A Study on Quality Traceability of Transmission Assembling Based on Kruskal-Wallis Method

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Abstract

Along with the development of tracing technique, the acquired data turns to be increasingly three-dimensional and complicated in quality traceability of transmission assembling, which requests of offering more scientific tracing statistical method of conversion from date information to decision information. In the paper, a statistical method is put forward based on Kruskal-Wallis test in light of data feature, pointing out test steps of applying Kruskal-Wallis method and offering scientific referential ground to next decision of directors according to traceability analysis on transmission assembling quality in the test. It is shown from the experimental result that application of Kruskal-Wallis takes effect in quality traceability of transmission assembling.

Keywords: Kruskal-Wallis,TextMethod,Quality Traceability

1. INTRODUCTION

Quality problems returning to zero are always the highest goal pursued n the quality management. With the development of tracing technique, the application of RFID technology in data acquisition, although complex data able to be collected in quality traceability management, it is difficult to use a suitable statistical methods for traceability. If the intuitive statistical methods commonly used in the past still used, the result obtained by quality diagnosis has no enough convincing. If the reference basis converting into decision-making information is not enough scientific, the front-line operator aimed by traceability measures of quality problems will raise objection so that quality problems can not be resolved and the quality management of the corporate will fail.

For Kruskal-Wallis method, the domestic and foreign scholars have done excellent research, carrying forward especially in testing process, and each one having its own object. West Ear.S has analyzed fully and illustrated methodologically the Non-parametric tests in the book Nonparametric statistics for the Gehavioral sciences [1]. GUO Dongxing etc. simplified the test process in the simplification for rank sum formula for the comparison of the multiple samples designed by group and between them [2]. Yu Changchun made a good application of the Kruskal-Wallis method in medicine field in the application of rank-sum test, Kruskal-Wallis' method and Nemenyi in the quality dynamic monitoring of department medical [3].

In the quality traceability of Transmission assembly, the working site for collecting data is objective and complex and affected by many unexpected factors. Aimed at the original features of the data, the Kruskal-Wallis method was used for quality traceability, and the quality analysis for quality problems according to the results of hypothesis testing done.

2. KRUSKAL-WALLIS

Assuming with the K populations X1, X2, ..., XK, sampling a simple sample X11, X12, ... X1n1, X21, X22, ... X2n2, ... Xk1, Xk2, ... Xknk from them, with the size n1, n2, ... nk. Let n = n1 + n2, + ... + nk be the size of the total sample. The idea of the overall rank-sum test is: firstly K samples were mixed together, and sorted by ascending order, and the rank sum of each one R1, R2, ..., Rk calculated, test statistic established based on this.

$$R=\frac{12}{n(n+1)}\sum_{i=1}^{k}\left(\frac{R_i}{n_i}-\frac{n+1}{2}\right)^2 n_i$$

$$=\frac{12}{n(n+1)}\sum_{i=1}^{k}\frac{R_i^2}{n_i}-3(n+1)$$

$$\sum_{i=1}^{k}R_i=\frac{n(n+1)}{2}=\sum_{i=1}^{k}\sum_{j=1}^{n_i}R_{ij}$$

Where, R_{ij} is the rank of the jth data in the ith population in each sample? It was easily to see that the larger the difference between k populations, the larger the difference between R_i and $\frac{n_i(n+1)}{2}$, and so that the larger the value of R, and vice versa. Therefore, when R is greater than some critical value, H0 should be rejected.

When H0 is in consistence, it can be proved that when ni> 5, n> 15, R is similar to X2(K－1).

So R can be used to test the consistence of distributions of K populations.

3. DATA ARRANGMENT AND INFERENCE IDEAS ON TRANSMISSION QUALITY PROBLEMS

3.1 Data Introduction

For a gearbox factory, during the traceability for Transmission quality problems, by the test results and maintenance records on the transmission running-in experimental table, we found that when the quality problem frequency of certain parts in the assembly process was at the highest, we investigated the involved stations by parts in the assembly process. Among the three stations associated with the part, three assembly operators also came into contact with this part. Through information tracking, data collected was summarized in Table.

