ISSN: 0974-5823 Vol. 7 No. 2 February, 2022

International Journal of Mechanical Engineering

Heat Transfer Investigation of Shock Absorber Test Rig with Different Damping Fluid

Ankit K. Patel

GIDC Degree Engineering College Navsari, Gujarat

Toral V. Patel

GIDC Degree Engineering College Navsari, Gujarat

Mayur J. Jalanapurkar

GIDC Degree Engineering College Navsari, Gujarat

Jigar K. Patel

Govt. Polytechnic Dahod, Gujarat

Abstract - The objective of this study is to analysis the heat transfer rate of the surface absorber body. The shock absorber test rig will develop to collect experimental data. This test rig also useful to test and indicates the condition of shock absorber. A new and modify shock absorber single/multi tube type will be used for this experiment. The problem of overheating will be effect on damping fluid characteristics and decrease shock absorber performance.

Key words- Heat transfer rate, Experimental data, Shock absorber, Shock absorber performance.

INTRODUCTION

The era of automobile started without any suspension system. Riding comfort was not available in early auto-vehicles. The whole vehicle was not supported by any mean of elastic medium. The inspection of pneumatic tyres served this purpose to some extend by providing air cushion, but this was not a complete and correct solution. The damper is the common name as shock absorber. We can, therefore, conclude that an automotive suspension system transits of mainly two arrangements viz. 1) Spring and 2) Shock absorber Suspension System plays an important role for a comfortable ride for passenger besides protecting the chassis and other working parts from getting damaged due to road shocks.[1]

Function of shock absorber: As the name implies a shock absorber has to absorb shock but technically speaking, it does not absorb road shock

I. Single Tube Shock Absorber

Functional principle of mono tube shock absorbers**:** With a one-piston shock absorber, the piston works directly in the damping case. Both, traction and also compression phase valve are integrated into the piston at the end of the piston rod. Depending on the velocity with which the shock absorber is compressed or extended, the

Forces rise. [2] A characteristic is the separating piston that separates the oil from the gas space which is under strong pressure. The gas space balances the oil expansion with temperature differences and volume changes while the piston rod retracts.

II. Twin Tube Shock Absorber

Functional principle of twin tube shock absorbers: With a Twin-Tube shock absorber, the piston works inside of an inner Tube. The space between the inner tube and the casing is used as an equalization chamber. Changes in volume due position of the piston rod change the oil level in the equalization chamber between the outer casing and inner Tube. [2]

III. Objective of the Study

- Analysis of the heat transfer rate at surface of shock absorber body.
- Analyzing alternative shock absorber damping fluid.
- To improve performance of shock absorber.

PROBLEM DEFINITION

The goal of the shock absorber is to dampen spring oscillation by converting the kinetic energy from spring movement into heat energy. In order to reduce spring oscillation, shock absorber absorbs energy. If high heat inside the absorber occurs, it will heat the damping fluid. This will change the molecular structure and density of fluid inside the absorber that cause it's damping capability to be decrease.

Heat transfer occurs when there has a temperature different in a medium or between media. When a temperature gradient exists in a stationary medium, which may be a solid or a fluid, the term conduction is used to refer to the heat transfer that will occur across the medium. The early style of shock absorber used friction to absorb the spring energy. The hydraulically shock absorber are basically oil pump that force the oil through the opening called orifice. This action generates hydraulic friction, which convert kinetic energy to heat energy as it reduces unwanted motion. The temperature of the working fluid in the liquid spring significantly alters the properties for working fluids; it is widely known that shock absorber characteristics vary with temperatures. So, the approach to counteract the problem is to improve heat transfer between Air-gap. In this research work, an objective is to improve the performance of shock absorber and maintain shock absorber performance with maximum use.

EXPERIMENTAL SETUP

I. SHOCK ABSORBER TESTER

According to experiment to produce actual damping condition of shock absorber in room it is necessary to construct a device which can produce up and down movement of shock absorber. For heat transfer study of shock absorber it is required to analyze the heat transfer rate of surface of shock absorber. The shock absorber test rig was developed to collect experimental date. [5]

II. COMPONENT OF SHOCK ABSORBER TESTER

- Electric motor
- DC Drive
- Piston crank mechanism
- RTD sensor
- Display device.

