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DESIGN MODIFICATION AND TESTING OF CI ENGINE MUFFLER

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ABSTRACT

Automotive Silencers (or) Mufflers are used to minimize the noise level and vibrations produced in the engine exhaust gas. The Mufflers usually contain complex internal components such as extended inlet and outlet tubes, thin baffles with eccentric holes, internal connecting tubes, perforated tubes, flow plugs, and sound absorbing materials. In this project, thermal analysis is carried out in the existing muffler of C.I.engine. The various influencing factors of muffler such as thermal concentration, thermal stress and properties of material have been analyzed by the software and the input values for the analysis are measured from the experimental setup. Based on the results of analysis, the optimal modification is to be done in the design in order to improve the life and performance of muffler.

Key words: Temperature, Fins, Conical Shape, Taper, heat

INTRODUCTION

An automotive muffler (or silencer) is a device for reducing the amount of noise emitted by an exhaust gas of engine and the exhaust gas blows out through this device and finally to the atmosphere. Mufflers are typically installed along the exhaust pipe as part of the exhaust system of an internal combustion engine to reduce its exhaust noise. The muffler accomplishes with a resonating chamber, which is specifically tuned to destructive interference of opposite sound waves that cancel each other, Catalytic converters also often have a muffling effect. The effect is mainly generated largely by restriction, rather than by cancellation.

General Information

Types of Muffler

- Baffle
- Wave cancellation
- Resonance
- Absorber
- Combined Resonance and Absorber
- Factors Affecting Muffler
- Exhaust gas temperature
- Exhaust gas pressure
- Back Pressure
- Vibration
- Erosion
- Material failure
- Crack formation
- Type of fuel used

Problems in Existing Muffler: The smaller holes in the muffler will be enlarged in its diameter due to the exhaust gas comes out with high temperature and thermal expansion in the muffler. This effects more vibration and noise in the muffler. Maximum heat will be occurred at the strikers' which is nearer to exhaust pipe inlet so that striker can be easily damaged because of thermal expansion.

Solutions for the problem: To overcome the above problems: Design and software analysis is made in the muffler, Manual analysis is also carried out to check the feasibility,

Input Data for analysis in software:

MILD STEEL PROPERITIES

Thermal conductivity : 53.6 W/m-k
Specific heat : 465 J/kg-k
Density : 7833 kg/m^3
Carbon content : 0.5%
At Boundary condition: 30 to 300 °C
(at no load and normal running condition)

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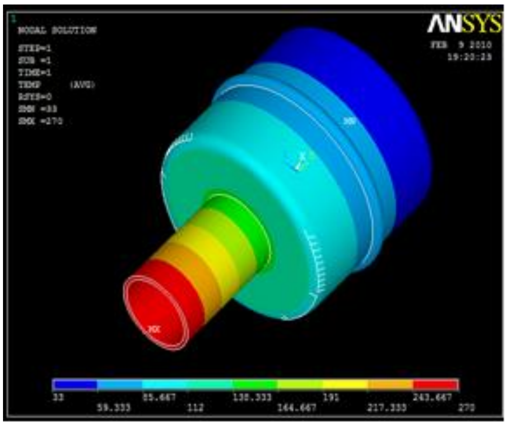

Fig : 1 Ansys output of original muffler

Outcome of the analysis: Found a vigorous HAZ, lead to material failure, Material failure

1. Crack formation
2. Corrosion – the reaction between the exhaust gas and the metal surface

Provisional Solution: To reduce the heat, following design changes are recommended

1. Fins are to be provided in the tubular surface
2. Increasing the length of the pipe
3. Converting the cylindrical back pressure area into a conical structure (Diverging)

Models to be considered for this analysis

- Model 1 : Conical Muffler
- Model 2: Muffler with fins at the tubular surface
- Model 3: Muffler with various diameters of fins
- Model 4: Conical shape muffler with fins
- Model 5: Conical shape muffler with fins at the entire muffler

Modeling: The modeling of all 5 models is given from fig no 3 to 6.

