Simulation Research on Braking Test Model of Speed Signal

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**Abstract.** We established an accurate mathematical model and get differential equations of the whole automobile and front and rear wheels by theoretical analysis. Based on braking theory, the author uses MATLAB / Simulink software to build simulation model of car braking process, and then tries to analyze the speed signal. The result of the speed signal analysis basically meets research requirements. Compared with the traditional field automobile brake test, this thesis will save a lot of manpower and resources through computer simulation, and will improve research quality and efficiency of automotive braking systems.

**Introduction**

Automobile braking is the most important part of automotive performances. It is closely related to people's life and the primary guarantee of vehicle safety travel. In the traditional automobile braking research, it often found each parameter of braking system whether reach the requirements of performance at the end of vehicle design or testing of prototype. At this time, it delays the development of new products and causes the waste of material and manpower if again for car modification \cite{1}. We combining the characteristics of the automobile braking process and according to some related problems of speed signal in automobile braking, wheeled vehicle as the research object and the MATLAB/Simulink simulation model was established and provides the reference for the speed signal processing and analyzing on the automotive brake experiment provides the reference.

**Vehicle Braking System**

**Major Components and Classifications of Braking System**

Vehicle braking system was composed of hydraulic system (for producing braking energy), control system (for having a braking action, control its effect, such as the foot pedal linkage), transmission systems (sent braking force to the various parts, like brake wheel cylinder, master cylinder, brake pipe line and hose) and the brakes (the parts that is finish braking action, such as disc brake and drum brake). Besides, braking system also has power systems, adjusting brake combination valve and alarms in modern vehicles.

There are many classification methods about braking system. According to brake efficacy, braking systems can be divided into the braking system, brake system, emergency braking systems and auxiliary braking systems. According to braking energy, braking system can be divided into human braking systems, powered braking system and servo braking systems. According to transmission mode, braking system can be divided into the mechanical brake system, hydraulic braking system, the air braking system and solenoid braking system. In addition, according to the brake pipe layout methods, Modern cars can be divided into single loop brake and double circuit brake.
Principle of Brake System

Currently, most cars take hydraulic braking so that the principle of brake system can illustrate by the diagram of the braking system basic principle [3], as shown in Fig. 1 below. As seen in Fig. 1, the surface of brake drum is an inner cylinder and it fixedly installed on the hub, circumvention with wheels. Brake back plates is locked, in which have two supporting pin that use to support the lower part of curved brake shoes. While the outside cylinder surface of brake shoes have installed brake strip. Brake wheel cylinder above brake back plates, through brake lines connected to the brake master cylinder which above frame. The piston of master cylinder for braking is by driver step on the brake and then push the brake of push rod.

When braking system is not action, there is a portion of gap between the external cylinder of brake friction and internal cylinder of brake drum, so that the brake drum can freely rotates with the wheel. When vehicle needs to brake, driver should to step on the brake with the foot and then push the brake piston through push rod, make liquid of the brake master cylinder flow to braking wheel cylinder under pressure, then push wheel cylinder piston and brake shoes moving about supporting pin, thus brake friction which installed on brake shoes push hard against the internal cylinder of brake drum. Because brake shoes are fixed, there is a friction moment among the moving brake drum which the direction is opposite to the wheel rotation direction. The moment can be passed to wheels by brake drum. Wheels hit the ground with an edge force because of there have an adhesive action between wheels and ground. According to Newton's Third of Motion action and reaction are equal and opposite, so that ground hit Wheels also with a rearward reaction force that is braking force. The braking force make vehicle have a deceleration, it means that the brake of brake system take effect. When releasing brake pedal, the brake shoes return to the original position for compressible spring of brake shoes, there is no friction and friction moment and the brake force between brake strip and brake drum, at the moment braking action is stop.

Establish of Simulation Models and Results Analysis

Using MATLAB/Simulink software, take math models of the process of automobile braking into computer simulation model in Chapter 3, the model including more sub modules. And encapsulating 6 subsystems, its parameters are barking force on the front and rear wheel, angular velocity of tire and adhesion coefficient on road surface. Fig. 1 is simulation models.

Figure 1. ABS system Speed Simulink simulation model.
Table 1. The calculation parameters of station wagon of Beijing brand model 632A.

