Heat Transfer Study of Damping Fluid and improvement of Air-gap in shock absorber operation

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Abstract

The aim of this research work is to Study the Heat Transfer from the Damper fluid to Shock Absorber body and from body to surround, to fulfil this objectives Shock Absorber test Rig was constructed. Most of shock absorber contains the air gap inside the shock absorber between internal cylinder and outer body, Air gap has lower heat transfer rate, and so Problem of overheating will be effect of damping fluid characteristics and decrease shock absorber performance, to improve heat transfer air gap is filled by fluid substance like turpentine, methanol and Water with coolant and collect Required data of improved Heat Transfer into Shock Absorber , Finally turpentine and methanol increase heat transfer but water with coolant give maximum heat transfer rate. With increase heat transfer rate from inside absorber to surroundings problem of overheating of damper fluid should be decrease and shock absorber performance increase.

Keywords— *Shock Absorber, Fluid Substance, Shock absorber test rig.*

1. Introduction

The Automobile chassis is or body mounted on Axels but not directly but through some form of spring to provide Safety and Comfort. This spring system called suspension system. Following objectives of suspension system,

1. To prevent shocks from Rough road.
2. To preserve stability while rolling & pitching during vehicle in motion.
3. To give comfort & smooth ride.

The energy of road shock causes the spring to oscillate, this oscillation are Restricted to a reasonable level by Shock absorber. The purpose of Shock Absorber is to dissipate any energy into vertical motion of body or any motion arises from rough road.

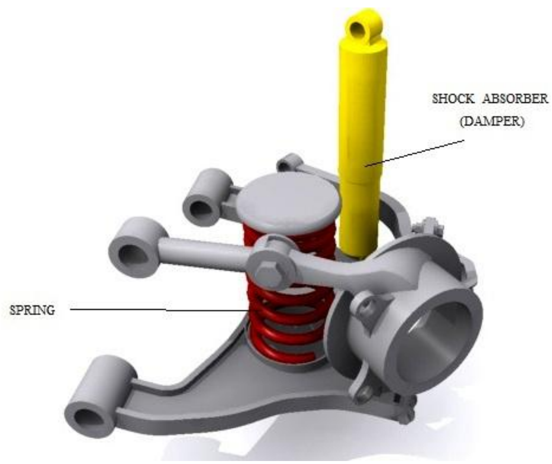


Figure 1 Suspension Unit

The removal of damper from suspension system can cause the vehicle Bounce up and down, and uncomfortable ride in order to reduce spring oscillation shock absorber absorbed energy. The shock absorber absorb different amount of energy depend on vehicle driving pattern and road condition. Shock absorber used fluid friction to absorb the spring energy. The shock absorber is 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 , If high Heat inside the absorber occurs, it will heat the damping fluid this can change the damping fluid property and also damping capacity decrease. Heat transfer occurs when there has temperature difference when shock absorber absorbed shock on Road and change the kinetic energy into heat energy. The temperature of working fluid in the damper significantly alters the property of working fluid. It is widely known that shock absorber configuration change with change in temperature.

2. 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. Shock absorber tester was developed for this purpose. The shock absorber test rig was developed to collect experimental date.

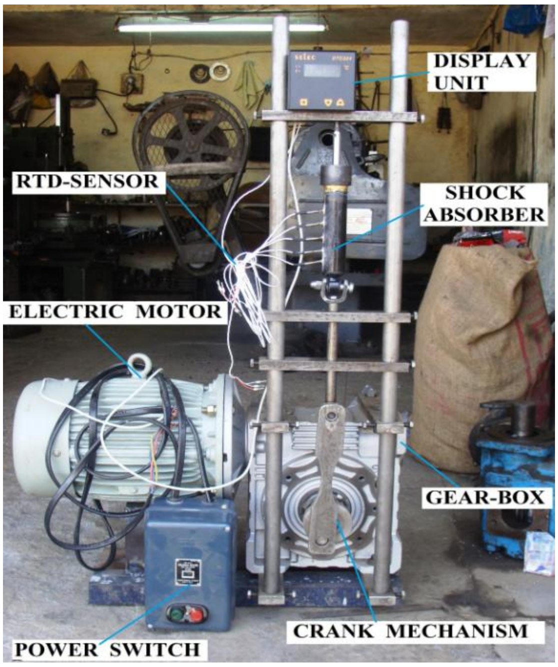


Figure 2 shock absorber test rig.

