REVIEW ON OPTIMIZATION APPROACH FOR WHOLE BODY VIBRATION

Ranjit Vasant Rajale
Mechanical Engineering Department,
SCSMCOE ,NEPTI
AHMEDNAGAR,INDIA
ranjit.rajale@scoea.org

M. P. Nagarkar
Mechanical Engineering Department,
SCSMCOE ,NEPTI
AHMEDNAGAR,INDIA

Abstract—the aim of optimization comes in to play in each and every field of engineering application. Thus such approach to make out to select correct method to adopt optimization would be great. The simulated annealing approach for simulation is taken to be basic to take out the and optimization can be done to genetic algorithm approach with convenient way

Keywords—component; formatting; style; styling; insert (key words)

I. Introduction

Much work has progressed in the area of Whole Body Vibration. High magnitude of whole-body vibration formed by the transportation modes like cars, trains, buses may cause diseases and health problems to the human. The study will give an account of daily exposure to vibration A (8) and Vibration Dose Value (VDV) exposed to the passengers travelling in the car and in order to optimized the responsible parameters to have magnitude of foresaid in as per standard norm

Optimal Design of Passenger Car Suspension for Ride and Road Holding by Anil Shirahatt gives the idea for full passenger car model. The model is with eight DOF and optimisation is achieved in ride comfort and road holding. A number of objectives such as maximum bouncing acceleration of seat and sprung mass, root mean square (RMS) weighted acceleration of seat and sprung mass as per ISO2631 standards, jerk, suspension travel, road holding and tyre deflection are minimized subjected to a number of constraints. The constraints arise from the practical kinetic and comfort ability considerations, such as limits of the maximum vertical acceleration of the passenger seat, tyre displacement and the suspension working space. The genetic algorithm (GA) is used to solve the problem and results were compared to those obtained by simulated annealing (SA) technique and found to yields similar performance measures. [1]

M Nuawiv from his experimental results, the whole-body vibration exposure level could be determined. It can be concluded that the whole-body vibration absorbed by the human body is enhanced when the magnitude of the vibration exposure experienced by the passengers increased. This was shown by the increased values of daily exposure to vibration A(8) and VDV calculated in the study.[2]

Lu Suna, Ximing Cai, they designed passive vehicle suspension, The system was handled in the framework of nonlinear optimization. The variance of the dynamic load resulting from the vibrating vehicle operating at a constant speed was used as the performance measure of a suspension system. A genetic algorithm is applied to solve the nonlinear optimization problem. It was found from the sensitivity analysis that appropriate mutation rate, crossover rate and population size. The optimum design parameters of the suspension systems obtained. [3]

Maciejewski concluded that for active suspension system transmission influences comfort, performance, and long-term health of the driver. He designed and experimented on control system which basing on several various controllers. The primary controller was used to evaluate the actual value of the desired active force that should be generated in the suspension system. The secondary controller is employed to calculate the instantaneous value of a signal which controls the active element by means of its reverse model. The adaptation mechanism recognizes the actual suspended mass in order to increase the effectiveness of vibration isolation.[4]

Sagar Deshpande, Sudhir Mehta, G. Nakhaie Jazar in their study stated that a comprehensive optimal design solution was presented for piecewise-linear vibration isolation systems. First, primary suspension optimum parameters were established, followed by an investigation of jump-avoidance conditions for the secondary suspension. The root mean square (RMS) of the absolute acceleration was minimized against the RMS of the relative displacement (Z). It was observed that certain band of parameters defined by primary damping, within which a valid frequency response can be obtained. An optimum numerical solution was sought within this band of parameters. Optimal solution curves were achieved for the secondary suspension. These can be used in conjunction with the optimal curve for the primary suspension to select design parameter values for the best possible vibration isolation performance in a given application.[5]

Zhongzhe Chi, Yuping He and Greg F. Nater in experimental study, it was found that the global search algorithm (GA) and the direct search algorithm (PSA) were more reliable than the gradient based local search algorithm (SOP). The numerical simulation results indicate that the design criteria were significantly improved through optimizing the selected design variables. The effect of vehicle speed and road irregularity on design variables for improving vehicle ride quality has been investigated. A potential design optimization approach to the vehicle speed and road irregularity dependent suspension design problem is recommended. [6]

Baumal et al. Demonstrated numerical optimization methods to partially automate the design process. GA is used to determine both the active control and passive mechanical parameters of a vehicle suspension system (5DOF) subjected to sinusoidal road profile. The objective is to minimize the extreme acceleration of the Passenger‘s seat, subject to constraints representing the required road-holding ability and suspension working space. Multi-body dynamics has been used extensively by automotive industry to model and design vehicle suspension. Before modern optimization methods were introduced, design engineers used to follow the iterative approach of testing various input parameters vehicle suspension performance. The whole analysis will be continued until the predefined performance measures were achieved. Design optimization, parametric studies and sensitivity analyses were difficult, if not impossible to perform. This traditional optimization process usually accompanied by prototype testing, could be difficult and time-consuming for complete complex systems. With the advent of various optimization methods along with developments in computational technology, the design process has been speeded up to reach optimal values and also facilitated the studies on influence of design parameters in order to get the minimum/maximum of an objective function subjected to the constraints. These constraints incorporate the practical considerations into the design process. [7]

