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Alternate Way of Running Air Conditioning System in Vehicle Using Hybrid Suspension System

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Abstract- Due to varying temperature in the Atmosphere at various places, vehicle air-conditioning system has played an important role in various atmospheric conditions. The conventional system used in vehicles in turn provides load on engine and thereby reducing the efficiency of the vehicle moreover most of the energy is lost by vehicle suspension in absorbing the bumps. So as a team we designed the suspension operated AC system. By installing this system we get a better output as the load on the engine will be reduced with increased cooling effect.

Index Terms- Air Conditioning (AC), Compressed Air, Heat Exchanging, Non - Conventional, Suspension System, Better cooling effect, Better vehicle response.

1 INTRODUCTION

As we know the job of the vehicle suspension is to damp out vibrations and reduce the stress in the frame, chassis, etc. The potential energy thus generated by the vehicle suspension is wasted for the purpose mentioned above. Also during AC running condition in the conventional system we notice lack of power while overtaking or accelerating as the load on the engine is increased and it affects pickup, engine response and efficiency of engine. So in this paper we describe how to use the vehicle suspension energy to provide the cooling effect in the passenger compartment and it will also reduce the load of the engine and give better response to the vehicle when needed.

2 LITERATURE REVIEW

In order to carry out this work we have undergone through extensive literature survey and contribution by various authors is as follows,

1. Akshay Gadekar, Prof. M. R. Jagdale, Prasad Khilari et al. In this research paper author has mentioned about the production of compressed air using vehicle suspension and storing this air for running an AC in car by reducing fuel used by engine to drive AC compressor.
2. Saiyyed Kamran, Maniyar Moij et al. In this research paper author has mentioned about the compressed air production through vehicle suspension system and passing this compressed air through heat exchanges for cooling which can be used for further applications.
3. Soundararajan. S, Aravind. R, Karthik.V et al. In this research paper author has mentioned about the production of compressed air as well as power generation through vehicle suspension.
4. V. VP. Dubey, R. R. Verma, P. S. Verma et al. this paper consists of extensive thermal analysis of the effects of severe loading conditions on the performance of the heat exchanger as well as they have out steady state thermal analysis on ANSYS 14.0 to justify the design of heat exchanger.
5. Asawari Barde. This paper represents the study of shell and tube type of heat exchanger along with the literature reviews of several scholars who have given the contribution in this regards. Classification, basic construction design and its application are also described in details inside the paper.
6. Prof. S. U. Ratnparkhi, Tejas Tharkude, Swarada Radkar et al. In this project study has been made to recover the waste energy of suspension system by using pneumatic cylinders and display it using temperature sensors and pressure gauge for the safety purposes and storing it using storage tank.

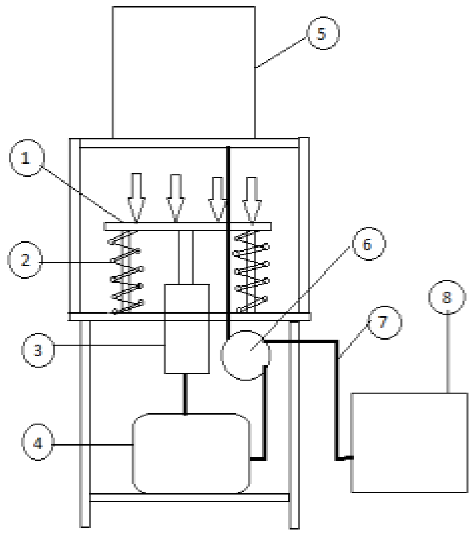
3 PROBLEM DEFINITION

As the air conditioning system of the conventional vehicle is driven by the engine, the load on the engine is increased which affects the power delivered by the engine and also lot of fuel is required for this purpose. So we replace this conventional air conditioning system by vehicle suspension system which will give better engine response and also less fuel consumption.

4 OBJECTIVES OF THE PROJECT

The objective of this project is to drive the AC system by the suspension of the vehicle so that there will be no effect on engine performance also elimination of compressor work will lead to less fuel consumption by vehicle as there will be no load acting on the engine by the AC system.

