Research of Evaluation Parameters on the Operating Performance of Steering Column Switches Based on Discrete Analysis

Jinhe Chen, Cuidong Wang, Xia Wu, Xiao Zhou, Jiayu Liang and Jianwen Li

ABSTRACT

By analyzing the shifting process of steeringcolumn switches, select the inflection point force, shift force, the difference between the force, down gradient, displacement as performance evaluation parameters of steeringcolumn switches. Tested and acquisition operating characteristic curve of 100 subjective assessment for steering column switches quality, and extracting the corresponding parameters of operation performance evaluation for discrete analysis. Determine the degree of influence on the performance of the dispersion according to each evaluation parameter. On this basis points out, the paper puts forward the on-line rapid detection method of automobile Steering column switches operating performance.

KEYWORD: Steering column switches; Operating performance; Evaluation parameters; Online assessment

GENERAL INSTRUCTIONS

Vehicle steering column switches is constituted by many small parts, because there are some differences between the various components of manufacturing error, assembly error, the lubricating effect and other factors, even though the same batch of the Steering column switches its operation performance will have some uncertainty and randomness. When testing the operation force characteristic curve, while the operating force characteristic curve with similar characteristics, but some mechanical parameters of the operating force characteristic curve is always more or less different[1].

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Performance quality good Steering column switches, its spare parts with high precision, measurement of each evaluation parameter range is relatively small, which operating feel is good, can get the higher subjective score;

The poor performance of quality automotive Steering column switches, because the larger manufacturing errors and assembly errors of parts, lubricating effect is not very good, leading to the evaluation parameter switch to be too large or too small, poor touch switch operation, its performance ratings will unable to get a high score.[2]

Literature [3] takes shifting process of steering column switches of two performance levels for analyze. Study found that, the switches of different performance level, the shift of some mechanical parameters in the process of distribution has obvious boundaries, can be used as a switch performance evaluation parameters. However, the study did not affect these parameters on the degree of steering column switches quantify performance. Literature [4] through the establishment of steering column switches operating performance evaluation model, realize the steering column switches operating performance of quantitative evaluation. The outcome of the study is to determine the impact of different evaluation parameters Steering column switches operating performance, but this model is based on the basis of the subjective evaluation data, and not through the test, the reliability of remaining questions. Therefore, we choose the same batch of high-quality steering column switches for study, according to the degree of dispersion of different evaluation parameters, quantitative analysis of the evaluation parameters will affect the operational performance.

SELECTION AND ACQUISITION EVALUATION PARAMETERS OF STEERING COLUMN SWITCHES

Evaluation Parameter Selection

Under the same experimental conditions, we operation force curve in the process of steering column switches shift, although there is some differences in the size of the mechanical parameters, it can be found that the shape of the curve is similar, so the change of performance good steering column switches operating force have similar laws. According to the characteristics of the steering column switchesshift process force, the curves of force can be divided into four parts: the initialstrength process, critical state and second strength process, the falling process. Figure 1 is a steering column switches shift operation force characteristic curve Fig.

![Figure 1. Steering column switches power curve shifting process schematic.](image)
Operating force characteristic curve depicts the shifting process of steering column switches. To explore the change rule of curve, we first find the special points with significant physical information from the force curve, to these special points as research object, to find the corresponding relationship each other between the steering column switches operating performance of and these points, to evaluate mechanical parameters of steering column switches operating performance. As shown in figure 1, selecting turning point \( F_c \), shifting forces \( F_m \), delta force \( F_d \), displacement \( G \) and falling gradient \( S \) as operating performance evaluation mechanical parameters of steering column switches.

The Test Process

Taking 100 HFC6500 steering column switches as test object, chosen by experts to evaluate its operating performance for the subjective quality, the samples are numbered from 1-100. According to the structure of the size of the steering column switches, adjust the position of the fixture, and to secure it. Selection pressure sensor of the range of 5N·M, the speed of the manipulator is 5°/s, the room temperature is 20°C, the curves of tested respectively to obtain the force, and extract the five mechanical parameters: displacement, shift force, inflection point force, delta force, force falling gradient.