Car suspension design for comfort using genetic algorithm by Saxena and Kalyanmoy Deb gives the basic ideas of the modelling of half car model and optimization using Genetic algorithm for which objective function is ride comfort. [8]

A New Model and an Optimal Pole-Placement Control of the Macpherson Suspension System by Keum-Shik Hong, Dong-Seop Jeon and Wan-Suk Yoo: This paper was very important as far as the test rig design is concerned. In four wheelers special type of suspension is used known as Macpherson's strut. The actual modelling of this strut was also done in the paper. In this paper a new model and an optimal pole-placement control for the Macpherson suspension system are investigated. [9]

Calculations for the Project of the Laboratory Stand for Testing Vehicle Suspensions by Janusz Kowal, Jacek Snamina, Tomasz Wzorek: This paper gives the design calculation to find the reaction at fixed ends and hinges to design the actual test rigs for dimensions. The standard materials are given and standard lengths are given. Thickness and stress calculations can be done from this paper. Some of the books are also found to be important for different optimization process using software and other tools. The software mainly used MATLAB 10a and ANSYS 12. [10]

The effect of stiffness and damping of the Suspension system elements on the optimisation of the vibrational behaviour of a bus by Dragan sekulic in paper effects of spring stiffness and shock absorber damping on the vertical acceleration of the driver‘s body, suspension deformation and dynamic wheel load were investigated, with the purpose to define recommendations for selecting oscillation parameters while designing the suspension system of a (intercity) bus. Oscillatory responses were analyzed by means of a bus oscillatory model with linear characteristics and three degrees of freedom, with excitation by the Power Spectral Density (PSD) of the roughness of asphalt-concrete pavement in good condition. The analysis was conducted through a simulation, in frequency domain, using statistical dynamics equations. A programme created in the software pack MATLAB was used to analyze the transfer functions, spectral density and RMS of oscillatory parameters. The results of the analysis show that the parameters which ensured good oscillatory comfort of the driver were conflicting with the parameters which ensured the greatest stability of the bus and the corresponding wheel travel. In terms of the driver‘s oscillatory comfort, the bus suspension system should have a spring of small stiffness and a shock absorber with a low damping coefficient. In terms of active safety, it should have a spring of small stiffness and a shock absorber with a high damping coefficient, while minimum wheel motion requests for springs of great stiffness and shock absorbers with a high damping coefficient. [11]

R. Alkhatib, G. Nakhaie Jazar applied genetic algorithm (GA) method was applied to the optimization problem of a linear one degree-of-freedom (1-DOF) vibration isolator mount and the method is extended to the optimization of a linear quarter car suspension model. They found that an optimal relationship between the root mean square (RMS) of the absolute acceleration and the RMS of the relative displacement is found. [12]

Hassan Nahvi done experimentation with objective to evaluation of vehicle comfort characteristics based on standard mathematical formulae and frequency analyses. A variety of road types were selected and quantified by using the International Roughness Index (IRI). To assess vibrations transmitted to the passengers, vibration dose values (VDV), kurtosis, frequency response functions (FRF), and power spectral densities (PSD) of the compartment recorded signals were evaluated. SEAT values based on VDV outputs qualified the seat suspension as a vibration isolator, whereas the FRF and PSD quantified that behaviour through frequency analyses. Results indicate that energy concentration is at frequencies lower than 30 Hz. Such low frequency excitations are well attenuated by seat suspension in the vertical direction but are amplified (up to five times in harsh conditions) by a backrest in the fore-aft trend. Signals are amplified beyond 30 Hz, but amplitudes are still very low. It seems that backrest assembly still can be improved to become a better isolator. However, T15 (time to reach severe discomfort), even in harsh conditions, is more than three hours, which exhibits the overall good quality of the vehicle suspension systems. Kurtosis and VDV correlate with IRI. [13]

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

II. Optimization Techniques

A. There are Much optimization methods for diverse troubleshoots that we face in industries or in our daily life. For these optimization techniques, there are always a best suited solution in case of various assorted core issue.

Metaheuristics

- a metaheuristic is a higher level of optimization as complexity of optimization is concern-
- level procedure or heuristic designed to find, generate, or select a heuristic (partial search

algorithm) that may provide a sufficiently good solution to an optimization problem, especially with incomplete or imperfect informationor lcomputation capacity. Metaheuristics sample a set of solutions which is too large to be completely sampled. Metaheuristics may make few assumptions about the optimization problem being solved, and so they may be usable for a variety of problems.