Table 1: Data statistical tables of quality problems

	Data of running-in experimental table		Assembly operator A				Assembly operator B				Assembly operator C			
Date	Assembled numbers	Number of occurrence of problem parts	Assembled numbers	Number of occurrence of problem parts	Defect rate	Rank order	Assembled numbers	Number of occurrence of problem parts	Defect rate	Rank order	Assembled numbers	Number of occurrence of problem parts	Defect rate	Rank order
5-1	0	0												
5-2	0	0												
5-3	79	1	40	1	25	33.5	39	0	0	4				
5-4	214	0	99	0	0	4	115	0	0	4				
5-5	112	1	68	1	14.71	21	44	0	0	4				
5-6	0	0												
5-7	0	0												
5-8	112	2					56	1	17.86	28.5	56	1	17.86	28.5
5-9	34	2									34	2	58.82	38
5-10	125	2					62	1	16.13	25	63	1	15.97	24
5-11	178	2					89	1	11.24	14.5	89	1	11.24	14.5
5-12	65	0					32	1	43.48	37	33	1	30.3	35
5-13	0	0												
5-14	0	0												
5-15	133	0	66	0	0	4					67	0	0	4
5-16	207	2	104	1	9.62	11					103	1	9.71	12
5-17	140	4	70	3	42.86	36					70	1	14.29	19
5-18	280	4	140	2	14.29	19					140	2	14.29	19
5-19	230	2	115	1	8.7	9.5					115	1	8.7	9.5
5-20	0	0												
5-21	0	0												
5-22	258	1					128	1	7.81	8	130	0	0	4
5-23	237	5					120	3	25	33.5	117	2	17.09	26
5-24	182	3					91	1	10.99	13	91	2	21.98	31
5-25	176	3					88	2	22.73	32	88	1	11.36	16
5-26	133	3					67	1	14.93	22	66	1	15.15	23
5-27	0	0												
5-28	0	0												
5-29	292	5	104	2	19.23	30	114	2	17.54	27	74	1	13.15	17

5-30	0	0												
5-31	0	0												
总计	3187	42	806	11	13.65		1045	14	13.4		13.36	18	13.47	
ni					9				13				16	
Ri						168				252.5				320.5

3.2 Inference ideas of quality problems

The purpose of transmission assembly quality traceability was to understand: 1, which station has quality problem? 2, which the location the operator at in the stations has quality problems?

Comparing the defect rate data of the three assembly operator, if there was a significant difference between the data distribution, there was discrepancy for the three assembly operator in the assembly process, and it may be the station with quality problems. If there was no relative difference between the rate data, it indicated the possibility of quality problems at the assembly station is little. For the other stations, test and troubleshoot were continued to be done.

From the form of data, the problem diagnosis from simple populations is flawed. Data of the three assembly operator was not consecutive in time. When one day, quantities of transmissions needed, three assembly operators all can participate in the assembly. If this day did not require so many transmissions, there may be only one or two of them at the post. It is consistent with the internal holiday system. And a post assembly tooling personnel was affected in the assembly process by human, machine, material, method and environment, the exception of the data generating is also an objective and true. For these complex situations, the Kruskal-Wallis statistical methods were suitable for such a test, and not be affected by the consecution and value itself of the data, and having no requirement for the sample distribution.

4. KRUSKAL-WALLIS

Validation results from KRUSKAL-WALLIS method and inference of quality problems

4.1 A Kruskal-Wallis

1) Assume that for H0: F1 (χ) = F2 (χ) = F3 (χ), the distribution of three population samples was the same; for H1: at least two distributions were significantly different; the location of the samples different or incomplete the same.

2) Giving significance level and ranking: α = 0.05 k = 3.

Firstly sorting the value of the defect rate by ascending order, and then ranking the three group data, in case of the same defect rate, such as the same data within the same group, its rank would be numbered according to the positional order; if the same data in a different group, its average rank taken. There were 7 of 0, 2 of 8.7, 2 of 0, 2 of 11.24, 2 of 17.86, 2 of 25, 3 of 14.29 in the case. Firstly defect rates of the three assembly operator were queued by ascending order, and then three sets of data ranked uniformly.

3) Determination of rank-sum and the rejection region.

Summing up rank orders of each group in the above table, ie. the subscript i of Ri indicating the group sequence (i = 1, 2,3).

