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Technical Paper

Selection of alternative material for common rail direct injection system

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Abstract

Common rail direct fuel injection is a modern variant of direct fuel injection system for petrol and diesel engines. The common rail system prototype was developed in the late 1960s by Robert Huber of Switzerland and the technology further developed by Dr. Marco. In petrol engine MPFI technology was developed and implemented in earlier days. Basically common rail tube was fabricated by steel for petrol engines. In the current study Steel, Brass, Aluminum alloy a356 and ABS materials were analyzed separately and aluminum is found the best material among the steel, brass and ABS material for common rail injection tube.

Keywords: *Common Rail Injection System, Alternate Material.*

1. Introduction

Scope of this project is to be developing a common rail pipe with light weight and stable at various load conditions. Corresponding materials such as Aluminum alloy (a356), Brass and ABS are use to analysis by FEM packages like ANSYS. By this analysis the suitable weightless material will be found for petrol engine common rail system. The great figure of technical papers regarding the modeling of the dynamic behavior of the injection system (e.g. Borghi et al. [1], Catania et al. [2] and Cantore et al. [3]) confirms this. Detailed modeling of the diesel spray development and combustion process inside the diesel engine (e.g. phenomenological or 3D CFD modeling) requires the injection rate and velocity (i.e. momentum) to be recognized as an input, Wickman et al. [4] Hiroyasu et al. [5], Barba et al. [6]).

1.1. Project schematic diagram

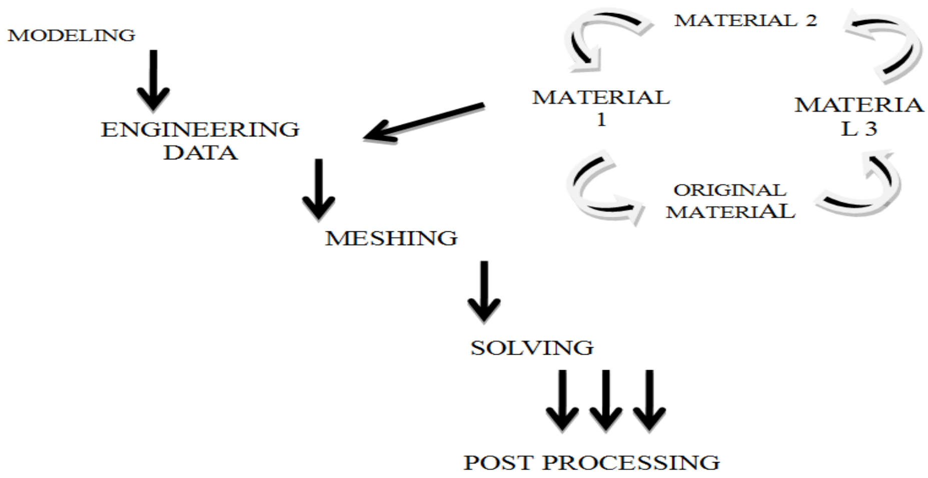

Fig. 1: Project schematic diagram

1.2. Layout of common rail injection

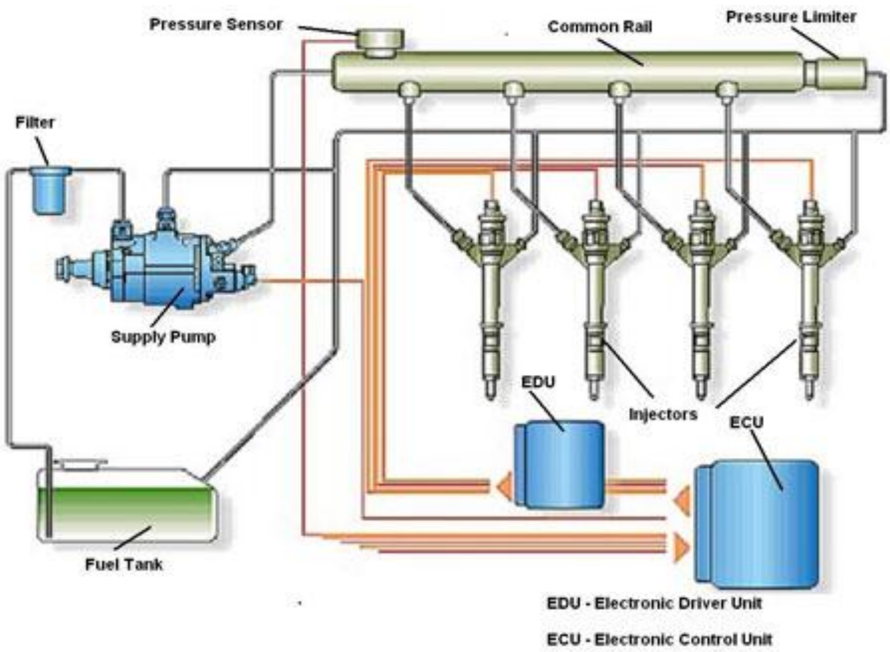

Fig. 2: Layout of common rail injection

2. Modeling

This model can be developed by cad packages like pro-e, catia. For the fine meshing we are choosing the solid modeller tool pro- engineer. The model should be compact and portable format like iges. Because the ansys environment supports these kind of the portable files.