5 CONSTRUCTIONAL DIAGRAM



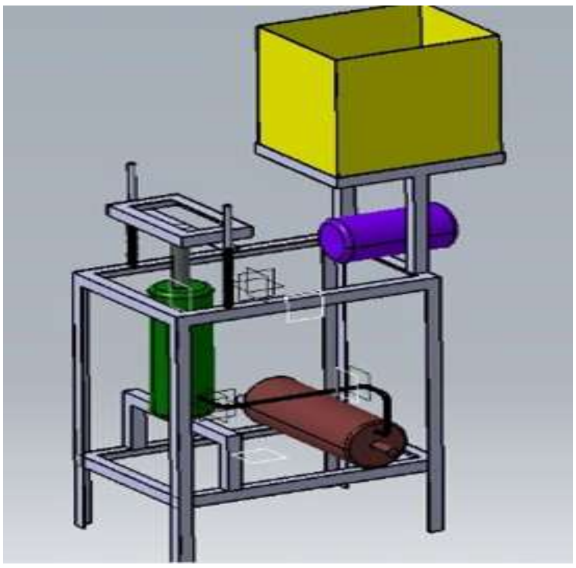


Fig.1: Schematic diagram of running air conditioning system using hybrid vehicle suspension system.

Sr. No.	Component / Part Name	Sr. No.	Component / Part Name
1.	Base	5.	Coolant Storage
2.	Spring	6.	Heat Exchanger
3.	Pneumatic Single Acting Cylinder	7.	Nylon Pipe
4.	Compressed Air Reservoir	8.	Cabin

Table.1: list of various components in system

STAGE 1: FABRICATION OF FRAME

STAGE 2: FABRICATION OF AIR TANK

STAGE 3: FABRICATION OF HEAT EXCHANGER

STAGE 4: JOINING OF PARTS

STAGE 5: FITTING OF SPRING AND PIPES

STAGE 6: FABRICATION OF CABIN

6 WORKING

When vehicle runs on the rough or bumpy road surface then suspension spring continuously move up and down. Piston is attached to the vehicle frame. Because of linear motion of piston, high pressure air comes out from cylinder. This pressurized compressed air from the cylinder will be then collected into reservoir which consists of a non-return valve to resist back flow of the air. This high pressurized air is send to the heat exchanger by using knob. Low temperature coolant i.e. water (3°c to 6°c) is passed through the heat exchanger where heat exchange takes place i.e. loosing and gaining of heat and air temperature becomes 18 °c to 30 °c which is further send at the required place which is to be cooled.

7 DESIGN CALCULATIONS

7.1 Calculation of springs

Maximum Deflection = δ_{max} = 100 mm
Maximum Mass = m = 100 kg
Maximum Force = F = mg = 200× 9.81 = 1962 N
$F_{max} = F_t/4$ =490.5 N
Spring Index = C = 6
Modulus of Rigidity = G = 80 × 10^3 N/mm^2
Maximum Shear Stress = τ = 1300 N/mm^2

7.1.1. Wire Diameter

Wahl Factor shear stress factor,

$$K_w = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{4\times6-1}{4\times6-4} + \frac{0.615}{6} = 1.2525$$

$$\tau = \frac{Kw\times F\times 8\times C}{\pi d^2}$$

$$1300 = \frac{1.2525\times490.5\times8\times6}{\pi d^2}$$

Wire Diameter = d = 2.68~3 mm

7.1.2. Mean Coil diameter

Mean Coil diameter =D = C × d = 6×3 = 18 mm

7.1.3. Number of Coils

Spring Stiffness = K = $\frac{Fmax}{\delta max} = \frac{490.5}{100}$ = 4.90 N/mm

Now, K = $\frac{Gd}{8C^3n}$

$4.9 = \frac{80\times1000\times3}{8\times6^3\times n}$

n = 29.31~29

Assume Plain End condition, so

Total number of coils = n'= n = 29

7.1.4. Solid length,

L_s = n × d = (29×3) = 87 mm

7.1.5. Free length,

L_f = Solid Length + Maximum Deflection + Total Clearance

= Ls + δ_{max} + 15 % of δ_{max}

= 87 + 100 +0 .15× 100

= 202 mm

7.1.6. Pitch of coil

Free length = L_f = p × n + 2d

202 = p× 29 + 2×3

p = 6.75 mm

7.2 Calculation of Single acting cylinder

Cylinder Bore : 50mm

Stroke : 100mm

Volume of cylinder = Stroke × Area of Piston

= 100× (π/4 × D^2)

=196349mm^3

Volume of tank,

L = 300 mm, D = 150 mm

V = π/4 × D^2×L

= π/4 × 150^2× 300

= 5301.437 × 10^3 mm^3

Strokes required for filling the air tank = Volume of tank / Volume of Piston Exhaust

= 5301.437 × 10^3 /196349

= 27 strokes

7.3 Calculation of air tank

Thin cylinder [(Di/t) > 20]**,** Thick cylinder [(Di/t) < 20]

We use thin cylinder as the ratio of internal diameter to thickness is greater than 20.

