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Research on Performance Test Platform of Automobile Mechanical Transmission Based on Bus Technology

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In order to improve the quality and performance of performance test platform for automobile mechanical transmission, the bus technology is applied in this paper. The system establishes a full-featured data acquisition hardware platform through the reasonable selection of sensors and data acquisition card. The software system is based on mixed of VC++ and MATLAB, including five modules: parameter setting, signal acquisition, signal analysis, quality testing and database. It achieves a synchronous acquisition of vibration signal and speed signal, while achieves online real-time analysis of vibration signal and speed signal taking advantage of the processing speed of MATLAB. From the experiment result and data analysis, the proposed method can improve the performance of performance test platform for automobile mechanical transmission substantially.

1. Introduction

Gearbox as the main components of the car, in the event of failure at worst affect the car's dynamic performance, serious may not be driving, there may even place a variety of traffic accidents, endangering life (Galvagno et al, 2012). Gearbox to maintain a good working state, it is necessary to pay attention to routine maintenance, but also need to ensure that when its loading is a qualified product. So the test after the gearbox assembly is crucial. But how to design a stable and reliable test bed to detect gearbox products, it has been a problem to explore for a vast number of research institutions and enterprises. As an important component of automotive, automotive transmission plays a significant impact on the overall performance of the car. Its technical parameters and working condition are important indicators to evaluate performance of the car. In the research areas of the automotive industry, the improving of the technical performance and reliability of the transmission is always the topics at the forefront of the automotive research (Takemasu, 2013). In order to ensure the quality of transmission and improve the detection rate and accuracy of quality, it is necessary to establish an online intelligent quality detection system of automobile transmission.

The automotive transmission is one of the critical components in automotive transmission system, whose performance makes a direct effect on comprehensive performance of automotive vehicle. With the continuous development of automobile industry, higher requirement is presented for improving load and rotating speed of transmission and vibration characteristic (Manring et al, 2013). As the heart of gear-train system, transmission also acts an important part in many other industry fields. Thus, investigating the dynamic characteristics of gear-train, it has a significance to assure normal and safe operation and lower service cost of device. In essence, the gear-train system is a multi-DOF nonlinear system with time-varying parameter and backlash nonlinearity. This nonlinear system appears complexity during analysing the dynamic behaviours of gear-train. Combing with the theoretic and techniques of gear dynamics, rotor dynamics, transfer matrix method, material mechanics, analytical mechanics, theoretical mechanics, nonlinear vibration, random vibration and chaotic dynamics, this paper researched on the performance test platform of automobile mechanical transmission (Maekawa, 2014).

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2. Overview

With the development of computer, communication and control technologies, the era of information has already come. During the 21st century, who can grasp more useful information and who will drive the advancement and development of the whole world? So we need study and work hard always. At the same time, we also need go ahead with the age and contribute our power for great country's boom and mightiness. As we all know, bus technology plays very important role during the information exchange of computers. Especially in the recent years, many new types of bus technologies came into being with the application (Kricheldorf et al, 2015). These new technologies' appearance made the information exchange process quicker and lighter. Whereas, USB and CAN bus technologies are typical representations of these new types of bus technologies.

CAN bus technology have been successfully applied to industrial control, automotive electronics, medical equipment, security, navigation equipment and other areas? CAN because of its excellent reliability and real-time, making it the most promising one of the industrial field bus and have been provided for the International Organization for Standardization for the ISO11898 international standards. In this paper, the CAN bus technology is applied in the performance test platform of automobile mechanical transmission (Popovic, 2012). Figure 1 shows the transmission principle for automobile mechanical transmission.

The vehicle handling & Stability for mechanical transmission contains two interrelated parts, one is handling that means the ability of vehicle exactly responding to driver's steering commands; another one is the stability that means the ability of vehicle recovering the original state of motion after external disturbance. The two are inseparable. The application of the transmission performance simulation platform and road test in vehicle riding & braking research through the front mechanical transmission biased design, impact strength and vibration attenuation of the simulation and comparative analysis of the road test results, the validity of the model is determined; through the comparative analysis between loaded with mechanical transmission calculation and the real test result, it is clear that the change of the vehicle parameters effect the performance of mechanical transmission (Sanada, 2012; Kim,2012). Figure 2 shows the structure for the automobile mechanical transmission.