Figure 1: Experimental Set-up for Shock Absorber

THEORETICAL INVESTIGATION

The literature on Heat transfer generally recognizes three distinct mode of Heat transmission

I. CONDUCTION
II. convection and
III. radiation

Heat transmission from shock absorber oil to Body and from Body to Atmosphere is process of Conduction. Conduction is a mechanism of heat propagation from a Region of Higher temperature to a region of low temperature within a medium (solid, liquid, gaseous) or between different medium in direct physical contact. Since conduction is essentially due to Random molecular motion, the concept is termed as microform of heat transfer and is usually referred to as diffusion of energy. The rate equation for flow of heat by conduction is prescribed by the Fourier Law. [7]

CALCULATION OF HEAT FLUX

$Heat\ Flux\ Q = -K\frac{\partial T}{\partial x}$

Where;

□□□□□T =Temperature difference

□X =Distance/Thickness of Shock Absorber Body

K= Thermal conductivity

A. SHOCK ABSORBER FLUID

According to the particular application, the oil type, and viscosity and density at standard temperature, may be specified. Usually a standard damper mineral oil will simply be defined by a manufacturer's reference number. For more difficult cases, low-viscosity-index synthetic oil may be required, but again indicated by a manufacturer and oil type number. Because of the considerable effect of high temperature, this reduces viscosity. It is necessary while selecting oil that viscosity variation should be less for good damping and viscosity affects minimum by temperature difference.

In experiment Shock absorber oil used is ISO 68 equivalent to SAE 20. Chemical property of shock absorber oil is shown in table

Table 2: Properties of shock absorber oil

Substance	ISO 68 oil
Formula	C25H52
Molecular Mass	305Kg/mol
Density	0.67 to0.86 g/cm
Thermal conductivity	0.15W/(mk2)
Colour	Amber

Castor oil is a vegetable oil obtained by pressing the seeds of the castor oil plant. It is a colorless to very pale yellow liquid with a distinct taste and odor once first ingested. Castor oil and its derivatives are used in the manufacturing of cold resistant plastics, brake fluids, inks, dyes, coating and lubricants etc.

Table 3: Properties of Castor Oil

Name	Castor Oil
Formula	$C_{18}H_{34}O_3$
Appearance	Yellow Colour
Melting point	−17 °C
Boiling point	88 °C
Density	991 kg/m³
Molecular Weight	298.4608 grams

EXPERIMENTAL PROCEDURE

THE EXPERIMENTAL SET UP INVOLVES FOLLOWING STEPS:

I. The shaft is driven through a single-phase DC motor.

II. The three phase DC motor speed is controlled by DC Drive System.

III. From these the shaft is driven at constant rpm.

IV. As the single slider crank mechanism is connected to the shaft, mechanism rotates from which the rotary motion is converted into reciprocating motion by means of follower.

V. The follower is guided by a bush and in order to overcome any distortion, side frames are welded to that.

VI. The shock absorber, which is subjected to both compressive and tensile force.

VII. The shock absorber is fitted in the air gap on the tester.

VIII. Measure the temperature of the shock absorber surface at all RTD sensor.

IX. Ensure that shock absorber oil seal and sensor works properly.

X. Keep the distance while starting the process and calculate the temperature of shock absorber after estimated cycles.

XI. Sensors are used to get output.

XII. On add another oil to check and repeat above process again.

From the value, the performance testing of the shock absorber is derived

CALCULATION AND DISCUSSIONS

Shock Absorber without Substance

The testing of shock absorber is started with getting the early absorber performance. Before the experiment is started, the room temperature and surface temperature of the absorber was measured. The experiment is started to make 100 cycles of bounce and jounce for 10 times.

