Study on Smoothness and Handling Stability of Mining Vehicle Based on Kinematic Object Function

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Keywords: Kinematics objective function; Mining vehicle; Ride comfort; Maneuverability and stability

Abstract: With the progress of science and technology, people's requirement for automobile performance is getting higher and higher. In this paper, the improvement of ride comfort and handling stability of mining vehicles is studied. The constraints, including upper and lower bounds and inequality constraints, are set for the actual working conditions through the parametric optimization design of kinematics objective function. It avoids the problem that the traditional optimization method stiffness optimization value often appears in the largest or small boundary area. When designing the control law, it is required to comprehensively consider various factors, reasonably select the weighting coefficient in the semi-active suspension performance index function, and control the motion response to improve the ride comfort and steering stability. It has a greater priority in the optimization process, that is, the goal is first guaranteed; and the goal with a smaller weighting factor is considered on the basis of achieving a larger weighting factor.

1. Introduction

Vehicle ride comfort is to maintain a certain degree of comfort in the vibration environment of the passengers during the driving process. Through pavement with water and slime [1] Mine trucks are used in underground roadways in coal mines where the environmental conditions are relatively bad. Because of the uneven road surface, the vertical force acting on the wheels has strong impact force, and the handling stability and ride comfort of the vehicles are poor [2]. Many scholars carry out suspension optimization and smoothness optimization. Only the steering stability is used as the constraint condition, and the smoothness is taken as the objective function, so that the local optimal solution, or the biasing property, or the steering stability is obtained. The kinematic objective function is used to solve the problem of the fastest speed manipulation of the starting point, the end point and the trajectory unconstrained. But in general, this situation is not universal [3]. The linear system optimal feedback control with the objective function as the quadratic form of the state vector and the control vector is the most commonly used control method for active and semi-active control of the automotive suspension system. The value of the weight matrix of the objective function reflects the degree of emphasis between different control performances [4].

The requirements of vehicle ride comfort and handling stability for suspension elasticity and damping parameters are often contradictory. In the oil-gas suspension system of mining vehicle, the movement of liquid in pipeline is much more complicated than that in laminar flow due to the action of road uneven excitation. It is not only necessary to overcome the internal friction between liquid layers, but also to overcome the turbulent friction caused by road impact, and the latter is much larger than the former [5]. The stiffness of elastic elements is non-linear and increasing (decreasing). The vibration frequency of the car body can be kept unchanged or changed little with the change of the car body mass by optimizing the parameters. Because the vehicle handling stability and ride comfort are contradictory, optimization based on one performance will often lead to another performance degradation. The objective function mainly refers to suspension positioning parameters, including camber angle, kingpin inclination angle, kingpin backward inclination angle and front bundle angle [6]. Constraints mainly refer to the range of variation of design variables and objective functions. Therefore, the multi-objective optimization problem for vehicle handling stability and ride comfort. According to the current state quantity of the system, the output also has future control inputs to predict the future output of the system [7]. The focus of our attention should be on the role of predictive models in predictive control, not the form in which predictive models are used. Using multi-body dynamics analysis tools and multi-objective optimization techniques to jointly simulate and balance the various indexes of steering stability and ride comfort is a way to solve the above problems [8].

2. Materials and Methods

In the analysis of vehicle ride comfort and handling stability, whether the road roughness accurately reflects the actual road surface has a great influence on the accuracy of vehicle performance analysis. When the mine vehicle is stimulated by road surface roughness, the swing frame swings up and down, and the adjusting rod in the follow-up mechanism moves up and down, which drives the valve core movement of the horizontal height control valve, thus controlling the high-pressure oil supply or releasing of the high-pressure oil in the oil and gas suspension. With parallel circuit, the left and right hydro-pneumatic suspension devices are independent. By controlling the piston chamber of the suspension cylinder with reversing valves, the height of the vehicle body can be adjusted, so as to change the minimum clearance between the body and the ground and improve the passing performance of the vehicle.On the one hand, the constraint condition of the objective function is mainly based on the recommended range of the variation range and the change trend of the positioning parameters in the automobile design, and on the other hand, it is also limited according to the specific design requirements. It has good consistency in the analysis of the intrinsic characteristics of each step.