As shown in figure that the structure will consist of strong policed bar which supported on gearbox body. Strong bar which is tied together with a strong top plate. One plate is placed on guide shaft which can be adjustable according to height of shock absorber. For up and down of shock absorber crank mechanism used to sliding steel rod connected with connecting rod and revolve according to crank mechanism. One end of absorber body fitted on top plate in which internal grooves developed according to thread of rod of absorber, and another end fitted at the end of sliding rod. The 3-phase motor directly mounted on gearbox flies and gear box supported on base steel channels.

3. RTD Sensor

In order to estimate the absolute temperature of shock absorber RTD (resistant temperature detection) is used and brazed on the surface of shock absorber to measure surface temperature. RTDs are temperature sensors that contain a sensing element whose resistance change with temperature. According to our use in experiment 3 Wire configurations is comfortable with display unit. This is the standard wire configuration for most RTDs. It provides one connection to one end and two to the other end of the RTD sensor. Connected to an instrument designed to accept three-wire input, compensation is achieved for lead resistance and temperature change in lead resistance. This is the most commonly used configuration.

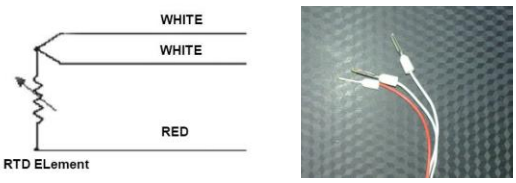


Figure 3 RTD sensors with line diagram

In display unit as show in figure RTD wire connected and unit powered by ac supply .as per our requirement five RTD sensor brazed on shock absorber surface. Brazing is a method of joining two pieces of metal together with a third, molten filler metal.

4. Shock Absorber Modification

Mostly common double tube shock absorber, According to our requirement to change and fill damping oil and additives shock absorber top is not welded but additional threads are machined on shock absorber body threaded and one cover is developed which fitted on threads and sliding rod passed in the cover Teflon tap is wound on threads so good sealing is conducted and problem of oil leakage is overcome which act as seal, so removal and filling of oil is easy, as shown in figure.

Figure 4 Shock Absorber Modifications

5. Result and Discussion

Shock Absorber with Air Substance

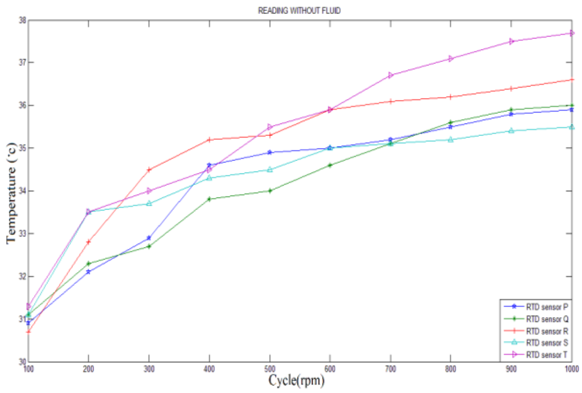
The testing of shock absorber is started with getting the early absorber performance. Before the experiment is started, the room temperature and surface temperature of the absorber was measured. The experiment is started to make 100 cycles of bounce and jounce for 10 times. Surface temperature will be measure after the end of each experiment. The results are shown as follow:

Room temperature: 31.3 °C
Early temperature at the P: 30.6°C
Early temperature at the Q: 30.8°C
Early temperature at the R: 29.9 °C
Early temperature at the S: 30.6 °C
Early temperature at the T: 30.9 °C

Exp	Cycle	Temperature				
		P	Q	R	S	T
1	100	30.9	31.1	30.7	31.1	31.3
2	100	32.1	32.3	32.8	33.5	33.5
3	100	32.9	32.7	34.5	33.7	34
4	100	34.6	33.8	35.2	34.3	34.5
5	100	34.9	34	35.3	34.5	35.5
6	100	35	34.6	35.9	35	35.9
7	100	35.2	35.1	36.1	35.1	36.7
8	100	35.5	35.6	36.2	35.2	37.1
9	100	35.8	35.9	36.4	35.4	37.5
10	100	35.9	36	36.6	35.5	37.7

Table 1: Arising temperature of shock absorber with air substance

From the recorded data, the graph of temperature against number of cycle can be plotted to show how the temperature rising at the 5 different points



Graph 1: Arising temperature of shock absorber with air substance.