Surface temperature will be measure after the end of each experiment. The results are shown as follow:

Room temperature: 32.3°C

Early temperature at the P: 32.4 °C

Early temperature at the Q: 32.2 °C

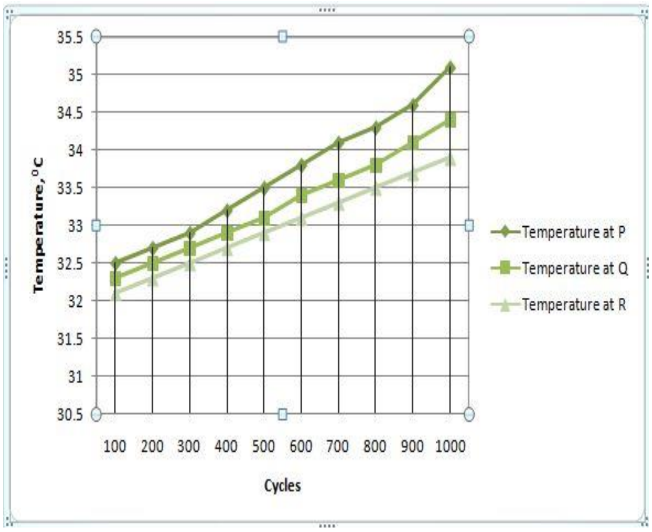
Early temperature at the R: 31.9 °C

Table 4: A Rising Temperature of shock absorber with air substance

Exp	Cycle	Temperature		
		P	Q	R
1	100	32.5	32.3	32.1
2	200	32.7	32.5	32.3
3	300	32.9	32.7	32.5
4	400	33.2	32.9	32.7
5	500	33.5	33.1	32.9
6	600	33.8	33.4	33.1
7	700	34.1	33.6	33.3
8	800	34.3	33.8	33.5
9	900	34.6	34.1	33.7
10	1000	35.1	34.4	33.9

From the recorded data, the graph of temperature against number of cycle can be plotted to show how the temperature rising at the 3 different points.

Figure 2: Graph of Temperature versus Number of Cycle with Air Substance



From the result and graph plotted above, it shows that the early temperature at the three points is similar with the room temperature. The temperature for the three places on the surface absorber is increases with number of cycle. This shows that the absorber is heated when it is operate.

As the piston compress and expand to absorb the shock, it will give a force to the oil inside the absorber. The friction force will occur at the piston surface and this friction force will transfer to heat energy around the surface cylinder. The arising temperature after 1000 cycle of bounce and jounce shown in table,

Table 5: Temperature difference of shock absorber with air substance

Temperature	Before Exp	After Exp	Temperature difference
Temperature at point P	32.435.1		2.7
Temperature at point Q	32.234.4		2.2
Temperature at point R	31.933.9		2.0

Maximum heat flux for experiment using air substance is 4.129 W/ (mk²).

II. SHOCK ABSORBER WITH CASTOR OIL

In order to improve the heat transfer inside the absorber, Castor oil is use as a second substance insert inside the absorber to fill the air gap between the internal cylinder (which contains piston and damping fluid) and outside cylinder. Its characteristic is shown as below,

Table 6: Properties of Castor Oil

Name	Castor Oil
Formula	$C_{18}H_{34}O_3$
Appearance	Yellow Colour Viscous Liquid
Melting point	−17 °C
Boiling point	88 °C
Thermal conductivity	0.180 W/m K
Density	991 kg/m³
Molecular Weight	298.4608 grams

Table 7: Arising temperature of shock absorber with Castor Oil

p	Cycle	Temperature		
		P	Q	R
1	100	35.4	35	34.5
2	200	35.7	35.4	34.8
3	300	36.3	35.7	34.9
4	400	36.3	35.9	35.1
5	500	36.3	35.9	35.1
6	600	36.8	36.3	35.2
7	700	37.2	36.5	35.4
8	800	37.3	36.7	35.7
9	900	37.6	36.8	35.9
10	1000	37.8	36.9	35.9

Figure 3: Temperature versus number of cycle with Castor Oil.