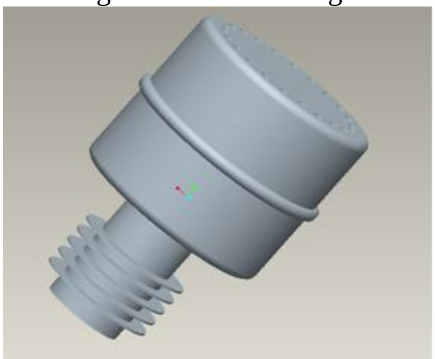

Fig: 2 Muffler with fins at the tubular surface

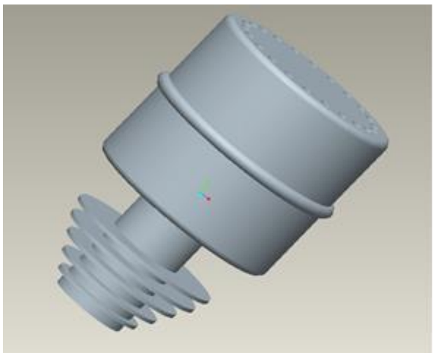

Fig: 3 Muffler with varying diameter fins

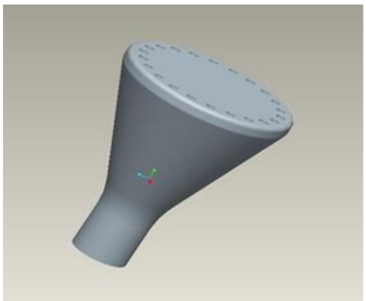

Fig: 4 Conical shape muffler

Fig : 5 Conical shape muffler with fins

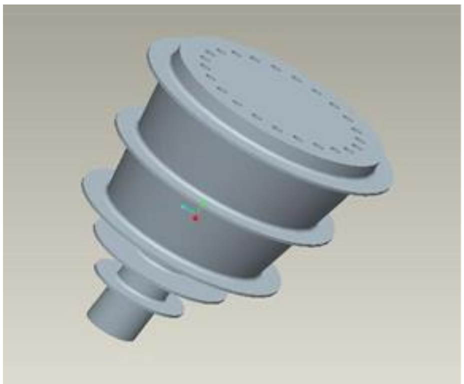

Fig : 6 Conical shape muffler with fins at the entire muffler

After modeling all 5 models were analyzed in ANSYS for temperature distribution and post processor output are given from Fig 7 to 11