From the result and graph plotted above the temperature for the five places on the surface absorber are increases with number of cycle. This shows that the absorber is heated when it is operate.

Calculation of Heat Flux:-

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

Where;

∂T = Temperature difference (°C)

∂X= Distance/ Thick of absorber body (M)
K=Thermal Conductivity (W/(mk))

At point P:
q x” = (-0.026) [(-5.3)/ (0.017)]
=8.10(W/ (mk²))

At point Q:
q x” = (-0.026) [(-5.2)/ (0.017)]
=7.95(W/ (mk²))

At point R:
q x” = (-0.026) [(-6.7)/ (0.017)]
=10.2(W/ (mk²))

At point S:
q x” = (-0.026) [(-4.5)/ (0.017)]
=6.72(W/ (mk²))

At point T:
q x” = (-0.026) [(-6.8)/ (0.017)]
=10.4W/ (mk²))

Maximum heat flux for experiment using air substance is 10.4W/ (mk²)).

Shock Absorber with Turpentine

Turpentine is use as a first substance insert inside the absorber to fill the air gap between the internal cylinder (which contains piston and damping fluid) and outside cylinder. Turpentine characteristic is shown as below:

Substance	Turpentine
Boiling Point	154-170(°C)
Melting Point	-60 to -50 (°C)
Density	0.854-0.868(g/cm³ at 20°C)
Colour	Colourless liquid
Chemical formula	$C_{10}H_6$
Thermal conductivity	0.136(W/ (mk))

Table 2: Properties of Turpentine.

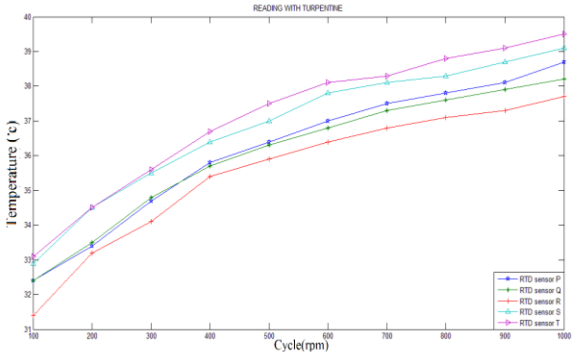
The room temperature and surface temperature of the absorber was measured in the beginning. The experiment is started to make 100 cycles of bounce and jounce for 10 times. Surface temperature will be measure after the end of each experiment. The results are shown as follow;

Room temperature: 33.9 °C
Early temperature at the P: 34.1°C
Early temperature at the Q: 34°C
Early temperature at the R: 33.9 °C
Early temperature at the S: 34.2 °C
Early temperature at the T: 34.2 °C

Exp	Cycle	Temperature				
		P	Q	R	S	T
1	100	32.4	32.4	31.4	32.9	33.1
2	100	33.4	33.5	33.2	34.5	34.5
3	100	34.7	34.8	34.1	35.5	35.6
4	100	35.8	35.7	35.4	36.4	36.7
5	100	36.4	36.3	35.9	37	37.5
6	100	37	36.8	36.4	37.8	38.1
7	100	37.5	37.3	36.8	38.1	38.3
8	100	37.8	37.6	37.1	38.3	38.8
9	100	38.1	37.9	37.3	38.7	39.1
10	100	38.7	38.2	37.7	39.1	39.5

Table 3: Arising temperature of shock absorber with air substance

From the recorded data, the graph temperature against number of cycle can be plotted to show how the temperature rising at the 5 different points.



Graph 2: Graph temperature versus number of cycle with Turpentine substance

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

Arising temperature after 1000 cycle of bounce and jounce shown in table,

Calculation of Heat Flux:-

At point P:
q x” = (-0.136) [(-8.3)/ (0.017)]
=66.4(W/ (mk²))

At point Q:
q x” = (-0.136) [(-7.4)/ (0.017)]
=59.2(W/ (mk²))

At point R:
q x” = (-0.136) [(-6.6)/ (0.017)]
=52.8(W/ (mk²))

At point S:

q x" = (-0.136) [(-8.3)/ (0.017)]
=66.4(W/ (mk²))
At point T:
q x" = (-0.136) [(-8.4)/ (0.017)]
=67.2(W/ (mk²))
Maximum heat flux for experiment using turpentine is 67.2(W/ (mk²)).