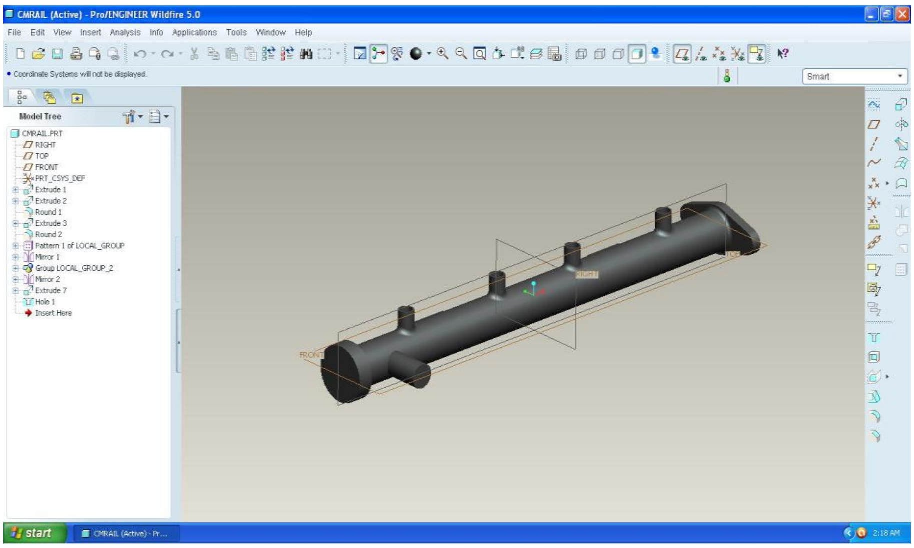

Fig. 3: Modelling

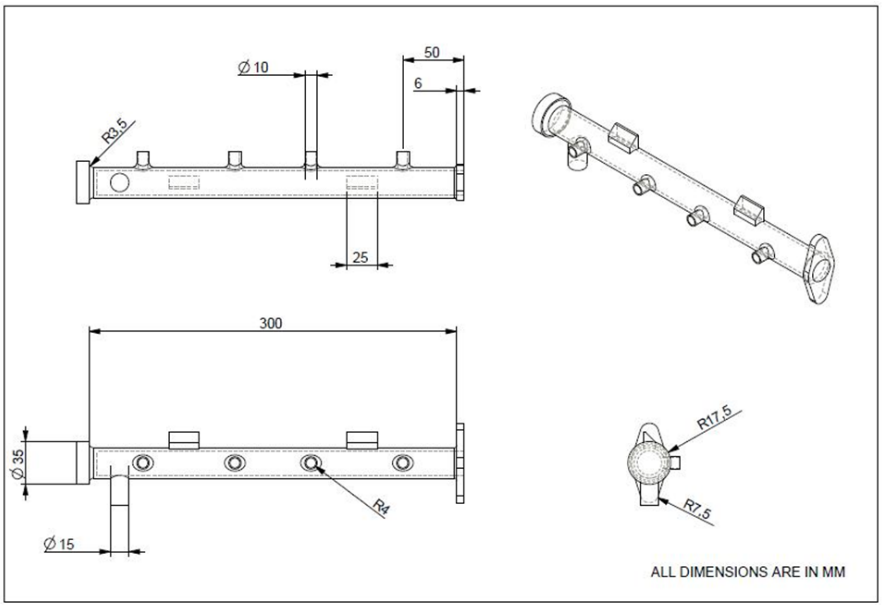

Fig. 4: Detailed Diagram

3. Steel

Table 1:

sl.no	properties	values
1.	density	7870 kg/m^3
2.	young's modulus	200gpa
3.	tensile yield strength	250 mpa
4.	poisson's ratio	0.3 (no units)
5.	max temperature	1180 deg

4. Alternative materials used

- Abs (Acrylonitrile Butadiene Styrene)
- Aluminium Alloy (A356)
- Brass

4.1. Acrylonitrile butadiene styrene (ABS)

It is a terpolymer made by polymerizing styrene and acrylonitrile in presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. The result is a long chain of polybutadiene criss - crossed with shorter chains of poly (styrene-co-acrylonitrile).