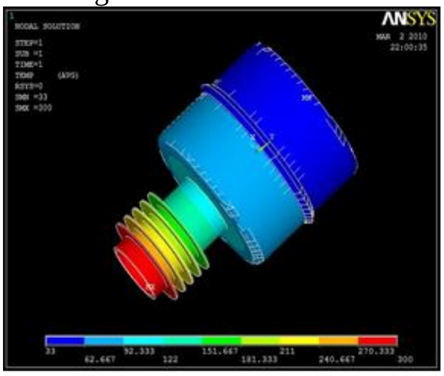

Fig : 7 Ansys Solution for Muffler with fins at the tubular surface

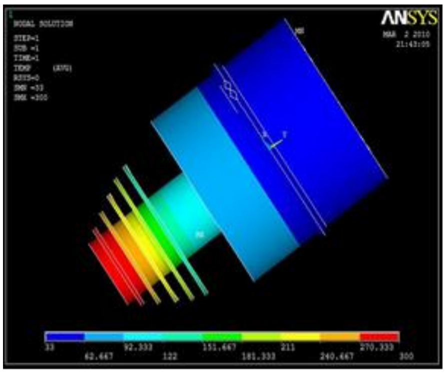

Fig : 8 Ansys Solution for Muffler with varying diameter of fin

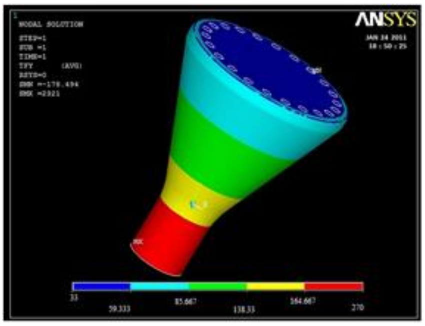

Fig : 9 Ansys Solution for Conical Muffler

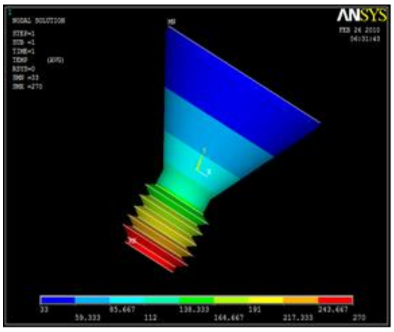

Fig : 10 Ansys Solution for Conical Muffler with fins

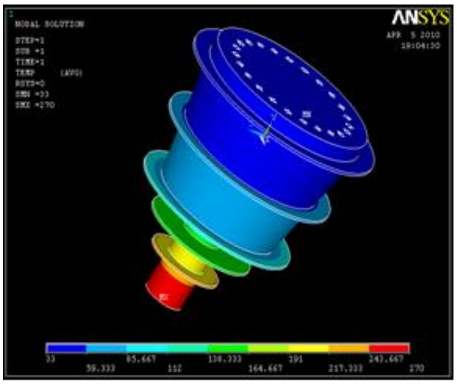

Fig : 11 Ansys Solution for Conical shape muffler with fins at the entire muffler

Checking The Feasibility Of Muffler: At the end of software analysis of these five models, the model 5 shows optimum result in all aspects, in particularly heat dissipation is uniform throughout the muffler areas and its fins. The fins are absorbed more amount of heat so that maximum heat flow to the muffler will be restricted. So it is not affected more by thermal expansion because of fins provided at the entire muffler. According to the software and experimental analysis, the heat flow in this muffler model 5 was very less. It does not allow the maximum flow through the muffler. Because the fins are absorbed the heat. So the surface does not affect by high temperature of exhaust gas. And another advantage is reduced back pressure because of conical shape of muffler. When exhaust gas comes out, due to the sudden expansion the back pressure created is stopped. This leads to increase the life of muffler.

Engine Specification

Engine type : Single cylinder four stroke Diesel Engine
Name of engine: kirloskar diesel engine
Speed : 1500 rpm
Power : 5 hp
Bore : 87.5 mm
Stroke : 110 mm
Piston displacement: 661. 5 cc
Compression Ratio : 17.5:1

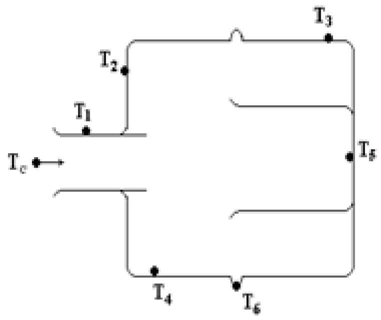

Fig : 12 Diagrammatic representation of temperatures in existing muffler

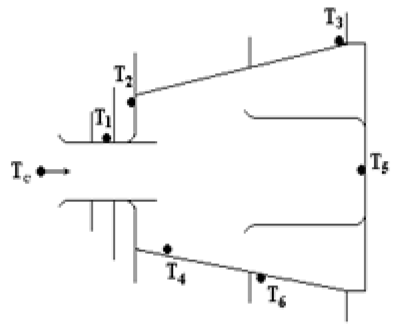

Fig : 13 Diagrammatic representation of temperatures in optimal designed muffler

From the results of software analysis and experimental setup values, the muffler model 5 has been identified as an optimum designed model which shows good result than any other model, hence model 5 (optimum designed model) was fabricated. The thermal analysis was conducted at predetermined points and results were compared with original existing muffler

