Review of Some Recent Findings on Structural Performance evaluation of carbon fiber composite material on Shock Absorber Suspension System

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***Abstract*- Suspension system of an automobile system is one of the most important part which is responsible for safety and comfort of the people riding on the vehicle. This consist of various shock absorbing parts such as helical coil springs and viscous dampers etc. In this review article several of recently published research article were studied for getting some ideas based on which the dynamic performance of shock absorber suspension system of automobiles can be enhanced. Construction and size, mechanical properties, innovative design, optimization methods and models, material of coil springs and fluids used in dampers are found to be the most prominent factors for improvement the dynamic performance and durability of a suspension system.**

I. INTRODUCTION

In a vehicle suspension system, shock absorbers reduce the effect of traveling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. Shock absorbers use valving of oil and gasses to absorb excess energy from the springs. Spring rates are chosen by the manufacturer based on the weight of the vehicle, loaded and unloaded. Some people use shocks to modify spring rates but this is not the correct use. Along with hysteresis in the tire itself, they damp the energy stored in the motion of the unsprung weight up and down. Effective wheel bounce damping may require tuning shocks to an optimal resistance [1].

Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars are used in torsional shocks as well. Ideal springs alone, however, are not shock absorbers, as springs only store and do not dissipate or absorb energy. Vehicles typically employ both hydraulic shock absorbers and springs or torsion bars. In this combination, "shock absorber" refers specifically to the hydraulic piston that absorbs and dissipates vibration. Now, composite suspension systems are used mainly in 2 wheelers and also leaf spring are made up of composite material in 4 wheelers [2].

Figure-1 Oil Filled Shock Absorber [1]

II. FACTORS AFFECTING PERFORMANCE OF SHOCK ABSORBER

After study of several of research article published recently we have found that these are the most important parameters and factors which affect the performance of a shock absorber suspension system. These are discussed below-

a) Construction and size of the shock absorber- Studied the performance of coil spring of shock absorber of bike considering bike mass, loads & number of person seated on the bike. The parameter

used for study was wire diameter of the coil spring. The testing was done on Pro-E/ ANSYS. They found that increasing of wire diameter to certain limits decreases the stresses and deformation of the spring [1]. Investigated a research program in which a high performance motorcycle shock absorber was tested by means of specific test bench which includes the measurement of pressure inside the chambers during harmonic tests (frequency range). They first shown some experimental results dealing with pressures inside compression, rebound and compression then made a simplified mathematical model which was able to capture the most relevant physical phenomenon that generate the hysteresis loop of the total force, after which they described the complete model of the shock absorber which takes into account details of oil motion inside the valves and was able to predict the behavior of the shock absorber for a wide range of working conditions. They showed that the performance of the shock absorber is also dependent on position and acceleration of damper rod force along with velocity of damper rod force [2]. Analyzed the conventional type of shock absorber spring and new glass type of shock absorber mathematically, experimentally and also on CAD/CAM software ANSYS. The parameters used for study were maximum failure load and maximum displacement. They found that glass fibre type shock absorber coil spring is better in comparison to conventional type steel spring in aspect of failure load and maximum displacement. However they suggested that it is double the cost of conventional spring. But this can be used where weight reduction is important [3]. Analyzed the helical coil springs design with the probabilistic approach with the help of ANSYS. The parameters taken were geometrical, material and loads, which all are random variables. The concluded that wire radius of spring and loads have significant influence on the output parameters such as displacement and stress. They also concluded that modulus of elasticity also affects the maximum displacement [4]. Studied the dual suspension shock of CBZ extreme bike. They used square profile & square fillet type of shock for analysis on ANSYS. They found that this type construction of shock absorber has less stresses and deflection when compared to circular and square (without square fillet) profile of the shock absorber [5].

b) Mechanical properties of shock absorber-

Compared the coil spring suspension system of Hero Splendor & Honda Shine with two different suspension oil Motul and Yam lube at the suspension chamber. They have done the simulation on MATLAB & validated the results with experimental setup. They found that system gives better results with under damped design. They concluded that for good ride transmissibility should be as low as possible and for that purpose low damping constant and high spring stiffness should be used [6]. Analyzed the vibration on a compact shock absorber. They had taken quarter of the suspension system of car and analyzed theoretically as well as through numerical simulation. They found that failure of the coil spring will take place earlier and then after the failure of the body will occur. They have also concluded that the unsprung mass will have the greater vibration effect when compared to sprung mass, hence more chances of failure [7]. Analyzed the fatigue behavior of springs used in shock absorber in automobile suspension system. The material for spring was SAE9254. The waves given for testing of vibration was of 4 Hz. SAE standard suspension loading history (SAESUS) was used for fatigue analysis. For finite element analysis of fatigue was done with the help of strain life method. They concluded that spring does not fail before 4×105 cycles at 4 Hz and SAESUS time history at critical location. They also showed that absolute maximum principal method is best suitable for analysis [8]. Investigated the influence of spring stiffness in the automotive suspension system. They used three types of springs which is namely soft, medium and hard for numerical analysis. They used full vehicle model and front suspension model for analysis. They showed the results that the medium spring stiffness provide comfort and handling in both numerical and real vehicle model. They also showed that the medium spring stiffness can minimize the roll effect which could further led to oversteer or understeer problem [9]. Studied parametric modeling and finite element analysis of helical compression spring with the help of ANSYS. They implemented the probabilistic design approach. They also have done response surface modeling by using FEA. They concluded that the strength of helical coil shock absorber can be affected by spring parameters such as wire diameter, coil diameter, load and free length. They stated that if