Table 2: Properties and Composition of Abs

sl.no	properties	values
1.	density	1080 kg/m^3
2.	young's modulus	2900mpa
3.	tensile yield strength	3.3e-002 Mpa
4.	poisson's ratio	0.33 (no units)
5.	max temperature	180 Deg

- Acrylonitrile- 15% to 35%
- Butadiene- 5% to 30%
- Styrene- 40% to 60%.

4.2. Brass

Brass is an alloy of copper and zincs the proportions of zinc and copper can be varied. Brass is a substitution alloy. It is used for decoration also in low friction is required such as locks, gears, bearings, doorknobs and zippers. Brass is often used in situations where it is important that sparks not be struck, as in fittings and tools around explosive gases.

Table 3: Properties and Composition of Brass

sl.no	properties	values
1.	density	8750 kg/m^3
2.	young's modulus	115 gpa
3.	tensile yield strength	0.365 mpa
4.	poisson's ratio	0.33 (no units)
5.	max temperature	1600 deg

- Copper- 68.5% to 71.5%
- Lead- 0.07%
- Iron- 0.05%
- Zinc- 24.8% to 28.8%.

4.2.3. Aluminiumalloy (a356)

- Aluminum is the world’s most abundant metal and is the third most common element, comprising 8% of the earth’s crust.
- The versatility of aluminum makes it the most widely used metal equal to steel.
- Worldwide demand for aluminum has grown n to around 29 million tons per year.
- About 22 million tons is new aluminum and 7 million tons is recycled aluminum scrap.
- Aluminum alloy (a 356) is important among the aluminum alloy with best properties.

Table 4: Properties and Composition of Brass

sl.no	properties	values
1.	density	2670 kg/m^3
2.	young's modulus	72.4 gpa
3.	tensile yield strength	280 mpa
4.	poisson's ratio	0.33 (no units)
5.	max temperature	1220 deg

- Si- 7%
- Mg Alloy- 0.3%
- Fe(Max)- 0.2%
- Zn(Max)- 0.10%
- Cu- 0.2%
- Al- 92.05%.

5. Steps involved in ansys environment

- This is structural kind of analysis. so we can choose static structural analysis environment.
- Import iges file into ansys environment.
- Apply the material value as per the analysis needs.
- Mesh the geometry by meshing.
- Apply the load conditions.
- Solve by ansys solver.
- Posts process the results.