Shock Absorber with Methanol

Methanol 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. Turpentine characteristic is shown as below:

Substance	Methanol
Boiling Point	75-85(°C)
Melting Point	-50 to -45 (°C)
Density	782 kg/m³
Colour	Colourless liquid
Chemical formula	CH_3OH
Thermal conductivity	0.203(W/ (mk))

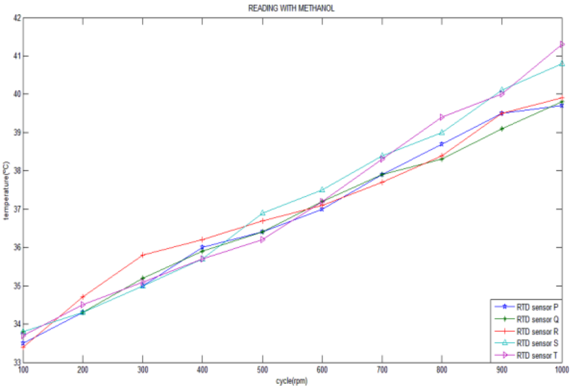
Table 4: Properties of Methanol.

The room temperature and surface temperature of the absorber was measured in the beginning. 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: 32.1°C
Early temperature at the Q: 32.1°C
Early temperature at the R: 32.3°C
Early temperature at the S: 32.5°C
Early temperature at the T: 32.7°C

Exp	Cycle	Temperature				
		P	Q	R	S	T
1	100	33.5	33.8	33.4	33.8	33.7
2	100	34.3	34.3	34.7	34.3	34.5
3	100	35	35.2	35.8	35	35.1
4	100	36	35.9	36.2	35.7	35.7
5	100	36.4	36.4	36.7	36.9	36.2
6	100	37	37.2	37.1	37.5	37.2
7	100	37.9	37.9	37.7	38.4	38.3
8	100	38.7	38.3	38.4	39	39.4
9	100	39.5	39.1	39.5	40.1	40
10	100	39.7	39.8	39.9	40.8	41.3

Table 5: Arising temperature of shock absorber with methanol

From the recorded data, the graph temperature against number of cycle can be plotted to show how the temperature rising at the 5 different points.



Graph 3: Graph temperature versus number of cycle With Methanol.

From the result and graph plotted above, it shows that the early temperature at the five points is similar with the room temperature. The temperature for the five places on the surface absorber is increases with number of cycle. This shows that the absorber is heated when it is operate.
Calculation of Heat Flux:-
At point P:
q x" = (-0.136) [(-7.6)/ (0.017)]
=90 (W/ (mk²))
At point Q:
q x" = (-0.136) [(-7.5)/ (0.017)]
=89 (W/ (mk²))
At point R:
q x" = (-0.136) [(-7.3)/ (0.017)]
= 93.14(W/ (mk²))
At point S:
q x" = (-0.136) [(-8.3)/ (0.017)]
=99 (W/ (mk²))
At point T:
q x" = (-0.136) [(-8.6)/ (0.017)]
=102.6 (W/ (mk²))
Maximum heat flux for experiment using methanol is 102.6(W/ (mk²)).

Shock Absorber with an engine coolant with water

An engine coolant with water is use as a third substance insert inside the absorber to fill the air gap between the internal cylinder (which contains piston and damping fluid) and outside cylinder.

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The engine coolant with water characteristic is shown as below:

Substance	engine coolant with water
Boiling Point	100 °C
Melting Point	0°c
Density	0.998(g/cm3 at 20°C)
Colour	Light green liquid
Chemical formula	H_2O
Thermal conductivity	0.672W/(mk)

Table 6: Properties of Water with coolent

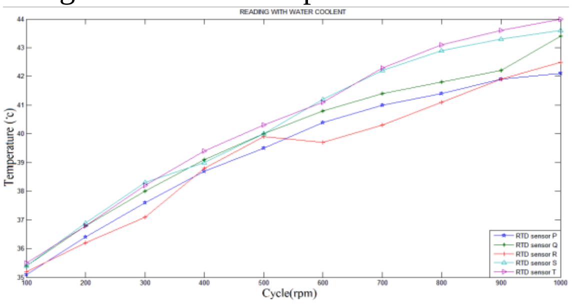
The room temperature and surface temperature of the absorber was measured in the beginning. The experiment is started to make 100 cycles of bounce and jounce for 10 times. Surface temperature will be measure after the end of each experiment. The results are shown as follow;

