Temperature Reduction of Active Shock Absorber Using Automotive Air Conditioning System

Saurabh R. Kulkarni[1], G. N. Deshpande[2]
[1]*Member, Shreeyash College of Engineering and Technology, Aurangabad, MH.*
[2] *Assistance professor, Shreeyash College of Engineering and Technology, Aurangabad, MH.*

Abstract— **In this paper, automotive air conditioning system coupling with the shock absorber cooling system is proposed for the thermal management of passenger cars. Based on the terrain and operating conditions, the heat generated from the shock absorber is applied to preheat the mixed refrigerant on heating mode, to reheat the cold refrigerant on cooling mode, and to exhaust to the refrigeration system. A numerical simulation has been carried out to analyze the performance of the integrated system. The results show that the heat extracted from the shock absorber can be used to preheat the refrigerant while entering into the compressor. This serves two purposes, primarily it reduces the temperature of shock absorber which minimizes the failures of its functions like damping and secondary it increases the efficiency of the air conditioning system.**

Index Terms- **Automotive Air Conditioning System, Shock Absorber, Temperature, Damping, Efficiency.**

I. INTRODUCTION

In these days passenger safety is the major concern for all the vehicle manufacturers. This includes using of high strength materials, which subsequently adds the weight of the vehicle. To support these heavy weights, more stiffen coil springs needs to be used. Because of which high amplitude oscillations generated and to dampen those, high damping force dampers needs to be used. Which results in higher temperature generations. Temperature failures are the major failure mechanism for the shock absorbers. Because of which damper loses its primary functions i.e. damping force generation. Elastomers inside it starts to melt because of high temperature and those melted particles will get trapped inside the rebound and compression valves. In many scenarios it creates serious damage to the piston band and this results into noise and oil leakage problems.

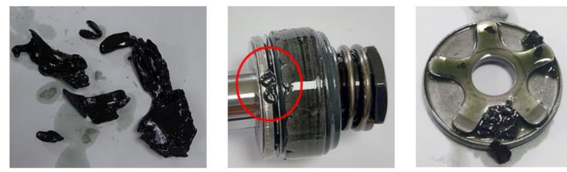

Figure 1: Damper failure because of excessive temperature

II. RESEARCH METHODOLOGY

To demonstrate this, experiment is performed in four stages.

A. Data collection

In first stage vehicle is taken and temperature of damper at various positions is measured in all terrain and operating conditions. Position of thermocouples decided based on the max wheel travel and damper travel instances.

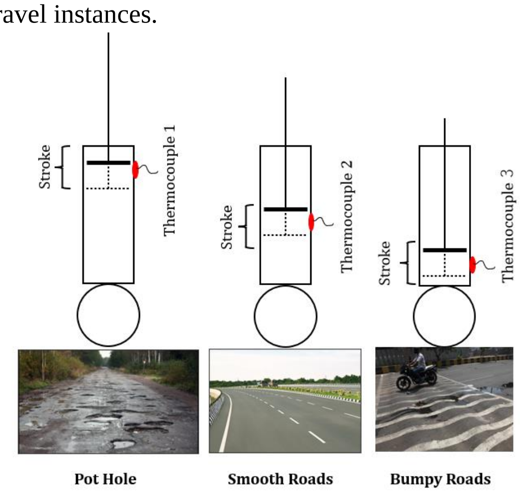

Figure 2: Thermocouple mounting locations.

During the large pot hole condition piston will reciprocates in top portion of the shock absorber body. Hence one thermocouple mounted over top side of the shock absorber body. During the high speed and smooth road surfaces, wheel travel is very less and hence piston will only be reciprocating in middle portion of the shock absorber body. To capture the temperature in this zone second thermocouple is mounted at the middle portion of the damper body. When vehicle passes over major bumps or speed brakers, piston generally reciprocates at the lower side of the shock absorber body and hence third thermocouple is mounted at the bottom side of damper body. (Refer Figure 2.)