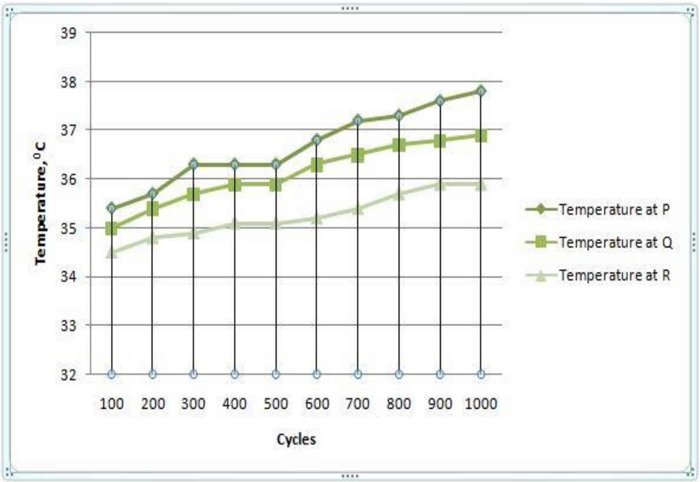


Table 8: Temperature difference of shock absorber with Castor Oil.

Temperature	Before Exp	After Exp	Temperature difference
Temperature at point P	33.3	37.8	4.5
Temperature at point Q	33.4	36.9	3.5
Temperature at point R	33.2	35.9	2.7

Maximum heat flux for experiment using castor oil is 47.647 (W/ (mk²)).

DISCUSSION

From the analysis of shock absorber with using substances like Air substance, Castor oil, give the obvious difference of increasing temperature at surface body. It becomes a major parameter in this research work of air-gap investigation. It is obviously shows that the arising temperature for modify design is much better than the aftermarket design. This is because the substances have a high thermal conductivity than the air. The substances help to transfer the heat inside the absorber through the outside body proportionate with air. From experiment the result shown in table is obtained.

Table 9: Heat Flux of Substances

Substances	Heat Flux ($WM^{-2}k^{-2}$)
Air	4.129
Castor Oil	47.647

CONCLUSIONS

As the absorber operates, it will become heated. If the heat cannot be transfer very well through the surrounding, it will heated the damping fluid inside the absorber thus changes the damping fluid characteristic and decreasing the absorber performance. In order to overcome this problem, a substance that has a high thermal conductivity must be added inside the absorber. After theoretical calculations and graph analysis following conclusions have been made:

Using Castor oil as a substance can improve the heat transfer inside the absorber up to 12.49 %

REFERENCES

[1] Binfa Bongfa, Abolarin, M. S., Aboh ,"Possibilities Of Vegetable Oils As Base Oils For Automobile Shock Absorber Fluids " *International Journal of Scientific & Engineering Research,* Volume 6, Issue 4, April-2015,950-956.

[2] Avinasha B, Shyam Sundar Sb, K V Gangadharana, "Experimental study of damping characteristics of air, silicon oil, magneto rheological fluid on twin tube damper " International Conference on Advances in Manufacturing and Materials Engineering, AMME 2014,Procedia Materials Science 5 (2014) 2258 – 2262.

[3] Deep R. Patel, Pravin P. Rathod, Arvind S. Sorathiya,"Analysis and improvement of air-gap between internal cylinder and outer body in automotive shock absorber" International Journal of Engineering Research & Technology,Vol. 1 Issue 3, May – 2012,1-7.

[4] H. R. Sapramer and Dr. G. D. Acharya,,"Test Rig Design for Measurement of Shock Absorber Characteristics" International Journal of Research Publications in Engineering and Technology ,Volume 3, Issue 3, March-2017 ,108-111.

[5] M.S.M.Sani, M.M. Rahman, M.M.Noor, "Study on Dynamic Characteristics of Automotive Shock Absorber System", Malaysian Science and Technology Congress, MSTC08, 16-17 Dec, KLCC, Malaysia, 2008, 623-628.

[6] Mr. Sudarshan Martande, Mr. Y. N. Jangale, "Design and Analysis of Shock Absorber", International Journal of Application or I nnovation in Engineering & M anagement,Volume 2, Issue 3, March 2013,195-199.