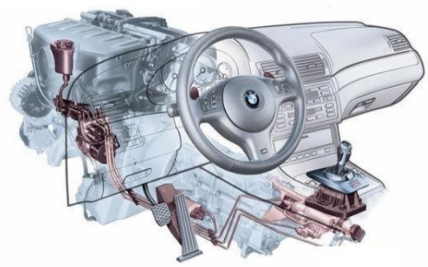

Figure 1: The transmission principle for automobile mechanical transmission

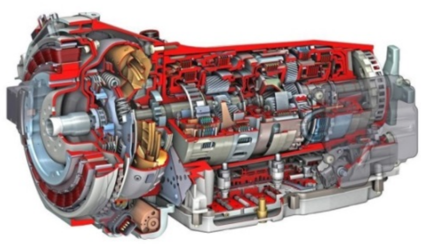

Figure 2: The structure for the automobile mechanical transmission

3. The basic model and algorithm

For the optimization of mechanical transmission, one of the first steps in any optimization process is the problem definition. Knowing what parameter you want to optimize and what factors contribute to its fluctuation are the core elements behind the set-up of an optimization problem. The derivation of the relationships between the parameter to be optimized and its controlling factors is very important. If a mistake is made during this problem formulation process the results of the optimization process will be incorrect. The purpose of this section is to go through the problem formulation process we used to develop the objective function, design variables and design constraints associated with our problem. The goal is to optimize the placement of the front shock absorbers that are used on the SAE Mini Baj a Car. The current configuration was found using a trial-and-error method, trying different mounting configurations and choosing the one that performed the best. Our goal is to optimize the mounting position given certain move limits and constraints so that upon impact the energy absorbed by the shock absorber will be maximized. The energy absorbed by the shock absorber will be equal to the potential energy of shock absorber in its final compressed state. So our aim is to find the mounting positions of the shock absorber so that its potential energy is maximized upon impact with the ground. There are many variables associated with the formulation of the optimization problem, so before going any further the notations used during the process are discussed.

According to the visual theory, the calculating formula can be obtained in equation (1)-(3) (Amisano et al, 2014).

$$\mathcal{g}(x,\omega)=\frac{1}{(2\pi)^3}\int \mathcal{g}(k,\omega)\exp(-i\mathrm{k}\cdot\mathrm{x})d\mathrm{k} \tag{1}$$

$$\mathcal{g}(k,\omega)=\begin{Vmatrix} G_{ik}(k,\omega) & \gamma_i(k,\omega) \\ \gamma_k^T(k,\omega) & g(k,\omega) \end{Vmatrix} \tag{2}$$

$$G_{ik}=(\Lambda_{ik}+\frac{1}{\lambda}h_i h_k^T)^{-1},\ g=-(\lambda+h_i^T\Lambda_{ij}^{-1}h_j)^{-1},\ \gamma_i=\frac{1}{\lambda}h_k^T G_{ki}, \tag{3}$$

To calculate the parameters in above equations, then we have:

$$\Lambda_{ik}(k,\omega)=k_j C_{ijkl}^0 k_k-\rho_0\omega^2\delta_{il},\ h_i(k)=e_{kil}^0 k_k k_l,\ h_l^T=e_{ikl}^{0T}k_i k_k,\ \lambda(k)=\eta_{ik}^0 k_i k_k \tag{4}$$

$$\frac{1}{2\pi}\int_{-\infty}^{\infty} e^{-ik_3x_3'}dx_3'=\delta(k_3) \tag{5}$$

$$s(X\to Y)=\frac{\sigma(X\cup Y)}{N} \tag{6}$$

$$c(X\to Y)=\frac{\sigma(X\cup Y)}{\sigma(X)} \tag{7}$$

The formula generates labels for each file block.

$$for(j=0;\ j\le n-1;\ j++); \tag{8}$$

$$\{W_j=r*(j+1);T_i$$
$$=[h(W_j)*m_j]^c \bmod N\}; \tag{9}$$

$$Output(T_0,T_2,...T_{n-1}); \tag{10}$$

And local fractional integral of f(x) defined by Eq.9.

$${}_aI_b^{(\alpha)}f(t)=\frac{1}{\Gamma(1+\alpha)}\int_a^b f(t)(dt)^{\alpha}$$
$$=\frac{1}{\Gamma(1+\alpha)}\lim_{\Delta t\to 0}\sum_{j=0}^{j=N-1}f(t_{\mathrm{j}})(\Delta t_{\mathrm{j}})^{\alpha} \tag{11}$$

Its local fractional Hilbert transform, denoted by $f_x^{H,\alpha}$ is defined by

$$H_\alpha\{f(t)\}=\hat{f}_H^{\alpha}(x)$$
$$=\frac{1}{\Gamma(1+\alpha)}\oint_R\frac{f(t)}{(t-x)^{\alpha}}(dt)^{\alpha} \tag{12}$$