For recording the operating temperatures of shock absorbers hilly road were chosen which were the mixture of pot holes, smooth roads and bumpy terrains. Minimum 250km were drove in single run to capture the worst-case scenarios. Basis thermal range is plotted and it is observed that for the 90% scenarios damper is operating in the range of 60-80°C. and for remaining 10% it was operating in the range of 80-105°C.

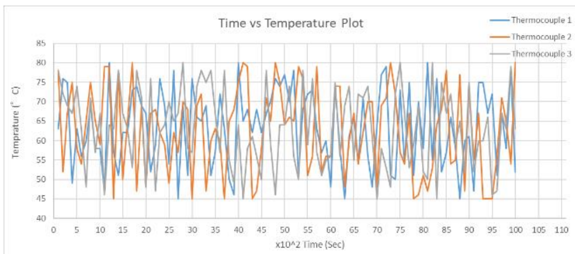

Figure 3: Recorded thermocouple temperatures.

B. Numerical Calculations

In second stage of this research numerical calculations performed to calculate the size of the cooling jacket and flow rate of the refrigerant require to maintain the temperature of damper body less than 75°C. Based on which cooling jacket design made.

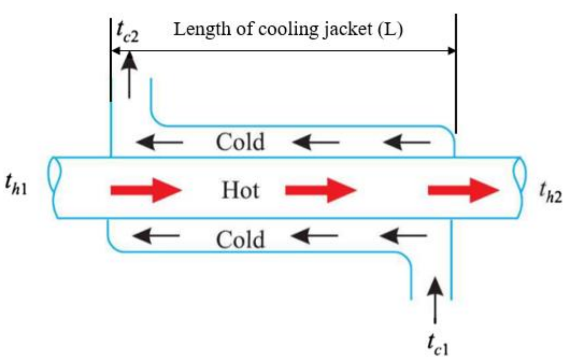

Figure 4: Freebody diagram for numerical calculations

Calculate heat transfer rate of cooling jacket= Qc

Qc=Mc*Cp*(Tco-Tci)

Qc=0.02*4.187*(15-2)

Qc=1.1 kJ/s

Heat loss by hot body = Heat gain by cold body

Qc=Qh

Mh*Cp*(Tci-Tco)= Mc*Cp*(Tco-Tci)

Mh=0.043Kg/s

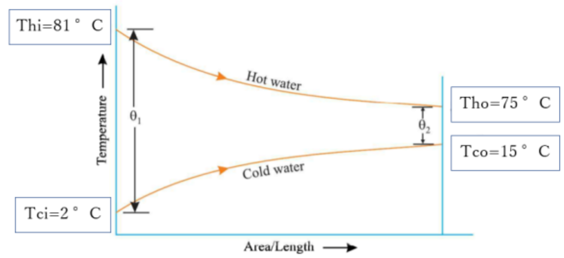

Figure 5: Logarithmic mean temperature

Calculate logarithmic mean temperature= Tm

Tm=(Theta 1- Theta 2)/Ln(Theta 1/ Theta 2)

Tm=69.1°C

Calculate overall heat transfer coefficient =U

1/U=(1/Hi)+(1/Ho)

U=350 W/m2°C

Calculate the length of cooling jacket to achieve required temperatures.

Q=U*A*Tm

A=Q/(U*Tm)

A=1.1x10^3/(350*69.1)

A=0.05 m2

L=A/pi*Damper OD

L=0.05/pi*41.3

L=385mm

C. Modeling and Analysis

In the third stage of the research, an experiment is performed to verify the temperature drop of the damper body. For which simple shell and tube heat exchange is made. In which inside tube represents the damper which was made of CEW tube and outer enclosed tube represents the cooling jacket which has two ports, i.e. inlet port through which refrigerant from evaporator will enter and out let port through which refrigerant will escape for compressor.