Rejection region:

R

$$= \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1)$$

$$> \chi_\sigma^2(\mathrm{K}-1) \overset{form}{=} ?$$

4) R would be calculated by the sample values. If R> $\chi_\sigma^2(\mathrm{K}-1)$ reject H0, otherwise accept H0. K populations would be considered with the same distribution.

$$n = n_1 + n_2 + n_3$$

=9+13+16

=38

$$R = \frac{12}{n(n+1)} (\sum \frac{R_i^2}{n_i}) - 3(n+1)$$

R=

$$\frac{12}{38(38+1)}(\frac{168^2}{9}+\frac{252.5^2}{13}$$

$$+\frac{320.5^2}{16})-3(38+1)$$

=0.008097166(3136+4904.327+6420.0156)-117

=117.088-117

=0.088

$$R_C=\frac{R}{C}$$

$$C=1-\sum\frac{(t_i^3-t_i)}{(N^3-N)}$$

There are 7 of 0, 2 of 8.7, 2 of 0, 2 of 11.24, 2 of 17.86, 2 of 25, 3 of 14.29

$$C=1-(\frac{7^3-7}{38^3-38}+\frac{3^3-3}{38^3-38}+4\frac{2^3-2}{38^3-38})$$

=0.992997

$$R_C=\frac{H}{C}$$

$$=\frac{0.088}{0.992997}$$

=0.08862

Determine the value of $\chi^2_\sigma(\mathrm{K}-1)$ and make inferences and conclusions. If Group number greater than 3, and cases of each group not less than 5, the H approximately was the χ^2 distribution with $v=k-1$.

In the case, $n_i>5$,

then $v=k-1$ =3-1=2. Look-up table $\chi^2_\sigma(\mathrm{K}-1)$ =0.103

If Rc < $\chi^2_\sigma(\mathrm{K}-1)$, accept H0; if H rejected, it can be considered that there is no difference between the three types of defect rate.

4.2 Quality problem inference

Results tested from the Kruskal-Wallis method showed the defect rates of three operator members of the assembly station belonged to the same population. There was no significant difference between the rates.

Generally if an assembly operator made more problem parts, there would be present on the value of the rate of defects. When the larger defect rate was much more, the permutation location of the defect rate into the rank would be close to the side too much without distributing randomly in the overall value of the defect rate. It showed from the nature that his samples of defect rate had difference with that of the two other operators, his samples is out from the population and differ from each other. This is the principle for hypothesis testing in test of Kruskal-Wallis method, which is the conclusion drawn from the test of the Kruskal-Wallis method is more convincing, more scientific than the single-level contrast defect rate in the total.

The transmission assembly site is objective and complex. There are many accidental factors and not the ideal state. The data has with spatiality and timeliness, rather than tiling in straight line. Just aiming at the complex situation in the paper, the data value error is down. By the testing of Kruskal-Wallis method that has no related with the value of the data itself performed, we observed whether the rank of the arrangement of multiple samples was randomly, so multi-rank sum test can improve the scientificalness of quality traceability.

The evidence of the three samples having no significant differences showed that the quality problems in this assembly station were unlikely to occur. For the traceability of transmission quality, it is needed to continue troubleshooting the stations associated with problem parts.

5. CONCLUSIONS

Appropriate statistical inference procedures enable us to make the right conclusions from the evidence provided by the samples. The application of statistical techniques has been always the weak link in all enterprises commonly. In the tracing of transmission quality, we used the Kruskal-Wallis method to test, and the procedure and result tested was effective for the traceability of quality problems. It provided a theoretical support for quality traceability, more solid basis for converting information into decision-making, and a scientific reference views for decision makers. Due to there is no case for reference that the Kruskal-Wallis test methods was used in the traceability of transmission assembly quality, we hope that the industrial experts propose suggestions. For this case, if there are the same test ideas, we hope to get more support.

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基於kruskal-wallis方法的變速器裝配品質溯源研究

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摘要

隨著追蹤技術的發展，在變速器的品質追溯中，採集到的資料更加立體化和複雜化，這就要求為資料資訊轉化為決策資訊提供更加科學的溯源統計方法。針對資料特點本文提出了基於Kruskal-Wallis檢驗的統計方法，給出了採用Kruskal-Wallis方法的檢驗步驟，並根據檢驗結果進行變速器裝配品質問題的溯源分析，為管理者下一步的決策提供科學的參考依據。實驗結果表明：Kruskal-Wallis方法在變速器裝配品質溯源中的應用是有效的。

關鍵字：Kruskal-Wallis；檢驗方法；品質溯源