Concept of Shock Absorber Test Rig and Approaching towards a Universal Testing Procedure

Ankit Kumar Dixit*, Aradhya Saxena,
Arpit Gupta, Chandransh Pandey, Prashant Chauhan
Department of Mechanical Engineering, J.S.S Academy of Technical Education, Noida, India

ABSTRACT

Shock absorber is a mechanical device designed to absorb unwanted vibrations or shock impulses. It does this by converting kinetic energy into another form, generally heat which is then dissipated. Due to its damping characteristics shock absorber is a major component installed in the suspension system of an automobile. It is necessary to determine the characteristics of damping system for various computational and analysis purpose which can be further utilized in Research & Development of shock-absorbers. The concept of a universal testing procedure for shock absorbers through various testing procedures, parameters and generating a detailed report and analysis as output which would help in rating, comparing & classifying various shock absorbers accordingly is described in this paper. Techniques such as simulating mathematical models, FEM Analysis and various physical testings are comprised by this concept. However, this conceptual approach is lengthy, vast and detailed which further makes it complex.

Keywords- Damping Characteristics, Quarter Car Model, Shock Absorber Test Rig, Universal Testing Procedure.

I INTRODUCTION

In ride comfort and road maneuverability an important role is played by the shock absorbers. For ride comfort, a relatively "soft" shock absorber is needed so that it can dissipate shock energy from the road, while a "hard" setting enables good vehicle handling. For better vehicle handling vibration control of vehicle is a major challenge which is influenced by the harmful effects of vibrations caused by road irregularities on driver's comfort. It is an example of under damped vibration system; creating the vibrations under the external loading. For various computational and analysis purpose it is necessary to determine the characteristics of a damping system which can be further utilized in Research & Development of shock-absorbers. In order to determine various properties of shock absorber using different techniques several attempts have been made previously but there is a very limited work on any universal procedure for testing the same.[1] Quality checking is required to test that prototypes or samples of production dampers meet their specifications within tolerance and are adequately consistent one to another [2]. It is also necessary for the dampers to be rated on the basis of their performance so that comparing various shock-absorbers can be made simpler. This will help the designers to design & choose a better damping system for their vehicles.

This paper aims towards defining a universal testing procedure for shock absorbers. A thorough analysis of a shock absorber is carried out in this process. Shock absorbers will undergo a specific test sequence . All the tests will be predefined and described in detailed. In order to properly investigate the variable controls of a shock absorber and enable greater performance of the suspension system, a more detailed and a universal testing procedure is needed. Longer braking distances, faster wear of tires and deterioration of handling is caused by the worn dampers. Endurance testing to monitor the physical wear effects is included in the process. Environmental effects such as the heat caused during damper operation will also be monitored. To test shocks and generate graphs for the shock characteristics test rigs will be used. These graphs can be printed or stored so the user can develop a database of how each shock-absorber works under the test conditions. Trial and error approach is converted into a reliable and efficient method by this concept. Evaluation of a complete car suspension system is complicated. A quarter car model is considered in order to make calculations efficient. It is a combination of a tire connected to an unsprung mass, which is further connected to a sprung mass through a shock-absorber. The system has two degrees of freedom. On field, different kind of loads are experienced by the damping system. Before testing the system, the input-loads must be predefined. Sine-input (Continuously varying endurance input), Impact(Impulse-input), Ramp-input, a combination of these inputs are included in the forces subjected to the system for this paper. The tests include:

1. Mathematical Modeling
2. Finite Element Analysis (F.E.M)
3. Physical Tests

The characteristics are then studied and compared with each other and performance of the system is evaluated. A full test report of a shock-absorber along with its rating is generated by this procedure.

II LITERATURE SURVEY

Various work has been done previously on test rigs for shock absorbers, [2] H. R. Sapramer & G. D. Acharya calculated the characteristics and ultimately performance of a shock absorbers at various loading conditions. This method is included in the concept of this paper. [1] Novikov, V. V, et al. developed an algorithm which optimized the existing rigs with more flexible and universal approach. While designing our test rigs, this paper is used to optimize the tests. [3] Heritier, C. designed a shock-absorber test rig for sinusoidal testing of racing car. Sinusoidal input characteristics are studied and adopted from this paper. [4] Czop, P., & SŁawik, D evaluated the vibrations produced by the shock-absorbers in their work [5] Zhang , et al. studied the energy flow of suspension systems and analyzed the model. [6] Omar, et al. designed suspension test rig for electro-hydraulic suspension which reduces the road input disturbances. [7] Maniowski et al. obtained characteristics of dampers using test rig and compared them according to their respective characteristics.[8] Chaudhari et al. described the conceptual design of shock-absorbetest rig using cam for determining dynamic characteristics of dampers. [9] Plummer, et al. developed an algorithm based on repetitive control to reduce disturbances in the damper test rigs. [10] Wszołek et al. designed shock absorber for minimizing the vibrations using model based approach.

III CONCEPTUAL APPROACH

The concept is vast and complex. It needs to simplified in order to understand. The method of testing and rating a shock-absorber can be divided into three segments (Fig. 1). Input, Processing and Output.

