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车辆控制臂疲劳损伤分析与寿命预测

Fatigue damage analysis and life prediction for vehicle control arm

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英文关键词:vehicles finite element method fatigue damage life prediction rain flow counting method

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中文摘要:

为提高车辆结构疲劳耐久性、完善车辆结构设计方法，该文对车辆控制臂进行了的疲劳损伤分析与寿命预测研究。通过有限元分析法，建立控制臂有限元分析模型，分析其结构应力，确定疲劳损坏热点。实测获得试验场条件下控制臂的应变载荷，进行频谱分析与低通滤波等数据处理，利用雨流计数法，编制控制臂载荷谱。利用局部应力应变法与Miner准则，考虑结构应力集中修正，完成控制臂的疲劳损伤分析与寿命预估。结果表明，控制臂损伤热点主要分布在与转向节连接的过渡处，控制臂载荷信号频域能量主要集中在15 Hz以内，与车体结构的实际频率分布相符，控制臂的疲劳损伤分布与实际路况条件的受力状况相符，得出控制臂试验场预期寿命为3.96万h。研究结果可为车辆疲劳耐久研究提供重要参考。

英文摘要:

Abstract: In order to improve the vehicle structure fatigue durability, and to perfect vehicle structure design method, In this paper, fatigue damage analysis and life prediction on the vehicle control arm were done by three parts, namely, finite element modeling and analysis, load spectrum testing and establishment, fatigue damage analysis and life prediction. A fatigue life prediction method of vehicle control arm was put forward. Firstly, the finite element analysis model of the vehicle control arm was built in ANSYS software, and its construction stress was calculated and analyzed under the action of lateral and longitudinal forces respectively. Two hot points on the control arm were determined, which could bring about fatigue damage. The location of each hot point is respectively at the transition of the control arm connected to the steering knuckle and to the subframe. Both locations were identified as load testing points of P1 and P2 that strain gauges were pasted. Secondly, the strain load of the control arm was measured under the condition of the proving ground, nine kinds of roads were chosen in the proving ground and the vehicle speed was different on the each road. During the process of the experiment, the test was done repeatedly six times by three skilled drivers. After doing the data processing such as frequency spectrum analysis and low passing filtering, filter frequency were respectively 40 Hz and 15 Hz from the two channels of points P1 and P2, and the pure signal of vehicle control arm was acquired. Then, using rain flow counting method, the load spectrum of the control arm was worked out, and load distribution histogram on the testing points were obtained, and the average value of the load was accordance with the normal distribution, the load amplitude was accordance with the Weibull distribution by using probability map method. Finally, on this basis, according to local stress-strain method and Miner standard, and stress concentration correction factor, the fatigue damage analysis and life prediction were completed for the control arm. That is, some values on the testing points of the control arm were obtained including the total damage, hour life and cycle life, etc. Structural fatigue damage distribution characteristics of the control arm were analyzed. The fatigue notch factor of the control arm two testing points were calculated respectively, and the values were 1.36 and 1.14. The main conclusions were as follows, the load signal frequency domain energy mainly concentrated within 15 Hz, which conformed to the actual frequency distribution of the vehicle body. The larger fatigue damage of the control arm were occurred mainly on vehicle sharp turns under stone road conditions, and the fatigue damage distribution of the control arm was consistent with the stress state under the actual vehicle proving ground road conditions. The final result showed that the prediction life of control arm was 39600 hours by using the ncode glyphworks 8.0 software. The paper provided an important method that combined the finite element analysis with the actual vehicle loading conditions for fatigue endurance study on the vehicle and other parts.

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