Room temperature: 33.9 °C
Early temperature at the P: 34.1°C
Early temperature at the Q: 34°C
Early temperature at the R: 33.9 °C
Early temperature at the S: 34.2 °C
Early temperature at the T: 34.2 °C

Exp	Cycle	Temperature				
		P	Q	R	S	T
1	100	35.1	35.4	35.2	35.4	35.5
2	100	36.4	36.8	36.2	36.9	36.8
3	100	37.6	38	37.1	38.3	38.2
4	100	38.7	39.1	38.8	39	39.4
5	100	39.5	40	39.9	40	40.3
6	100	40.4	40.8	39.7	41.2	41.1
7	100	41	41.4	40.3	42.2	42.3
8	100	41.4	41.8	41.1	42.9	43.1
9	100	41.9	42.2	41.9	43.3	43.6
10	100	42.1	43.4	42.5	43.6	44

Table 7: Arising temperature of shock absorber with an engine coolant with water

From the recorded data, the graph temperature against number of cycle can be plotted to show how the temperature rising at the 5 different points.



Graph 4: Graph temperature versus number of cycle for coolant substance

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

Calculation of Heat Flux:-

At point P:
q x" = (-0.67) [(-8)/ (0.017)]
=315.2(W/ (mk²))

At point Q:
q x" = (-0.67) [(-9.4)/ (0.017)]
=370.02(W/ (mk²))

At point R:
q x" = (-0.67) [(-8.4)/ (0.017)]
=331.8(W/ (mk²))

At point S:
q x" = (-0.67) [(-9.4)/ (0.017)]
=370.02(W/ (mk²))

At point T:
q x" = (-0.67) [(-9.8)/ (0.017)]
=386(W/ (mk²))

Maximum heat flux for experiment using Water and coolant is 386(W/ (mk²)).

From the analysis of shock absorber result with different substance, the obvious difference of increasing temperature at surface body of the absorber become a major parameter in this analysis. Based on the result that the temperature rising for the modify design is better than the aftermarket design. From the calculation based on the data that has been gathered from the experimental, maximum Heat flux with modify design using turpentine as the substance and aftermarket design that contain the air gap inside the shock absorber is 67.2(W/ (mk²)). , maximum Heat flux with modify design using methanol as the substance and aftermarket design that contain the air gap inside the shock absorber is 102.6(W/ (mk²)). Maximum Heat flux with modify design using methanol as the substance and aftermarket design that contain the air gap inside the shock absorber is 386(W/ (mk²)). From the experimental and analysis, it is obviously shows that the arising temperature for modify design is much better than the aftermarket design.

This is because the Turpentine Methanol and water with coolant has a high thermal conductivity than the air. The turpentine methanol and water with coolant improve transfer the heat internal cylinder to outer body of the absorber. Using turpentine, water with coolant and methanol as the substance to fill the air gap inside the absorber can give a more improvement to the absorber. The higher temperature rising at the surface body of the absorber gives higher advantage to the absorber. This is because the temperature is transfer out of the absorber and prevents the overheating of damping fluid inside the absorber. These prevent the damping fluid from changing its properties and maintain the performance of the absorber for a long time.

6. Conclusion

The purpose of this research work is to test and analyse the absorber using the different working fluids. As the absorber operates, it will become heated. If the heat cannot be transfer very well through the surrounding, it will heated and effect the damping fluid inside the absorber thus changes the property and decreasing the absorber performance and result in overheating. to overcome this problem of overheating, a substance that has a high thermal conductivity must be added inside the absorber. Many existence absorbers have an air gap between the internal cylinder and outside body of the absorber. The air which is a poor substance for transfer of heat, Using water with coolant, turpentine, methanol to improve air-gap can give better heat transfer. This is because turpentine, methanol and, water with coolant has a higher thermal conductivity than air-gap this shows that with increase rate of heat flux also improve the heat transfer inside the absorber and the absorber will have a long time usage.

7. Future Scope

After completing the research work, following future scope has been summarized.

1. Improvement in shock absorber fluid, and additive or substance for increase heat transfer should be obtained.
2. The top cylinder ends of shock absorber body are mostly pressed from steel sheet, which cannot be further use, so which replaced by metal cover which give direction to reuse.

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