Table.1.Temperature distribution of original Muffler

S.No	Current (Amps.)	Voltage (Volt)	Brake Power in KW	Muffler Temperature in °C					
				T_1	T_2	T_3	T_4	T_5	T_6
1	0	230	0	99	90	108	95	122	110
2	0	235	0	111	121	103	110	136	112
3	1	240	0.3	117	138	133	120	150	114
4	2.5	240	0.75	135	150	140	138	172	118
5	5	242	1.525	144	164	151	166	189	140
6	5.1	244	1.525	143	168	149	170	192	147
7	5.4	244	1.525	154	161	153	172	193	146
8	7	250	2.187	167	168	167	187	219	172
9	9	249	2.801	172	223	215	201	261	197
10	11.5	240	3.45	207	227	234	215	287	199

Table.2.Temperature distribution of original Muffler

S.No	Current (Amps)	Voltage (Volt)	Brake Power in KW	Muffler Temperature in °C					
				T_1	T_2	T_3	T_4	T_5	T_6
1	0	230	0	81	90	94	80	118	115
2	0	235	0	94	108	98	106	141	116
3	1	240	0.3	84	111	104	117	156	115
4	2.5	240	0.75	115	118	96	130	177	126
5	5	244	1.525	102	148	114	142	195	128
6	5	244	1.525	105	123	117	150	202	133
7	5	244	1.525	102	148	139	149	201	158
8	7	250	2.187	114	164	125	156	220	140
9	9	249	2.801	123	186	183	170	240	170
10	11.5	240	3.45	174	210	219	199	268	187

Temperature Distribution Graph between original muffler and optimum designed muffler:

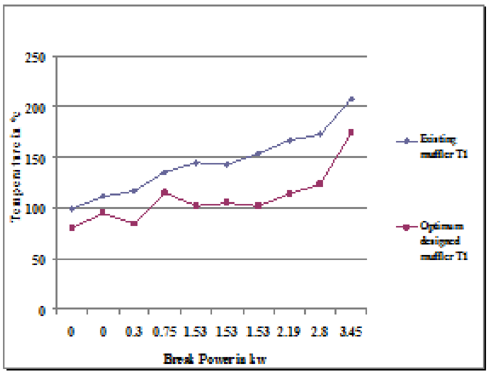

Fig :14 Temperature T_1 distribution in original and optimum designed muffler

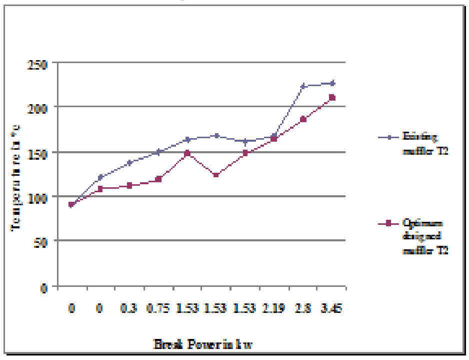

Fig :15 Temperature T_2 distribution in original and optimum designed muffler.

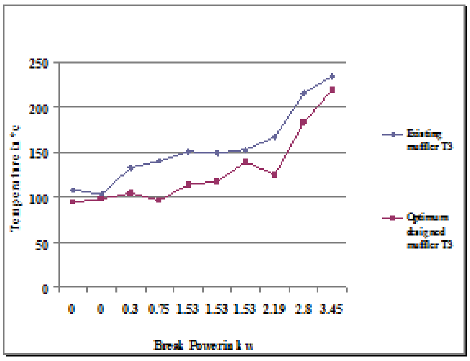

Fig :16 Temperature T_3 distribution in original and optimum designed muffler.