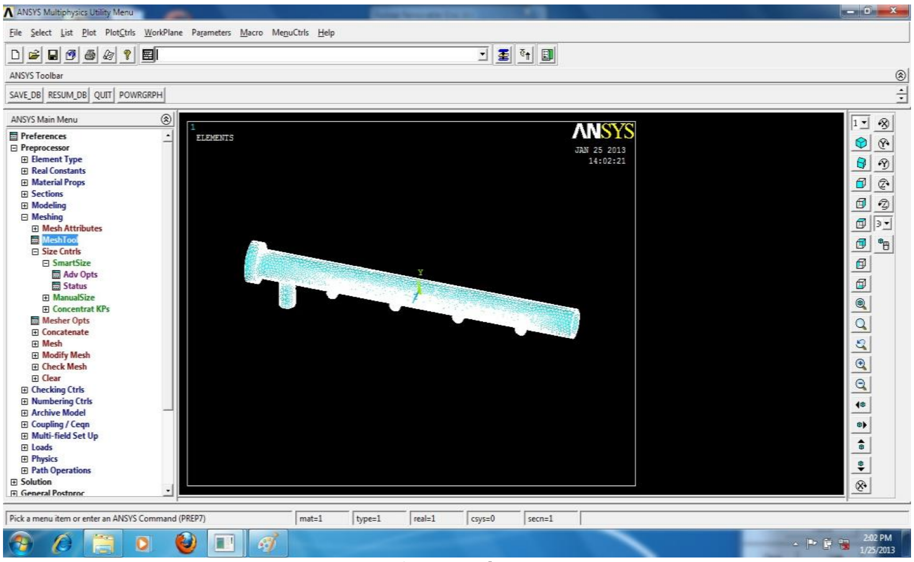

Fig. 5: Meshing

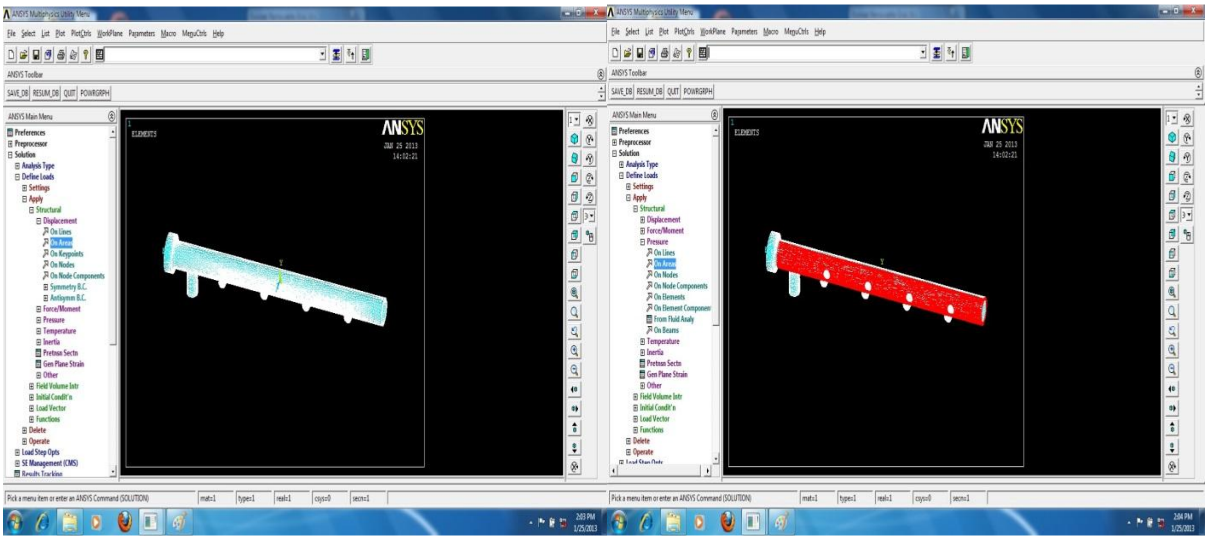

Fig. 6: Displacement Load and Pressure Load.