the wire diameter increases, stress on helical spring reduces, increase in coil diameter results in an increase in stress, increase in free length increases stresses. They showed that probabilistic design gives better judgment for selection composite material [10].

c)Optimization methods for shock absorber suspension system-

Analyzed about the motorcycle mounting system. The optimum values of spring stiffness, location and orientation are analyzed by using the method of optimization or parameterization. They found that the values obtained for stiffness, location and orientation of engine system mountings are very close to target values. This method is quite useful in optimization of the suspension system of the engine mounting of the motorcycle [11]. Studied the performance of coil spring used in absorber using Pro- E & ANSYS respectively with the optimization method of genetic algorithm. They used stiffness of the spring as the parameter. They optimized the value of spring stiffness & damping co-efficient with genetic algorithm. They found that this optimized values reduces the stresses and deflection of spring which is desirable in shock absorber [12].

d)Innovative design of shock absorber-

Studied for developing a shock absorber model of a passenger car. They did the experiments for getting the force – displacement & force – velocity characteristics of damper. They developed different models of shock absorber to represent the non linear & hysteresis force velocity behavior of the damper. The models were also validated with experimental results. It is found that a combined hybrid shock absorber model using neural network technique can only capture the experimental behavior of the damper very closely due to the incorporation of hysteresis characteristics of the shock absorber which linear and piecewise models of shock absorber cannot do [13]. Analyzed a two degree of freedom car model suspension system numerically with the help of MATLAB. They plotted the frequency of base excitation with transmissibility on X & Y axis for damping ratio 0.40 to 0.70. It was observed that very small amount of change in damping ratio can affect the motion of unsprung mass by a huge quantity [14]. Studied and analyzed a magnetic shock absorber in which they placed the coil spring in a cylinder. Coil spring has a north and a south pole at its two ends. The cylinder consist pair of north and south poles at its two ends to repel the movement of spring working as piston. They concluded that this kind of shock absorber can reduce the deflection of the coil spring and thus can enhance the performance of shock absorber [15]. Analyzed the coil type of spring and wave type of spring with two different materials namely beryllium copper and spring steel. They did the numerical calculation with the help of PRO-E AND ANSYS. The parameters used for study was deflection and maximum stress. They found that wave spring undergoes less deformation than coil spring. They stated that stainless steel is preferable over beryllium copper [16]. Studied for mono suspension spring shock absorber. They have analyzed the mono suspension spring with the use of ANSYS and also analyzed theoretically. They used load, stress and deflection as the parameters. They found that when the load increases the deflection and shear stress of spring also get increased. They also stated that the analysis on ANSYS & theoretical solution gives approximate same values [17]. Designed the double wishbone suspension system for increasing comfort in automotive suspension system. They have made the model in LOTUS software and analyzed the structural analysis in ANSYS. They achieved the objectives of getting greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of suspension system & better handling of vehicle while cornering. They suggested that this suspension system can be further modified for decreasing the weight and cost. Also suggested that transverse leaf spring can be used to decrease the weight of the suspension assembly. Also listed pneumatic suspension system as a prominent incorporation in suspension system in future [18]. Reviewed different research article to get an idea for developing efficient and hybrid shock absorber suspension system. They reviewed that hydraulic rectifier can work as an energy generator and shock absorber by converting bi directional shocks into unidirectional rotation with help of 4 check valve. Passive damper can be converted into active damper with help of electromagnetic damper which can also generate energy and fulfill purpose of hybrid shock absorber. Regenerative electromagnetic shock absorber recover dissipated energy. Coil assembly moves relative to magnetic assembly which produces

energy. Magneto rheological fluid changes braking force by electronic control. MR fluid can operate directly from low voltage power supplies. It can vary damping co-efficient and give good performance for large range of vibration frequency. They concluded that these factors are very much considerable & important in developing the hybrid suspension system [19]. Studied about the premature failure of helical coil of die set system which is used in wire straightening and cutting. They analyzed the numerical solution with the help of ANSYS. The parameters taken for study were wire diameter, deflection and shear stress. They concluded that increase in wire diameter decreases the deflection and shear stress of spring. It happens due to the less spring index which is caused by increased wire diameter. They also stated that too low spring index results into design failure [20]. Analyzed a proposed shock absorber, which could approach the performance obtained by the semi active control suspensions without an electronics or further energy consumption. They were inspired by switch logic with the semi active control damping and they proposed a special hydraulic structure, which realizes the velocity and displacement dependent damper (VDD) features and could get similar F-V curve with semi active controlled damping. Simulation of the proposed damper and the quarter car model with VDD shows the compatibility of these dampers. They concluded that VDD gives superior ride comfort at the expense of road holding & suspension deflection. The mechanical realization of the semi active suspension is as simple as a traditional passive damper. Energy free & electronic free are the main advantage of the VDD damper [21].