- Compared to optimization algorithms and iterative methods, metaheuristics do not guarantee that a globally optimal solution can be found on some class of problems. Many metaheuristics implement some form of stochastic optimization, so that the solution found is dependent on the set of random variables generated. In combinatorial optimization, by searching over a large set of feasible solutions, metaheuristics can often find good solutions with less computational effort than optimization algorithms, iterative methods, or simple heuristics. As such, they are useful approaches for optimization problems. Several books and survey papers have been published on the subject.
- Most literature on metaheuristics is experimental in nature, describing empirical results based on computer experiments with the algorithms. But some formal theoretical results are also available, often on convergence and the possibility of finding the global optimum. Many metaheuristic methods have been published with claims of novelty and practical efficacy. While the field also features high-quality research, unfortunately many of the publications have been of poor quality; flaws include vagueness, lack of conceptual elaboration,

The genetic algorithm (GA) is an optimization and search technique based on the principles of genetics and natural selection and it comes under the category of mathematical programming technique. A GA allows a population composed of many individuals to evolve under specified selection rules to a state that maximizes the ―fitness‖ (i.e., minimizes the cost function). The method was developed by John Holland (1975) over the course of the 1960s and 1970s and finally popularized by one of his students, David Goldberg, who was able to solve a difficult problem involving the control of gas-pipeline transmission for his dissertation (Goldberg, 1989). Holland‘s original work was summarized in his book. He was the first to try to develop a theoretical basis for GAs through his schema theorem. The work of De Jong (1975) showed the usefulness of the GA for function optimization and made the first concerted effort to find optimized GA parameters. Goldberg has probably contributed the most fuel to the GA fire with his successful applications and excellent book (1989). Since then, many versions of evolutionary programming have been tried with varying degrees of success.

Some of the advantages of a GA include that it

- Optimizes with continuous or discrete variables,
- Doesn‘t require derivative information,
- Simultaneously searches from a wide sampling of the cost surface,
- Deals with a large number of variables,

How optimization is done in the GA?

the bounds of variables included in the function. Genetic Algorithm (GA) works on a population using a set of operators that are applied to the population. A population is a set of points in the design space. The initial population is generated randomly by default. The next generation of the population is computed using the fitness of the individuals in the current generation.

The following outline summarizes how the genetic algorithm works: 1. The algorithm begins by creating a random initial population. 2. The algorithm then creates a sequence of new populations. At each step, the algorithm uses the individuals in the current generation to create the next population. To create the new population, the algorithm performs the following steps: a. Scores each member of the current population by computing its fitness value. b. Scales the raw fitness scores to convert them into a more usable range of values. c. Selects members, called parents, based on their fitness. d. Some of the individuals in the current population that have lower fitness are chosen as elite. These elite individuals are passed to the next population. e. Produces children from the parents. Children are produced either by making random changes to a single parent—mutation—or by combining the vector entries of a pair of parents—crossover. f. Replaces the current population with the children to form the next generation.

• Is well suited for parallel computers, • Optimizes variables with extremely complex cost surfaces (they can jump out of a local minimum), • Provides a list of optimum variables, not just a single solution,

- • May encode the variables so that the optimization is done with the encoded variables,

B. **Stopping Criteria**

Stopping Conditions for the Algorithm

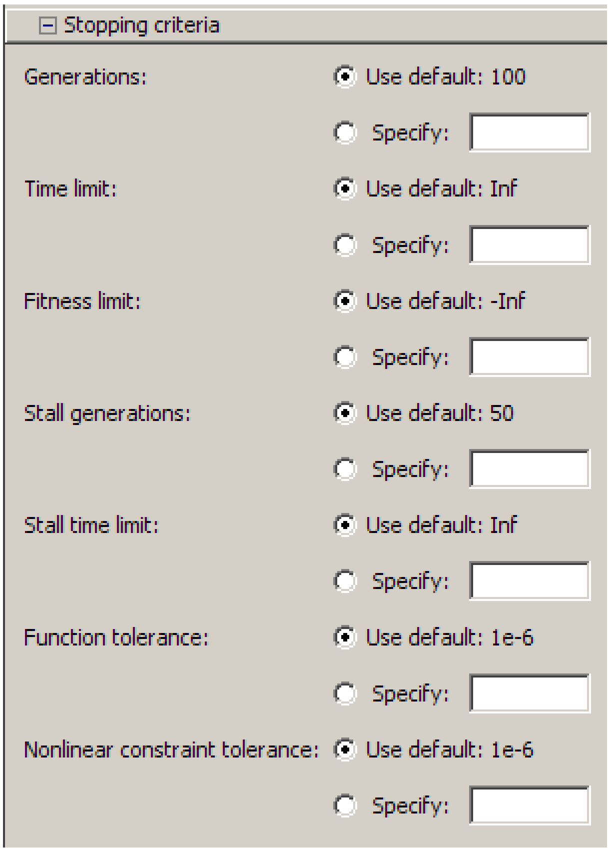
The genetic algorithm uses the following conditions to determine when to stop: Generations — The algorithm stops when the number of generations reaches the value of Generations. Time limit — The algorithm stops after running for an amount of time in seconds equal to Time limit.