THE ANALYSIS OF DISCRETE DEGREE OF THE EVALUATION PARAMETERS

The Analysis of Discrete Degree of the Shift Force

Processing the test data of shift force of steering column switches, the distribution range of data is equally divided into 20 intervals, the frequency sample and the normal probability density of each section were calculated. As shown in figure 2, Ordinate is sample frequency, the abscissa is shifting force, time coordinate is probability density. The shift force of samples test data is normally distributed, 61 samples in 100 samples shifting force concentration between 0.968 ~ 1.013N·M. This suggests that the shift force of superior steering column switches distribution is relatively concentrated, shifting force can be used in steering column switches operating performance evaluation.

![Figure 2](image1.png)  ![Figure 3](image2.png)

Figure 2. Shift force distribution range. Figure 3. Inflection point force distribution range.
The Analysis of Discrete Degree of the Inflection Point Force

Processing the test data of inflection point force of steering column switches, the distribution range of data is equally divided into 20 intervals, the distribution of inflection point force is shown in figure 3. Inflection point force test data of the samples distribution in a relatively concentrated area. 81 samples in 100 samples inflection point force concentration between 0.5812~0.62425 N·M. This suggests that the inflection point force of superior steering column switches distribution is relatively concentrated, inflection point force can be used as an important parameter in steering column switches operating performance evaluation.

The Analysis of Discrete Degree of the Delta Force

Processing the test data of delta force of steering column switches, the distribution range of data is equally divided into 20 intervals, the frequency sample and the normal probability density of each section were calculated, as shown in figure 4. The delta force of samples test data is normally distributed, only 56 samples in 100 samples delta force concentration between 0.365~0.41 N·M. This suggests that the delta force of superior steering column switches is more dispersed, delta force as steering column switches operating performance evaluation parameters of little value.

The Analysis of Discrete Degree of the Displacement

Processing the test data of displacement of steering column switches as shown in figure 5. The displacement test data of the samples distribution in a relatively concentrated area. 70 samples in 100 samples displacement concentration between 10.9719°~11.7904°. This suggests that the displacement of superior steering column switches distribution is concentrated, displacement can be used as a parameter in steering column switches operating performance evaluation.

The Analysis of Discrete Degree of Force Falling Gradient

Figure 6 shows that, with respect to other evaluation, the samples test data of falling gradient distribution of is relatively uniform, discrete degree is bigger. Only 52 samples in 100 samples force falling gradient concentration between
10.9719~11.7904N·M/°. This shows power falling gradient of superior steering column switches is low concentration, the reference value of force falling gradient as steering column switches operating performance evaluation factors is not high.

Figure 6. Force falling gradient distribution range.

PHOTOGRAPHS ANALYSIS THE RELATIONSHIP BETWEEN DISCRETE DEGREE OF EVALUATION PARAMETERS AND OPERATING PERFORMANCE

Steering column switches performance evaluation is a multi-index comprehensive evaluation, there are differences in dimensions and dimensional evaluation between different units, this paper is a discrete analysis of different indicators, in order to overcome the differences caused by the dimensionless incommensurability, dimensionless treatment must be carried out for each index. We used average method for data processing, able to save more complete information in raw data contains, keep variation degree of each index and ensured the evaluation results more accurate [7-8]. The reduction method of the average formula is as follows:

$$y_{i,j} = \frac{X_{i,j}}{X_j}$$

(1)

After dealing with the average change, the average of each index is 1, and the variance is:

$$\text{var}(y) = E[(y_i - 1)^2] = E\left[\frac{(x_i - \bar{x})}{\bar{x}_j}\right] = \frac{\text{var}(x)}{\bar{x}_j} = \left(\frac{\sigma_j}{\bar{x}_j}\right)^2$$

(2)

According to the above formula data processing, we get the variance of evaluation parameters as shown in table 1.
Table 1. Variance of indicators data.