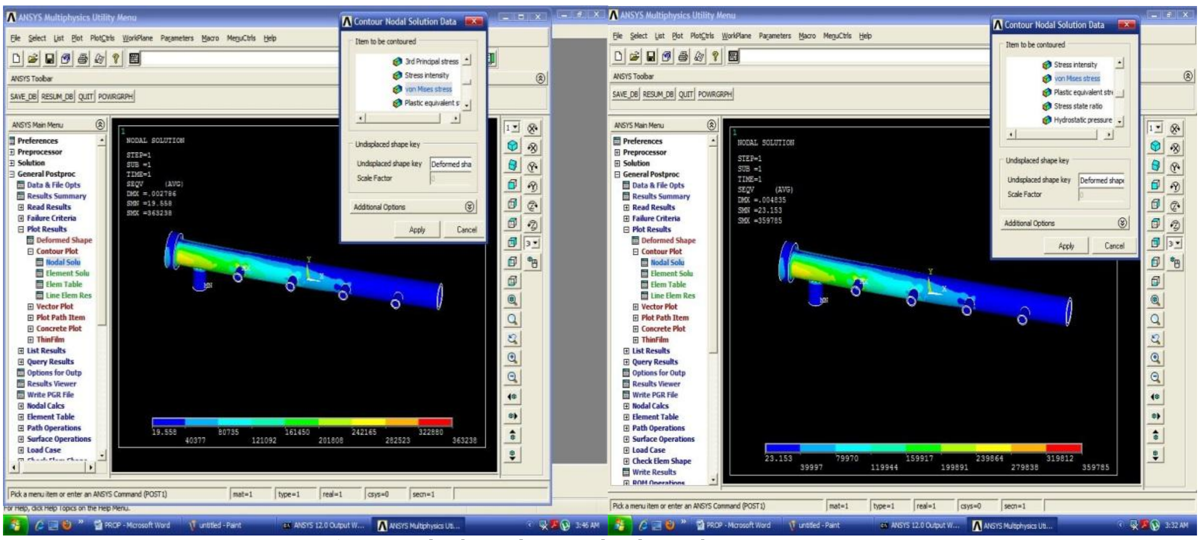

Fig. 7: Result Obtained For Steel and Brass by Von Mises Stress

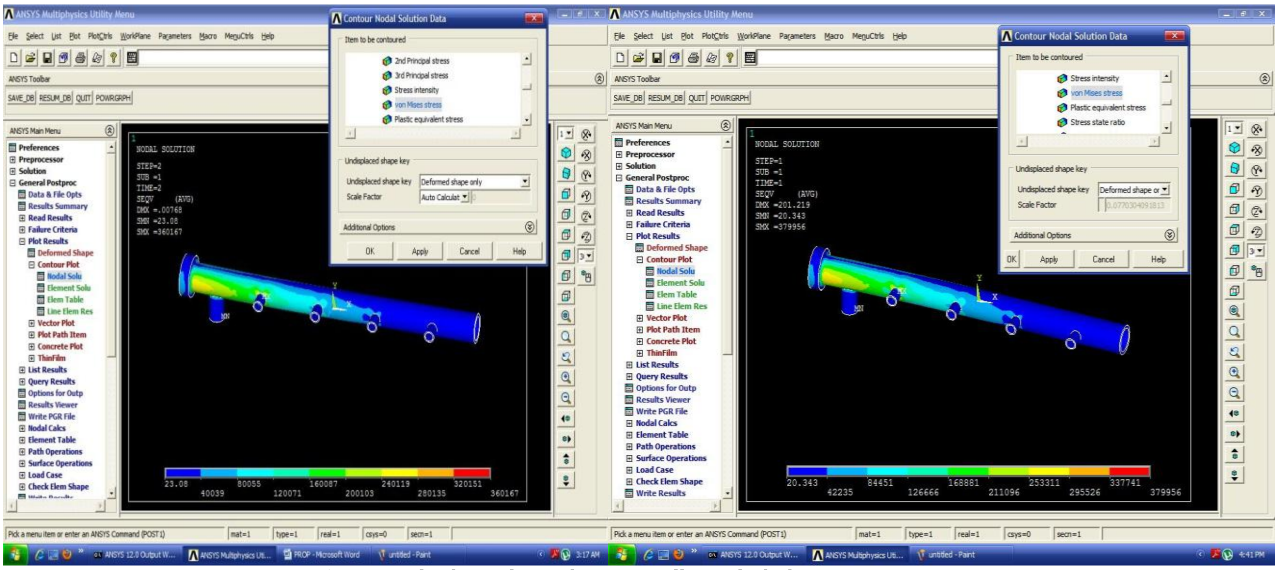

Fig. 8: Result Obtained For Aluminium Alloy and Abs by Von Mises Stress

6. Result

Table 5: Comparison Of Vonmises Stress Steel, Brass, Aluminium Alloy And Abs

Vonmises Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	19.559	23.153	23.08	20.343
Max	363238	359785	360167	379956

Table 6: Comparison Of Ist Principal Stress Steel, Brass, Aluminium Alloy And Abs

Ist principal Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-50825	-59107	-59156	-55826
Max	411686	420076	419698	318503

Table 7: comparison of 2nd principal stress steel, brass, aluminium alloy and abs

2nd principal stress (n/m$^{2)}$	steel	brass	aluminium alloy	abs
min	-88488	-98552	-98548	-91829
max	87769	102757	102787	91832

Table 8: comparison of 3rd principal stress steel, brass, aluminium alloy and abs

3rd principal Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-303526	-306106	-306299	-430477
Max	53453	66373	66342	53420

Table 9: comparison of x component stress steel, brass, aluminium alloy and abs

X component Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-301654	-303572	-303764	-430431
Max	411643	420012	419636	315919

Table 10: comparison of y component stress steel, brass, aluminium alloy and abs

Y component Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-176710	-178329	-178343	-79066
Max	75524	90085	90115	180726

Table 11: comparison of xz component stress steel, brass, aluminium alloy and abs

Xz shear Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-62691	-61782	-63802	-64811
Max	62056	61471	61544	65461

Table 12: comparison of z component stress steel, brass, aluminium alloy and abs

Z component Stress (n/m$^{2)}$	Steel	Brass	Aluminium alloy	Abs
Min	-90650	-104143	-104098	-85605
Max	81899	93407	93345	94975

Table 13: comparison of xy component stress steel, brass, aluminium alloy and abs

Xy shear Stress (n/m^{2})	Steel	Brass	Aluminium alloy	Abs
Min	-73339	-72117	-71989	-86037
Max	81642	80118	80275	77181

Table 14: comparison of yz component stress steel, brass, aluminium alloy and abs

Yz shear Stress (n/m^{2})	Steel	Brass	Aluminium alloy	Abs
Min	-32447	-31431	-31424	-24869
Max	23825	24839	24882	34025

7. Conclusion

We have analyzed Steel, Brass, Aluminum alloy a356 and ABS materials separately and come to a conclusion that aluminum is the best material to use in common rail injection tube. Through the details given above in the tabular columns it is crystal clear that Aluminum is the most economical and has properties greater or equal to steel but cheaper than steel. So, Aluminum has to be considered as the better replacement for steel since Brass is costly as well as steel.

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