e)Coil material of shock absorber

Analyzed a spring coil shock absorber with different loading condition such as chassis load, entire load of the body of car and with a passenger seated on it. They analyzed the calculation for maximum deflection and maximum stress developed in the spring coil with different materials such as stainless steel, chromium vanadium AISI 6150 and low carbon steel. They concluded stainless steel to be the most efficient among all these materials to increase the performance of shock absorber [22]. Studied for failure of suspension system of a rail road vehicle. They analyzed the material composition of the suspension springs using spectrometer. They also analyzed various loading conditions due to which this failure occurred. They concluded that the less percentage of vanadium may be responsible for failure of spring. They also stated that CANT excess which is the amount of super elevation that needs to be reduced so that the current vehicle speed will be equal to the balance speed as well as the CANT deficiency which is the amount of the super elevation that is needed to be increased so that the vehicle current speed will be equal to the balanced speed. Due to CANT deficiency the vehicle has high lateral forces that can cause undesirable motion on the higher rail. These lateral forces if high enough will fail springs and produce a wheel climb that can lead to a wheel derailment [23]. Studied the fatigue analysis of the spring by assigning material to spring such as structural steel, AISI 1050 steel & chrome vanadium steel. They analyzed the results for deflection experimentally, theoretically and through numerical simulation on Pro- E. they used parameters such as load, deflection and stress. They found that chrome vanadium is the strongest material for manufacturing of springs of shock absorbers [24]. Analyzed the full assembly of shock absorber of coil spring type by separating each part by lathe cutting. They used three different materials namely spring steel, beryllium copper and carbon fibre. They done their analysis on CAD/CAM software ANSYS. They used deflection and stresses as parameters for study. They found that carbon fibre is weakest material among them which has highest deformation and shear stresses. Spring steel is the strongest material among them [25]. Analyzed the rear shock absorber coil spring with the help of ANSYS using weight of one and two person respectively. They used a new material E glass epoxy composite for coil spring construction. They analyzed the coil spring numerically with ANSYS structural. They found that the material E glass epoxy composite cab bear more stresses than the conventional spring steel material. They showed that E glass epoxy composite causes more deformation than conventional spring steel [26]. Analyzed the coil spring shock absorber with four type of material which is namely as chrome vanadium, hard drawn spring wire steel, oil tempered carbon steel & stainless steel respectively. They have done the structural analysis using CREO 2.0 & ANSYS. They have done the calculation for

maximum shear stress and maximum deformation at different loads. They concluded that chrome vanadium has minimum deformation among all materials. The value of maximum shear stress is almost similar for all materials [27]. Proposed a novel compact shock absorber with both damping and stiffness variable characteristics. The shock absorber was developed based on Magneto Rheological fluid flow through an innovative design. They tested the prototype with the help of MTS to characterize the variable damping and stiffness properties. For identifying the parameters an optimization method and a mathematical model was developed. They concluded that the prototype with dual damping and stiffness is controllable [28]. Designed a shock absorber by using Pro- E software. They have done the structural strength analysis of the shock absorber by using the materials which is namely conventional spring steel and a new material ASTM A228 (high carbon spring wire). They concluded that analyzed stresses for both materials are less than their yield stresses, hence design is safe. Also they concluded the result that deflection for high carbon spring is less and natural frequency for ASTM is more than spring steel. Hence they stated that high carbon spring wire will be superior to conventional spring steel [29]. Studied for designing of helical coil spring for use with Magneto rheological fluid. They used silicon oil and ethylene glycol as MR fluids with helical spring on a piston cylinder arrangement (working as a damper). They analyzed that MR fluid reduces the displacement of spring much enough as compared to without MR fluids. It was also concluded that silicon oil MR fluid is much better than ethylene glycol MR fluids [30].

III. RESULT AND SUMMARY OF REVIEW

After studying various research articles about the improvement of dynamic performance of suspension system, we have analyzed that these following parameters and factors play important role in achieving a comfortable ride with the help of suspension system in an automobile system-

a. Construction and size of the shock absorber
   Mechanical properties of shock absorber
b. Optimization methods for shock absorber suspension system
c. Innovative design of shock absorber
d. Coil material of shock absorber
e. These are the factors and parameters which can be further optimized and analyzed for improvement of design of shock absorber suspension system.

IV. CONCLUSION

In this review article we have analyzed various research articles which given us various aspect and areas where the improvement in design of shock absorber still needed. The parameters such as size & construction, mechanical properties, optimization models, coil materials and innovative design are the key areas and factors whose optimization can lead us to a more comfortable and safe riding on an automobile system by improving dynamic performance of suspension system.

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