In hydro-pneumatic suspension, oil is the force medium and gas is the elastic medium. Therefore, the amount of air inflated will directly affect the static characteristic curve of the suspension, the stiffness of the suspension, and consequently the ride comfort of the vehicle. The kinematics simulation and result analysis of suspension, setting design variables and objective functions, giving constraints, selecting optimization methods, and carrying out kinematics simulation again according to the optimization results, finally the kinematics performance comparison of suspension before and after optimization is obtained. Under the random excitation of mining vehicles, trucks and inferior roads, it is bound to bring a certain degree of impact to the level control valve. Therefore, the ride comfort and ride comfort performance of mining vehicles are difficult to guarantee, directly affecting the mine. Use the car's performance. Improve the ride comfort of the vehicle. Such as engine front and rear support, cab support, radiator support, front and rear axle limit blocks, muffler support and various bushings. Most of the vibration isolators are made of metal as a skeleton and rubber as an elastomer. In the kinematics objective function, both parties seek a correct mix of strategies to achieve equilibrium. The value of the countermeasure at this equilibrium point can be uniquely determined by the correct strategy mix, and this value will satisfy the minimax principle inequality. To achieve stability, the fitting equations of the road surface roughness must satisfy the conditions of all the complex root pairs of the coefficient characteristic equations located in the unit circle.

Because the mining vehicle is used for underground transportation equipment, its unique design shape limits its climbing performance, that is, when entering the slope angle, it must ensure that the front suspension part of the advancing mining vehicle can not touch the ground, and the maximum climbing performance also needs to meet this boundary condition. Generally speaking, the roll gain and time delay are minimized under the condition of insufficient steering gain. The actual front wheel angle of the vehicle changes smoothly, and there is no obvious sudden change and fluctuation. This shows that the output of the intelligent vehicle lateral controller is within the constrained range, and the control increment is small, which can meet the actual requirements of the vehicle. By reasonably adjusting the damping coefficient of the suspension and appropriately reducing the stiffness of the suspension secondary spring, it will be beneficial to the improvement of the ride comfort of the vehicle; to ensure that the vehicle has sufficient roll stiffness to meet the requirements of steering stability. The optimization problems derived from them often have the characteristics of non-convex, nonlinear, multi-peak and multi-dimensional. When the kinematic objective function is used to solve the multi-objective optimization problem with the feasible domain being concave, the local solution of the optimal solution will appear. It is not necessary for each component to be constrained, so the matrix can be taken as a semi-positive definite matrix. The optimization constraints are shown in Table 1. Practice shows that it is very important to correctly select the value of the weighting matrix, and different weighting matrices will get different system performance.

Table 1 Optimizing Constraint Conditions

	Initial value	Weighting factor
Transient understeering gain	0.32	0.06
Transient roll gain	0.19	0.03
Steering wheel angle delay	0.20	0.04
Yaw angular velocity delay	0.21	0.03

3. Result Analysis and Discussion

Because mining vehicles are mainly used for off-highway transportation, their running conditions are relatively poor, and the kinematics performance of mining vehicles is different under different operating conditions. Usually, the unbalanced force and moment produced by engine vibration can be eliminated or weakened by adding balance shaft and installing balance block. Its value needs to be specified by the designer according to the specific system conditions, and different values allow different weights to be added to different components. If a component is considered to be particularly constrained, the weight factor added to it will be increased. For different types of tires, the value of weighting factor should also be different. Such as: expensive bullet-proof tires, low-pressure, radial tires should be increased, while high-pressure, skew tires can be reduced appropriately. The specific conditions should be determined according to the price and service life of tires. The zero line of each measured variable is recorded, and then the test section is passed, and the time history curve of each measured variable and the time passing through the effective pile area are recorded. If the vehicle's centroid side angle is relatively small, the steering characteristics of the vehicle during driving can be characterized by the yaw rate of the vehicle; if the vehicle's centroid side angle is relatively large, the vehicle's trajectory cannot pass directly through the vehicle's yaw rate. To reflect.