Thin cylinder-

Operating pressure = 4 bar = 0.4 N/mm^2, Capacity (V) = 0.005 m^3

V = π/4 × Di^2× L L = 2Di …. (Assume)

0.005 × 10^9 = π/4 × Di^2 × 2 × Di

Di = 147.126 mm

Di = 150 mm ….Selected

Therefore, L = 2 × Di = 2 × 150 = 300 mm

Corrosion Allowance for cast iron at natural gas, CA =1 mm

t = [(P_i × D_i) / (2 σ_t η)] + CA

η = 0.6 (design data book)

Cylinder material C40 (S_{yt} = 340 N/mm^2)

σ_t= 340 / 2

σ_t = 170 N/mm^2

t = [(0.4 × 150) / (2 × 170 × 0.6)] + 1

= 1.29 ~ 2 mm

Di / t = 150 / 2 = 75

Di / t > 20

Thus, the cylinder is thin and our assumption is correct.

7.4 Calculation of frame

Frame length =320mm, Cross section=25.4 mm×25.4 mm, Material = M.S,

E=210 GPa, Max.wt=15 kg

Max.bending moment = (wl^2)/8

= (15× 9.81×320^2)/8 =1883520 N-mm

B=D=1"=25.4 mm, Thickness = t = 3mm

B=d=25.4-3×2=19.4 mm

Moment of inertia = I= $\frac{(BD^3-bd^3)}{12}$ =$\frac{(25.4^4-19.4^4)}{12}$ = 22882.048 mm^4

Y=D/2=25.4/2=12.7 mm

We know that, $\frac{M}{I} = \frac{\sigma}{y}$

Bending stress = σ=M y/I

=1883520×12.7/22882.048

=1045.39 N/mm^2

7.5 Theoretical Calculation

T1 = surrounding air temperature = 303 K

T2 = inlet temperature of air in heat exchanger

T3 = outlet temperature of air in heat exchanger

P1 = 1.013bar, P2 = 1.471 bar

Isentropic compression,

$$\frac{T2}{T1} = \left(\frac{P2}{P1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T2}{303} = \left(\frac{1.471}{1.013}\right)^{\frac{1.4-1}{1.4}}$$

T2 = 337.077 K

Heat exchanging process,

$$\epsilon = \frac{T2-T3}{T2-Twater}$$

$0.70 = \frac{337.077 - T3}{337.077 - 283}$ Assume $\in = 70\%$

T3 = 299.22 K

8 MERITS

1. Air is available free of cost.
2. No external supply is required.
3. No pollution & less noisy system.
4. No supervision is required.
5. It can be used with any Rotating systems.
6. Easily & immediately get results.
7. It can work for long time continuously.

9 DEMERITS

1. Problem of leakage
2. Clogging may occurs.
3. System may affect by thermal stresses.
4. Due to working burring of material occurs.
5. Initial cost of this arrangement is high.

10 EXPERIMENTAL RESULTS

Time required for air tank to released entire pressure = 3.24 min

T_{Water} = 13.1°C

$T_{surrounding}$ = 35.8°C

After every 1 min values of T3 are as follows in plot,

Actual effectiveness,

$$\in = \frac{T2 - T3}{T2 - Twater}$$

$$\in = \frac{337.077 - 301.5}{337.077 - 283}$$

$$\in = 0.6578$$

$$\in = 65.78\ \%$$

Logarithmic Mean Temperature Difference,

$$\Delta Tm = \frac{(Th1 - Tc1) - (Th2 - Tc2)}{\ln\left(\frac{Th1 - Tc1}{Th2 - Tc2}\right)}$$

$$\Delta Tm = \frac{(337.077 - 283) - (298 - 290.5)}{\ln\left(\frac{337.077 - 283}{298 - 290.5}\right)}$$

$$\Delta Tm = 296.55\ K$$

Mass of air in tank = 0.006125 kg

i.e. m= V×ρ

Where, $\rho = 1.225\ kg/m^3$, V = 0.005 m^3

Volume of cylinder = 79.40 m^3

Mass of air inside cylinder = m_a = $\rho\ \times volume\ of\ cylinder$

= 1.225 × 79.40

= 0.02701 kg/ sec

Heat transfer rate = Q = $m_a \times C_{pa} \times (Th1 - Th2)$

= 0.0270 × 1.005 × (337 - 298)

= 1.0590 KW

Heat transfer coefficient = h = $\frac{q}{\Delta T}$

$$\frac{dQ}{dt} = h \times A \times \Delta T$$

$$\frac{1.0590}{60} = h\ \times 0.0942\ \times 0.9$$

h = 0.02081 W/m^2 K

Overall Heat Transfer Coefficient,

Q = U × A × ΔTm

Where, Q = Heat Transfer Rate (W)