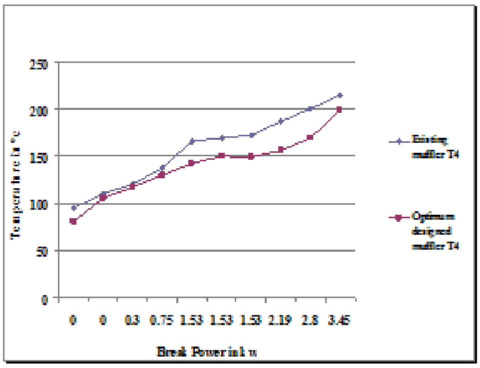

Fig :17 Temperature T_4 distribution in original and optimum designed muffler.

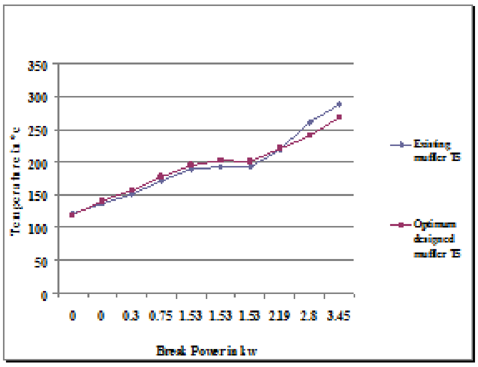

Fig :18 Temperature T_5 distribution in original and optimum designed muffler.

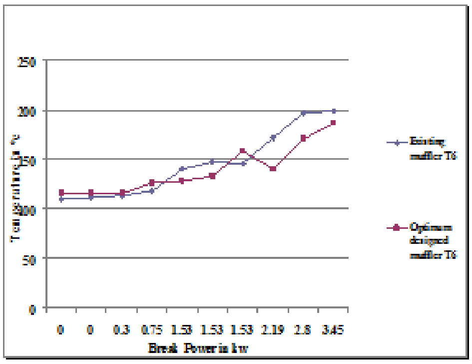

Fig :19 Temperature T_6 distribution in original and optimum designed muffler.

CONCLUSION

The following conclusions were made based on the results obtained from the experimental investigations on both the original muffler and model 5 muffler of a single cylinder diesel engine.The model 5 muffler can be replaced the original muffler. Hence, It has been identified as optimal designed muffler. The heat dissipation is quicker than the original muffler. Its value decreases about 20°C. The thermal stress and thermal expansion developed on the model 5 muffler material may be less than the original muffler. This is due to uniform distribution of heat by the fins. The muffler failures such as outlet hole expansion and cracks are reduced in the optimum designed muffler. The backpressure developed inside the muffler has reduced due to decrease of the exhaust gas velocity. In general model 5 muffler i.e., optimum design muffler improves the performance and life with a significant reduction in muffler failures

REFERENCES

A Critical Survey of Basic Theories Used in Muffler Design and Analysis

A three-dimensional finite element approach for predicting the transmission loss in mufflers and silencers with no mean flow

Anjan sarkar, S.K. Behera, A.Sarkar, Natural convection within differentially heated square enclosure with partitions', SAE international volume-90, 2009.

Beomkeum kim, seohg lee and eunhyum less, Effect of a fastener hole design of inlet flanges on the durability of the exhaust manifold for a turbo-diesel engine, SAE international, 221, 2006

Dale L.Hartsock, Analytical and Experimental Evaluation of a Thermally Insulated Automotive Exhaust System, SAE Transaction, 940312.

Daniel and Potente, General design principles for an automotive muffler, daydesign.com, volume–I, 2005

Daniel W.Wendland, Automobile Exhaust-System Steady-State Heat Transfer, SAE Transaction 931085.

Exhaust – Muffler for Engines by Milton O. Reeve and Marshal T. Reeve, of Columbus, Indiana. Patent Investigations on mufflers for internal combustion engines

No. 582, 485, dated May 11, 1897.

Pawan Kumar, Significance of the ratio of exhaust temperature to coolant temperature and Its effect on various engine working parameters', World congress on engineering, volume-II, 2009.