| Index          | shift force | inflection point force | delta force | displacement | force falling gradient |
|----------------|-------------|------------------------|-------------|--------------|------------------------|
| Arithmetic mean | 0.98629     | 0.60409                | 0.3822      | 11.45183     | 1.02371                |
| The standard variance | 0.03250     | 0.03425                | 0.09450     | 0.04125      | 0.10932/8              |

Preliminary analysis, the distribution of Steering column switches mechanical index test data have a certain regularity, we put the mechanical dispersion index as an evaluation parameter to judge the merits of the Steering column switches operating performance. The lower the degree of dispersion of indicator data, the lower the standard deviation, indicating the greater impact on the performance of the index Steering column switches, the higher the standard deviation, the higher the degree of dispersion of indicator data, indicating that the smaller the impact of the indicators on the performance of the Steering column switches. Known from the analysis of the above results, the shifting force, inflection point force and displacement data distribution is relatively concentrated, the bigger influence on the performance of automobile combination switch. Delta force, falling gradient data distribution is relatively dispersed, the less effect on the properties of combination switch. For more in-depth analysis of the importance of different indicators, we performed non-dimensional treatment of the mechanical parameters of each index, then the standard deviation of the different indicators were compared. The table 1 shows the variance of the five indicators, namely sizes of discrete degree, from small to large, respectively: shifting force value, inflection point force, displacement, difference, gradient.

APPLICATION OF THE OPERATION PROPERTY EVALUATION PARAMETERS AND ONLINE ASSESSMENT METHOD

The test results show that the shift force, inflection point force and shift displacement can be used as a combination switch operating performance evaluation index. Delta force and force falling gradient can not be used as the evaluation index. Inflection point, shifting forces and delta force index can be used alone, you can also use them to evaluate performance combination switch at the same time. In these three indicators, shift force play the most important role on the operating performance evaluation of combination switch, shift evaluation of minimum displacement. Thus, in the combination switch operating performance evaluation, fluctuation quantity of shift force parameter is the smallest, and the displacement fluctuation quantity is the biggest of all. It should be noted that Before operating performance evaluation, the combination switch should be inspected to ensure that their basic performance standards, namely that combination switch should satisfy the installation size, appearance, contact voltage drop, the basic requirements, and then operating performance evaluation on it.

With a single index for evaluation of the operating performance of the combination switch, you can use the shift force distribution area as evaluation parameters, according to the type of combination switch and the actual demand, set
the product's shift force mean \( F_m \) and the allow amount of fluctuation \( \delta_i F_m \). If the combination switch shift force to meet:

\[
\frac{F_m - \delta_1 F_m}{F_m} \leq \frac{F_m}{F_m} \leq \frac{F_m + \delta_1 F_m}{F_m}
\]

We can determine the combination switch for excellent maneuverability.

When evaluating the performance of the combination switch with three indicators, we need to set the shift switch mean and the allow displacement of the fluctuation range, as well as the fluctuating point force mean and inflection range. Among them \( \delta_1 < \delta_2 < \delta_3 \).

\[
\frac{\bar{S} - \delta_2 \bar{S}}{\bar{S} + \delta_2 \bar{S}} \leq \frac{\bar{S}}{\bar{S}} \leq \frac{\bar{S} + \delta_2 \bar{S}}{\bar{S} - \delta_2 \bar{S}}
\]

\[
\frac{\bar{F}_c - \delta_3 \bar{F}_c}{\bar{F}_c + \delta_3 \bar{F}_c} \leq \frac{\bar{F}_c}{\bar{F}_c} \leq \frac{\bar{F}_c + \delta_3 \bar{F}_c}{\bar{F}_c - \delta_3 \bar{F}_c}
\]

CONCLUSION

This article adopt the method of multiple sampling, carried out a large number of trials in view of the master of automobile combination switch operating characteristics and the corresponding statistical analysis. The results show that: (1) the performance evaluation of the different operating parameters have different range, namely its discrete degree is different; (2) according to the variance of different evaluation parameters, which can determine the influence of evaluation parameters the to the combination switch operation performance; (3) distribution of shift force, inflection point force and shift displacement can be used as combination switch operating performance evaluation parameters, applied to production field, achieve rapid detection of combination switch operating performance.

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