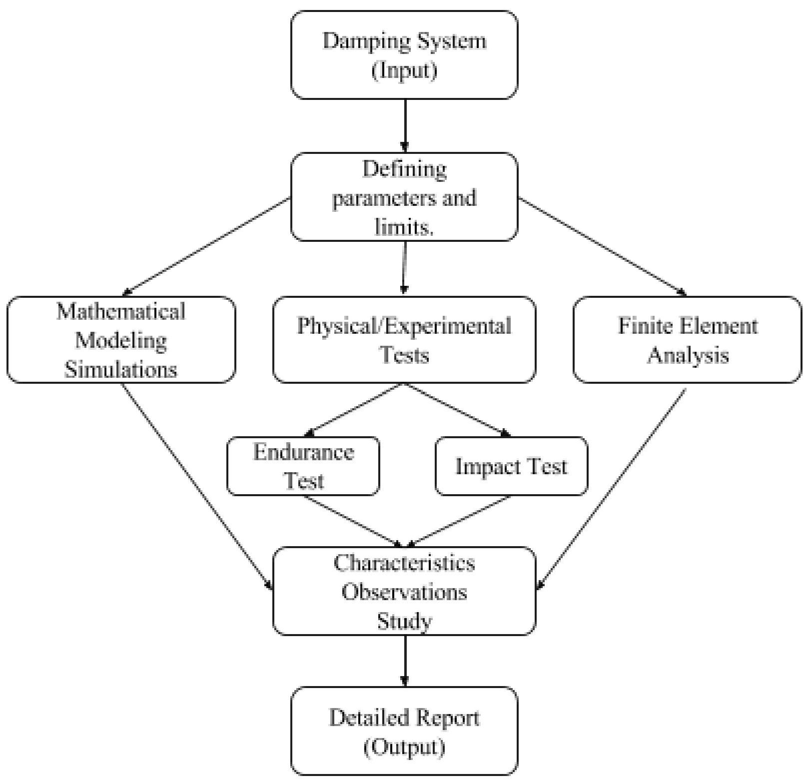

Fig. 1 Process flow chart.

3.1 Input Parameters

Input includes a physical prototype/model of a shock-absorber, Quarter Car model of the damping system & constant values of the damper (Fig. 2). A physical shock-absorber is the specimen that will be subjected to various tests. It is the specimen under consideration. Model of the damping system includes a mathematical model of the suspension system. It includes the description of other elements involved in the system other than the shock-absorber. Constants include spring constants, damper constants and other important physical parameters.

3.2 Processing

The procedure is a little complex and can be simplified by dividing it further into sub-parts. Processing is further branched into 3 processes. Solving the Mathematical model, Finite Element Analysis & Physical Tests.

3.2.1 Mathematical Modelling

While solving Mathematical models, the system is subjected to all the load-inputs mentioned above and a few basic parameters are predefined. The quarter car model (Fig. 2) is simulated on SCILAB/MATLAB. The objective is to determine ideal damping characteristics, ideal response to impact loading, ideal response to fatigue loading and response to randomly varying inputs. These characteristics will help us in determining important parameters and an ideal-performance report. The same will be used to evaluate the maximum energy stored in a shock-absorber and the amount of regenerative energy that can be extracted. The output characteristics are printed, studied and described. A detailed sub-report is generated with the simulation of the mathematical model that include five graphs.

$$M_s(\ddot{z}) = k_s(y-z) + c_s(\dot{y}-\dot{z})$$
$$M_u(\ddot{y})=k_t(x-y)-k_s(x-y)-c_s(\dot{x}-\dot{y})$$

Fig 2. Quarter Car suspension system model along with the shock absorber used in a two wheeler.

3.2.2 Finite Element Analysis (F.E.M)

The next process is finite element analysis, the model will be reproduced on Ansys workbench and subjected to different loads. The process will cover fatigue module, suspension module & thermal module. The model will be subjected to fatigue-loading along with thermal considerations, impact loading and random loading. The process will yield response to fatigue loading under different thermal conditions. This will help analyze the system's performance under rugged circumstances. The output characteristics are printed, studied and described. A detailed sub-report is generated with the finite element analysis that include 3 graphs.

3.2.3 Physical Tests

The next process of physical testing is performed on test rigs. There are two tests that will be performed on test rigs, impact test and real-time endurance test. The endurance test rig is designed for a range of maximum loads experienced by shock-absorbers. The shock-absorber is subjected to sine-input. It will feature, variable displacement (amplitude control), variable RPM (frequency control) and variable input load (Acceleration control). The parameters being recorded included output displacement, output transmitted-force and temperature of the specimen. The impact test rig is designed for a range of physical size of a shock-absorber. This rig subjects the shock-absorber to impact loading. This rig features variable height of mass drop, records displacement and output transmitted-force. Both the rigs are interfaced with a PC for control. Output is monitored live on screen. The characteristics are then printed, performance is recorded, observed, studied and described. A detailed sub-report is generated with 4 graphs.

3.3 Output

All the sub-reports are compiled and all the information is assimilated and a full report is developed. On the basis of the information acquired a final observation and a conclusion table is generated. From the conclusion table the shock-absorber is rated on a scale of 10 on the basis of comfort quality, maneuverability, ruggedness, safety and reliability. All these ratings will be combined to aggregate a final performance rating.

IV CONCLUSION

The concept of a universal testing procedure has been projected by this paper. Determining, analyzing & rating the performance of shock-absorbers is discussed in this paper. The concept discussed enables the industry to evaluate, compare and choose between various shock-absorber systems and help them improve their damping system and vehicle performance. It is a thorough analysis and a full report generation approach which will help the industry to know more about the shock-absorbers. The concept is in operation and would not be suitable for mass testing or where accuracy and exact values are not major concern. However, this conceptual approach is lengthy, vast and detailed which further makes it complex and time consuming. The concept can be materialized and implemented to obtain experimental results and development of data-base in future. The concept will benefit future researches and complement other projects based on suspension systems greatly.

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