A = Heat Transfer Surface Area (m^2) = 2πrh

ΔTm = Logarithmic Mean Temperature Difference (K)

$$U = \frac{Q}{A \times \Delta T}$$

$$= \frac{1.0590 \times 10^3}{0.0942 \times 23.55}$$

U = 478.38 W/m^2K

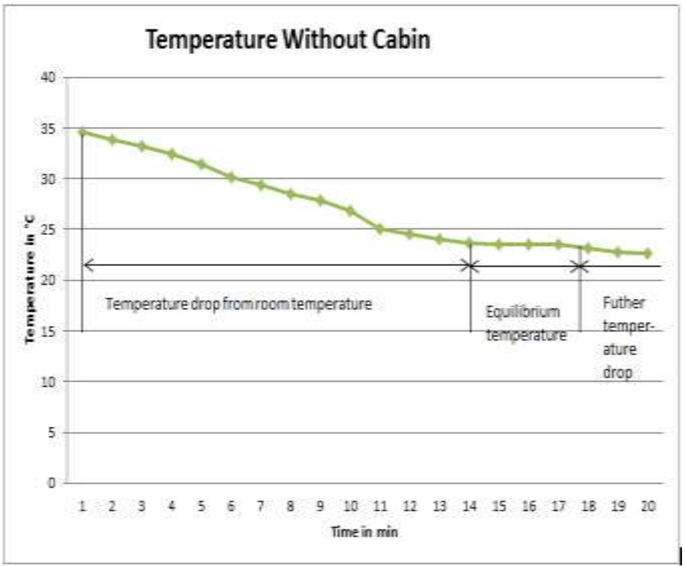
Refrigeration Effect = $m_a \times C_{Pa} \times \Delta T$

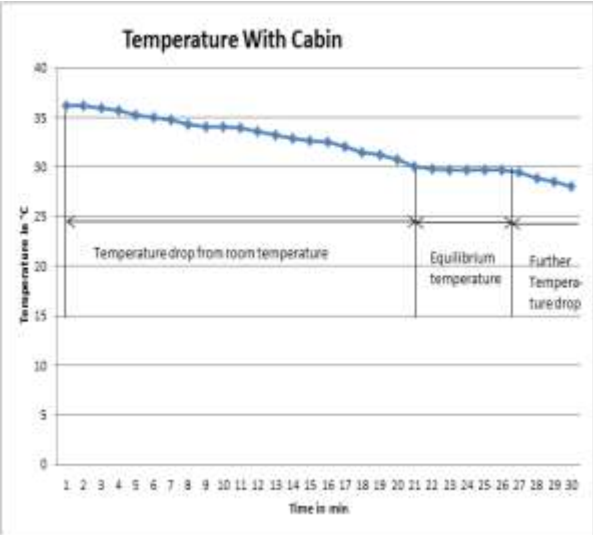
R. E = $m_a \times C_{Pa} \times (T1 - T3)$

= 0.02701 × 1.005 × (303 – 298)

= 0.1357 KJ/min

= 0.0387 TR





Time in min	Temp in °C	Time in min	Temp in °C
1	34.6	11	25.0
2	33.9	12	24.6
3	33.2	13	24.1
4	32.5	14	23.6
5	31.4	15	23.5
6	30.1	16	23.5
7	29.4	17	23.5
8	28.5	18	23.1
9	27.8	19	22.8
10	26.9	20	22.6

Table no. 2 Without Cabin

Time in min	Temp in °C	Time in min	Temp in °C	Time in min	Temp in °C
1	36.2	11	33.9	21	30.1
2	36.2	12	33.6	22	29.8
3	35.9	13	33.2	23	29.7
4	35.7	14	32.9	24	29.7
5	35.2	15	32.7	25	29.7
6	35	16	32.5	26	29.7
7	34.8	17	32.1	27	29.4
8	34.3	18	31.5	28	28.9
9	34.1	19	31.2	29	28.5
10	34.0	20	30.7	30	28.1

Table no. 3 With Cabin

11 FUTURE SCOPE

Power i.e. Electrical can be generated through the suspension which can be used to run the pump, which can be further used to re-circulate the Coolant exiting from heat exchanger. This system can also be further implemented beneath the seat of the driver so that the vibrating effect will be used to work this System.

CONCLUSION

Compressor runs through the power developed by the engine, which leads to generate more amount of energy in case to operate transmission and compressor. Thus eliminating the work of compressor by utilizing the kinetic energy wasted by the suspension system and hence increasing efficiency of overall system.
The air conditioning utilizes the refrigerant which is quite costlier to obtain the refrigeration effect as well as which helps in incrementing to green house gases. Hence replacement of refrigerant with water and achieving the desirable approximate effect.
After performing the test and comparison of theoretical calculations [7.5] and experimental data from table no. 2 and 3, we concluded that we got a temperature drop approximate about 8°C to 10°C less than surrounding temperature.

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