Where x is real and the integral is treated as a Canchy principal value, that is,

$$\frac{1}{\Gamma(1+\alpha)}\oint_R\frac{f(t)}{(t-x)^{\alpha}}(dt)^{\alpha}$$
$$=\lim_{\varepsilon\to 0}[\frac{1}{\Gamma(1+\alpha)}\int_{-\infty}^{x-\varepsilon}\frac{f(t)}{(t-x)^{\alpha}}(dt)^{\alpha}+$$
$$\frac{1}{\Gamma(1+\alpha)}\int_{x+\varepsilon}^{\infty}\frac{f(t)}{(t-x)^{\alpha}}(dt)^{\alpha}] \tag{13}$$

$$for(j = 0;\ j \le n-1;\ j++);\ Output(T_0, T_2, ...T_{n-1}); \tag{14}$$

The output of the network is given as:

$$y_m(k) = wh = w_1h_1 + w_2h_2 + ... + w_mh_m$$
(15)

Assuming the ideal output is y (k), the performance index function is:

$$E(k) = \frac{1}{2}\left(y(k) - y_m(k)\right)^2 \tag{16}$$

The response functions are shown in the equation (9)-(13):

$$\begin{aligned} w_j(k) &= w_j(k-1) + \eta\left(y(k) - y_m(k)\right)h_j \\ &+\alpha\left(w_j(k-1) - w_j(k-2)\right) \end{aligned} \tag{17}$$

$$\Delta b_j = \left(y(k) - y_m(k)\right)w_jh_j\left(\frac{\left\|X - C_j\right\|^2}{b_j^3}\right) \tag{18}$$

$$\begin{aligned} b_j(k) &= b_j(k-1) + \eta\Delta b_j \\ &+\alpha\left(b_j(k-1) - b_j(k-2)\right) \end{aligned} \tag{19}$$

The matrix algorithm is as follows:

$$\frac{\partial y(k)}{\partial u(k)} \approx \frac{\partial y_m(k)}{\partial u(k)} = \sum_{j=1}^{m} w_jh_j\frac{c_{1j} - x_1}{b_j^2} \tag{20}$$

4. The experiment and result discussion

The nonlinear constrained minimization problem formulated for the suspension system was solved using the optimization tool-box in Matlab specifically with the command function. This is the most suitable command for a nonlinear objective function with multiple nonlinear constraints. It uses a sequential quadratic programming technique to find the optimal solution. This technique converts the objective function to quadratic form and linearizes the constraints. Then in test iteration, an approximation of the Hessian of the Lagrangian is made using a Quasi-Newton updating method. This method proved to be very effective and efferent as convergence was reached generally within a matter of seconds. The number of iterations and function evaluations were consistently low causing the problem to converge rapidly. The method could start from either an extreme infeasible point or a feasible point near an actual optimum, with just a slight increase in the number of iterations and function evaluations.

The minimum potential energy function is a multi-parameter optimization, since all 5 variables in the vector x must be optimized for the single objective function. In the GA, each individual is comprised of a single possible solution to the optimization. Therefore, each individual is defined by only 5 values, or genes, one for each of the parameters. In the algorithm used, iteration begins with the selection of the best individual from the entire population. The algorithm then processes each individual in the population. For each individual, two individuals from the population are randomly selected (population sample) and combined to create a perturbing vector. This perturbation is added to the best individual forming a reproduction candidate. Each individual may have a different reproduction candidate, since each has a different perturbation vector (created from a different population sample). The individual is then potentially crossed (mated) with the reproduction candidate. If crossing occurs, there is a potential for mutations in the genes being passed. Figure 3 shows the 3D model and the real map for the performance test platform of automobile mechanical transmission based on bus technology.

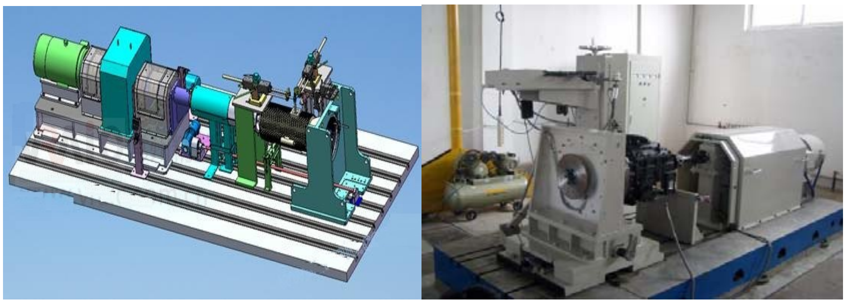

Figure 3: The 3D model and the real map for the performance test platform of automobile mechanical transmission based on bus technology