<table>
<thead>
<tr>
<th>parameter</th>
<th>M / Kg</th>
<th>a / m</th>
<th>b / m</th>
<th>h / m</th>
<th>r1 / m</th>
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<tbody>
<tr>
<td>value</td>
<td>2340</td>
<td>1.48</td>
<td>1.19</td>
<td>0.6</td>
<td>0.35</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>parameter</th>
<th>r2 / m</th>
<th>l1 / (Kg·m²)</th>
<th>l2 / (Kg·m²)</th>
<th>k1 / (N·m·s⁻¹)</th>
<th>k2 / (N·m·s⁻¹)</th>
</tr>
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<tr>
<td>value</td>
<td>0.35</td>
<td>18</td>
<td>39</td>
<td>10300</td>
<td>12100</td>
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</tbody>
</table>

Table 2. The calculation parameters of adhesion coefficient on road surface.

<table>
<thead>
<tr>
<th>parameter</th>
<th>n1</th>
<th>n2</th>
<th>K1</th>
<th>K2</th>
<th>φ0</th>
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<tbody>
<tr>
<td>value</td>
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<td>-2.2</td>
<td>0.004</td>
<td>0.2</td>
<td>0.8</td>
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</tbody>
</table>

Simulation Results and Corresponding Analysis

Simulation models were established on this article and it is based on Beijing brand model 632A station wagon, as shown in table 1 and 2 [7-10].

According to the providing parameters and the design of vehicle braking simulation models, Programming and modeling simulation in MATLAB and the simulation results and corresponding analysis as described below.

![The response curve of braking force](image)

Fig. 2 is the response curve of front and rear wheels braking force when vehicle is barking with 10Km/h. Due to the braking force using To Workspace structure format on the encapsulated sub-system of F1 and F2, thus workspace data called directly from MATLAB program statements and its graphs are derived. The analysis for Fig. 4 is as follows:

When t=0~0.38s, front wheels adhesion coefficient on road surface is gradually increase base on the above analysis, thus the braking force is gradually reaches a maximum. When t=0.45s, the braking force tend to be constant, this moment the front wheel of automobile locking and dragging, the braking force keep constant until the automobile is stop.

When t=0~0.28s, the braking force of rear wheel is gradually increase and reaches a maximum. When t=0.37s, the rear wheel of automobile is completely locked and ragging, the braking force tend to balance until the automobile is stop.
Fig. 3 is the response curve of vehicle brake speeds when vehicle is barking with 10Km/h. Due to the braking force using structure format, workspace data called directly from MATLAB program statements and then its graphs are derived or get by 'oscilloscope V' on the simulation model. The analysis for Fig. 5 is as follows:

When $t=0$~$0.12s$, the automobile is in braking delay stage and automobile is braking on a 20 slope, thus constitutes a certain acceleration, the speed of automobile is still increasing during the time.

When $t=0.12s$, the brake is acting and the automobile is begin to braking and keep rolling and sliding. Until about 0.45s, the wheel of automobile is completely braking and the speed have a linear decreasing. When $t=1.2s$, speed becomes 0 and the automobile is stop, the process of braking is over.

**Conclusions**

The paper begins with the background of the significance of modern society traffic safety, reviewed the necessity of automobile great braking performance to traffic safety, combining with the study about automobile braking system and proposed the reasonableness of simulates and analysis speed signal. And then considering the principle of automobile braking, establish the automobile braking system mathematics model, combining with MATLAB/Simulink translate mathematical model into computer simulation model, thus get the simulation results, at last analysis and process about speed signal in the simulation results. The cardiograph work is as follows:

This paper describes the background and significance of the study and makes a brief summary to the research situation at home and abroad. And then start by the development of automotive braking technology, analyses the major component and classification of automobile braking system. Considering from disc brake and drum brake, analysis the working principle of automobile braking system respectively and discussed the advantage and disadvantage of different types of brake, finally make a brief analysis about the estimation methods of vehicle braking performance.

By analyzing the automobile braking process is divided into three categories, and then the differential equation model, the motion differential equation model of the front and rear wheel on the braking process are established.

The thesis simply clarifies the function and benefits of MATLAB/Simulink simulation shows that using Simulink simulation is rational. Combining with the mathematical model of automobile braking system establish Simulink simulation and calculates that the braking speed and deceleration on the process of braking by the designed parameters, finally make a concrete analysis of simulation result.

In short, this paper modeling and simulation the braking process of automobile, basically realizing the computer simulation study with the speed signal of automobile braking process.
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References