most importantly, lowering the pollution it produces and promoting environment friendly manufacturing.

5. ACKNOWLEDGEMENT

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PROIECTAREA PEDALEI DE ACCELERAȚIE CU AJUTORUL IMPRIMARE 3D ȘI FABRICAȚIE ADITIVĂ

Rezumat: Un sistem de focalizare în cadrul cuplului Quad implică ansamblul clapetei de accelerație. Sistemul este compus dintr-un sistem complicat de pedale și un sistem de cabluri mai puțin complex pentru a transmite mișcarea pedalei la accelerația motorului. Se acordă suficientă atenție ansamblului pedalei, dar nu suficient ansamblului de cabluri. La vehiculele obișnuite, pedalele de accelerație sunt grele și sunt fabricate din oțel aliat sau aluminiu. În această lucrare, optimizăm greutatea pedalei (reducerea greutății cu 50%) păstrând parametrii de rezistență neafectați, folosind modelarea topologiei, imprimarea 3D și fabricarea aditivă. Punctul de deformare al pedalei de accelerație este mai sigur decât cel tradițional atunci când este simulat cu SolidWorks și verificat cu diferite tensiuni, deformări și deformări. Deoarece aspectele modelului de corp și topologie sunt bine proiectate, tensiunea, deformarea și deplasarea sunt în regiunea albastră.

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