[7] Santhosh Sivan. K, Chandrasekar Sundaram and Hari Krishnan. R,"Smart Fluid Self Adaptive Damper System",International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.3, No.4, November 2014,17-23.

[8] Haycock, R F., & Hillier, J. E. "Automotive Lubricants Reference Book", Inc, Warrendale, USA, SAE International, (2004), ISBN 0-7680-1251-1

[9] J.C.Ramos,A.Rivas,J.Biera,G.Sacramento and J.A.Sala."Development of a Thermal Model for Automotive Twin-Tube Shock Absorbers".Journal Applied Thermal Engineering 25(2005) 1836-1853.

[10] W. Schiehlen and B.Hu. "Spectral Simulation andShock Absorber Identification",International Journal of Non-Linear Mechanics. Volume 38, Issue 2, March 2003, Pages 161-171.

[11] Hussein Mohammed, Hanim Salleh, Mohd Zamri Yusoff, "Design and fabrication of coaxial surface junction thermocouples for transient heat transfer measurements", International Communications in Heat and Mass Transfer 35 (2008) 853–859.

[12] Prashant Mulik1 E. N. Aitavade"Mathematical Modeling and Experimental Validation of Modification of mono-Tube Shock Absorber" Ijsrd - International Journal for Scientific Research & Development| Vol. 4, Issue 04 , 2016,1154-1157.

[13] Sharp, R. S. and Crolla, D.A., "Road Vehicle Suspension System Design-Review", Vehicle System Dynamics, 16, 1987, 167-192.

[14] Mollica R., Youcef-Toumi K., "A Nonlinear Dynamic Model of a Monotube Shock Absorber", Proceedings of American Control Conference, Albuquerque, NM, June 1997, 704-708.

[15] Sehgal.P, Kumar.B, Sharma.M, Salameh A.A, Kumar.S, Asha.P (2022), Role of IoT In Transformation Of Marketing: A Quantitative Study Of Opportunities and Challenges, Webology, Vol. 18, no.3, pp 1-11

[16] Kumar, S. (2020). Relevance of Buddhist Philosophy in Modern Management Theory. Psychology and Education, Vol. 58, no.2, pp. 2104–2111.

[17] Roy, V., Shukla, P. K., Gupta, A. K., Goel, V., Shukla, P. K., & Shukla, S. (2021). Taxonomy on EEG Artifacts Removal Methods, Issues, and Healthcare Applications. Journal of Organizational and End User Computing (JOEUC), 33(1), 19-46. http://doi.org/10.4018/JOEUC.2021010102

[18] Shukla Prashant Kumar, Sandhu Jasminder Kaur, Ahirwar Anamika, Ghai Deepika, Maheshwary Priti, Shukla Piyush Kumar (2021). Multiobjective Genetic Algorithm and Convolutional Neural Network Based COVID-19 Identification in Chest X-Ray Images, Mathematical Problems in Engineering, vol. 2021, Article ID 7804540, 9 pages. https://doi.org/10.1155/2021/7804540

[19] Nitinkumar Anekar1, V.V. Ruiwale, Shrikant Nimbalkar, "Design and Testing Of Unbalanced Mass Mechanical Vibration Exciter",International Journal of Research in Engineering and Technology Eissn: 2319-1163 | Pissn: 2321-7308.

[20] Adrian Simms and David Crolla, "The Influence of Damper Properties on Vehicle Dynamic Behaviour" Technical Paper Series, 2002-01-0319.

[21] De Espíndola, J. J., Bavastri C. A., & Eduardo M. D. L. "Design of Optimum Systems of Viscoelastic Vibration Absorbers for a Given Material Based on the Fractional Calculus Model", Journal of Vibration and Control, vol. 14 no. 9-10 ,(2008) , 1607-1630.

[22] Carlson J David.,Jolly Mark R.,Bender Jonathan W., "Properties and Applications of commercial Magneto-rheological Fluid" ,Journal of Intelligent material systems and structures. Vol. 10, 1999, 1-5.