Dynamic programming under kinematics objective function is an effective mathematical method to deal with the optimal control problem whose control vectors are limited to a certain closed set. It transforms the complex optimal control problem into a recursive function relationship of multi-level decision-making process. Its basis and core is the principle of optimality. Its dynamic stiffness is greater than static stiffness, impact stiffness is greater than static stiffness and dynamic stiffness, even if it is subjected to considerable impact, it is not easy to be damaged and seriously damaged; it is both an elastic and a damper, which is conducive to crossing the resonance zone. Under a certain load, the speed of mining vehicle increases gradually, and the acceleration decreases relative to the smooth road surface during the climbing process. Under different loads, the acceleration decreases gradually with the increase of the load, and the speed of the climbing process is relatively large at the same time. Pavement input can be roughly divided into impact and continuous vibration. Impact is a discrete event in a short period of time and has a higher intensity. After optimizing the position of the steering trapezoidal breaking point, the amount of change of the toe angle of the wheel can be significantly reduced, and the tire wear is reduced. Therefore, when encountering a problem where the toe angle seriously deviates from the design requirements, the toe angle can be considered as the main target, while other positioning parameters are optimized as secondary targets. The distribution in the target space is more uniform, and each optimal solution is superior to the solution corresponding to the initial parameters of the suspension at least in one optimization target.

The ultimate goal of solving the multi-objective optimization problem is to coordinate and trade-off among the objectives, so that the objective functions can be optimized as far as possible.

However, the optimization is rolling, which can compensate for the uncertainty caused by model mismatch in time, so as to ensure that each optimization solution is based on the actual situation. The approximate model usually smoothes the response function naturally. In most cases, it can also improve the convergence of the optimization process and help to converge to the global optimum faster. According to the relationship between the optimized design variables and the structural parameters, the layout structure of the stabilizer rod was adjusted, and the diameter of the stabilizer rod was increased, so that the roll stiffness of the vehicle was improved. If a certain objective function changes greatly in the process of single objective optimization, which means that its convergence speed is faster, then it is multiplied by a larger weight in the optimization of kinematics objective function to show its importance. Then a set of simulated vertical acceleration and pitch acceleration of the body mass center are substituted into the trained network to identify road roughness.In theory, active suspension can take into account various dynamic requirements, can achieve the ideal suspension control objectives, in line with the trend of automotive development, but energy consumption, high cost, complex structure. When the wheel is on the ground, it will slide to the outside while rolling, which will increase the wear of the tire. In order to avoid this cone rolling effect, the two front wheels are appropriately deflected inwardly to form a front wheel toe. It is assumed that the driving force is not large, and the influence of the ground tangential force on the tire side-off characteristic is not considered, and the tire side-off characteristic is considered to be in the linear range. Considering the steering inertia of the vehicle, the yaw motion, the lateral motion and the steering system rotation are considered. The degree of freedom linearity is shown in Figure 1.

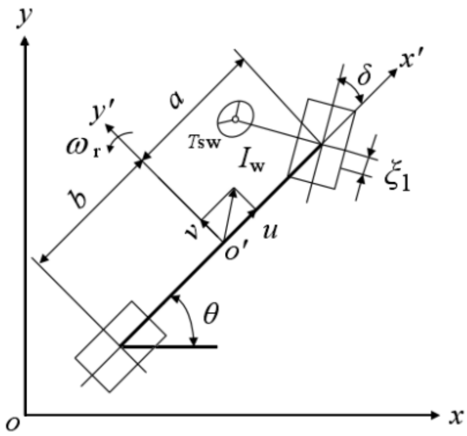

Fig.1. DOF Linear Direction

4. Conclusion

In this paper, the ride comfort and handling stability of mining vehicle based on kinematics objective function are studied. According to the control objective, the objective function and constraints are designed, and the kinematics objective function is used to solve the objective function to obtain the current time control quantity, so as to control the vehicle longitudinal speed and front wheel rotation angle. Due to the limitation of body layout, the change of hard point coordinates can only be limited to a small range, so the optimal value obtained by any optimization method is only a relative value, not an absolute optimal result. The vertical acceleration of the whole vehicle has the greatest impact on the ride comfort of mining vehicles. Through the analysis of the smoothing of the road surface of mining vehicles, it is found in the control simulation that the optimal control can improve the ride comfort or steering stability, but because the evaluation indicators are mutually Contradictions often sacrifice another performance when improving a particular performance. It can carry out comprehensive collaborative optimization simulation of various performance indexes of vehicle dynamics, and has practical engineering design practical value. The fastest speed maneuver problem is transformed into the optimal control problem by taking the given path as the control target in the shortest time.

Acknowledgement

Chengdu University Science and Technology Development Fund: Simulation study on the smooth ride of mine dump truck based on virtual prototype technology. Number: 20805176.

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