Fitness limit — The algorithm stops when the value of the fitness function for the best point in the current population is less than or equal to Fitness limit. Stall generations — The algorithm stops when the weighted average change in the fitness function value over Stall generations is less than Function tolerance. Stall time limit — The algorithm stops if there is no improvement in the objective function during an interval of time in seconds equal to Stall time limit. Function Tolerance — The algorithm runs until the weighted average change in the fitness function value over Stall **generations** is less than **Function tolerance**.

Nonlinear constraint tolerance — The Nonlinear constraint tolerance is not used as stopping criterion. It is used to determine the feasibility with respect to nonlinear constraints.

The algorithm stops as soon as any one of these conditions is met. You can specify the values of these criteria in the

Stopping criteria pane in the Optimization Tool. The default values are shown in the panel



- The word “data” is plural, not singular.

Conclusions -

In this paper modern optimization techniques are explained in detail. These include: Genetic Algorithm (GA), Simulated Annealing (SA), A brief description of each method is presented along with a example to facilitate their implementation. Modern optimization technique is used to solve Non Linear and non-differentiable optimization problems which are not possible to solve by traditional optimization methods.

References

[1] Anil Shirahatt, P.S.S. Prasad, Pravin Panzade, M.M. Kulkarni, "Optimal Design Passenger Car Suspension for Ride and Road Holding", 'Journal of the Braz. Soc. of Mech. Sci. & Eng.', Vol. XXX January-March 2008,pp66-76. [

[2] A.R. Ismail, M.Z. Nuawi, C.W. How, N.F. Kamaruddin, M.J.M. Nor and N.K. Makhtar, ‗Whole Body Vibration Exposure to Train Passenger‘, American Journal of Applied Sciences, 2010, 7 (3): 352-359.

[3] Lu Sun ‗Genetic algorithm-based optimum vehicle suspension design using minimum dynamic pavement load as a design criterion ‗Journal of Sound and Vibration 301 (2007) 18–27.

[4] I. Maciejewski ‗Active control of a seat suspension with the system adaptation to varying load mass‘Journal of Mechatronics Vib 2009324:520–38.

[5] Sagar Deshpande, Sudhir Mehta, G. Nakhaie Jazar‘ Optimization of secondary suspension of piecewise linear vibration isolation systems ‗International Journal of Mechanical Sciences 48 (2006) 341–377.

[6] Zhongzhe chi, yuping he and greg f. naterer‘ Design optimization of vehicle suspensions with a quarter-vehicle model‘ transactions of the csme ide fa scgm vol. 32, no.2, 2008. [7]

[7] Tetsuya Higuchi, Yong Liu,Xin Yao, "Genetic and Evolutionary Computation", Springer,2006,pp14-32

[8] Kalyanmoy Deb, Vikas Saxena, "Car suspension design for comfort using Genetic Algorithm"

[9] Keum-Shik Hong,Dong Seop Jeon and Wan Suk Yoo"A new model and optimal pole placement control of the Macpherson Suspension System", 'SAE technical paper series', International Congress Expositiion,Detroit,Michigan,March14.1990 p1-10

[10] Jonusz Kowal,Jacek Snamina,Tomasz Wzorek,,"Calculations for the project of the laboratory stand for the testing vehicle suspensions",'Active Noise and Vibration control Methods',2011,June 06-08,pp109-114. PDVVP COE Ahmednagar Design Engineering 72

[11] Dragan Sekulić1‘the Effect Of Stiffness And Damping Of The Suspension System Elements On The Optimisation Of The Vibrational Behaviour Of A Bus ‗International Journal For Traffic And Transport Engineering, 2011, 1(4): 231 – 244.

[12] Alkhatib, G Optimization and integration of ground vehicle systems", 'Vehicle System Dynamics', Vol. 43, No. 6–7, June–July 2005, 437–453. [13] Hassan Nahvi Mohammad Hosseini Fouladi and Mohd Jailani Mohd Nor ‗Evaluation of Whole-Body Vibration and Ride Comfort in a Passenger Car ‗International Journal of Acoustics and Vibration, Vol. 14, No. 3, 2009 (pp. 143-149).

[13] Blum, C.; Roli, A. (2003). "Metaheuristics in combinatorial optimization: Overview and conceptual comparison". 35 (3). ACM Computing Surveys:268–308.