The test stands on the use of a dynamic shift pattern. The test platform is to meet the input power 500kW, input torque 3000N.m transmission performance of heavy vehicles designed for large-scale life test measurement and control system test rig is mainly used for controlling and measuring transmission speed, torque, power, temperature, etc. kinds of parameters. System used in the design process mature and reliable JC-type phase-type torque-speed sensor for measuring the original, with the Lanzhou Engineering Group 560KW AC variable motor and ABB, AC800 Series AC inverter drive and torque control as the driving force, and through a total of approach to load DC bus electrical power generated electricity back to the drive motor closed form, so to save energy. The test platform modular structure design, full use of test bed on the floor, electrical sensors, clamps and other resources, through a combination of different forms of evolution can be achieved in the same test bed for different types of test transmission of the performance test. Test with the installation quick, easy adjustment, high degree of automation features. Automatic test process can be intelligent control, and have manual control mode. Test bed simulation of dual frequency motor vehicle transmission of the actual conditions to realize the true test of the transmission performance. To ensure the smooth progress of test, test rig equipped with oil temperature control system, oil temperature control system can guarantee that in the testing process of the transmission oil temperature within the set of real-time control, to get the transmission in a variety of speed, twisted moment, the oil under the curve. Mechanical transmission through the existing common test specification preliminary study, based on our company produces transmission structure and, combined with specific requests made by OEMs and the introduction of new technology-related provisions drawn up by test transmission of the test specifications, as the Transmission bench test method. System adopts PLC programmable controller to control transmission, automatic transmission oil temperature control system of institutions and movements. The computer system is control the entire system of process, data acquisition, data storage, generate statements and draw curve print out report. Through the diligent work of partners, on behalf of our advanced level of integrated power transmission test stand has been closed design completed and debugged. Figure 4 shows test results of transmission characteristic curve and figure 5 shows test results of speed regulation characteristic curve. The experiment result shows the proposed method can improve the performance of performance test platform for automobile mechanical transmission substantially.

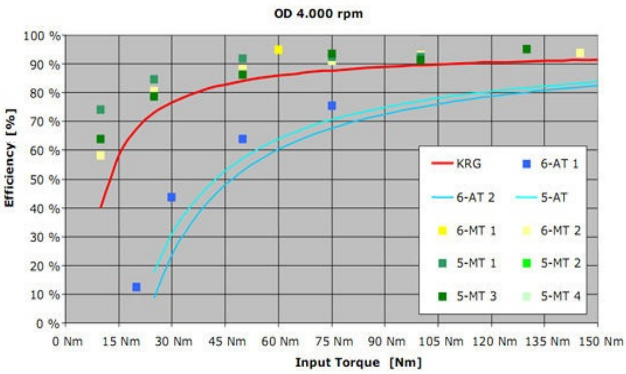

Figure 4: results of transmission characteristic curve

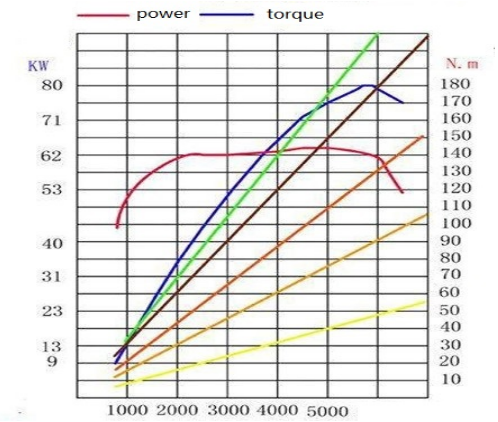

Figure 5: results of speed regulation characteristic curve

5. Conclusions

The purpose of this paper is to improve the quality and performance of performance test platform for automobile mechanical transmission, the bus technology is applied in this paper. The application of the transmission performance simulation platform and road test in vehicle riding & braking research through the front mechanical transmission biased design, impact strength and vibration attenuation of the simulation and comparative analysis of the road test results, the validity of the model is determined; through the comparative analysis between loaded with mechanical transmission calculation and the real test result, it is clear that the change of the vehicle parameters effect the performance of mechanical transmission. From the experiment result and data analysis, the proposed method can improve the performance of performance test platform for automobile mechanical transmission substantially.

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