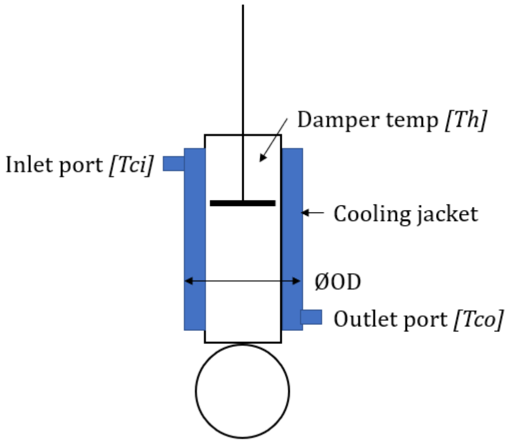

Figure 6: Construction of cooling jacket over the damper for adaptive cooling

Figure 7: Simulator used to demonstrate the experiment

D. Results and Discussion

At the output of the experiments data of temperature at various locations captured. In which temperature at exit of the evaporator tubes, at inlet and outlet port of cooling jacket, damper body at various flow rates were recorded. It is observed that with the designed cooling jacket temperature of the damper body maintain below 70°C. The results taken for various. With this elastomer inside the damper body can be redesign to lower temperature range which will reduce the cost of the compound of elastomers.

Table 1. Temperature data

Evaporator	Cooling Jacket		Damper
Outlet Port (°C)	Inlet Port (°C)	Outlet Port (°C)	Surface (°C)
2.1	2.354	7.168	69.87
1.4	1.544	8.526	67.21
1.2	1.423	10.25	62.21
0.98	1.127	11.59	59.88

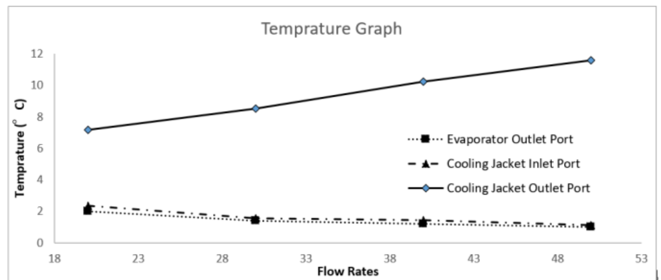

Figure 8: Temperatures at various ports.

III. CONCLUSION

With the above experiment it proved that integration of automotive refrigeration system with shock absorber cooling system can effectively reduce the shock absorber temperature which will increase the life and durability of the shock absorbers. In addition to that, with the lower operating temperature range elastomers inside the damper can be redesigned for lower temperatures which will reduce the cost and carbon footprints.

Although the cost of the system for the production version may high because of the various integration devices, this system would be effective for the active as well as semi active dampers where the cost of the dampers itself is very high. This will reduce the potential risk of damaging the expensive suspension system and performance of the vehicle.

REFERENCES

[1] Jensen JO, Vestbo AP, Li Q, Bjerrum NJ. The energy efficiency of on board hydrogen storage. J Alloys Compd 2007;446e447:723e8.

[2] Friedlmeier G, Schaaf M, Groll M. How to measure pressure concentration- isotherms

representative for technical applications. Z Phys Chem 1994;183:185e95.

[3] N. Sato. Thermal behavior analysis of lithium-ion batteries for electric and hybrid vehicles. Journal of Power Sources, 2001; 99:70-77.

[4] Z.Rao, SH.W. Experimental investigation on thermal management of electric vehicle battery with heat pipe. Energy Conversion and Management. 2013; 65:92□97.

[5] Bhatti MS. Evolution of automotive heating□riding in comfort: Part I. ASHRAE J 1999;41(8):51-7.

[6] Q.Wang, B.Jiang, et al. Investigating heat pipe based Li-ion battery thermal management for electric vehicles. International (Under review)

[10] W. D. Doyle, ―Magnetization reversal in films with biaxial anisotropy, ‖in *Proc.1987INTERMAG Conf.*, 1987,pp. 2.2-1-2.2-6.

[11] "Heat and Mass Transfer" by R. K. Rajput.