The Variance Analysis and Friedman Check of Randomized Block Design for Motor additive

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Abstract. In order to research the significancy level and difference in different motor assistant’s oil saving, the randomized block test design is introduced. The two stage cross-over design was realized using SAS and the test data were gained. The test data was analyzed using variance analysis. The oil saving level and sample difference are gained. The study in this paper can be adopted in other fields of test design and data analysis.

1. Introduction

Motor additive for oil saving is presented recently and the oil saving level is researched in many papers. The performance and the synergistic effect of the antiwear and extreme-pressure additive as vehicle lubrication oil are researched by Qiao Yulin et al [1]. The oil saving efficient of the lubrication oil additive is researched by Wang Gengsheng [2]. The performance of antiwear of additive is researched by Yao Guangtao [3]. The affect to vehicle emissions of additive is researched by Li Jin [4]. Fuel additive for future fuel and vehicle technologies is researched by Joseph W. ROOS et al [5]. The effect for vehicle of gasline additive is researched by Deng Xueli [6]. The efficiency of lubricant additive for large transport vehicles is researched by Guan Haiying et al [7]. These paper pay attention to data comparation, but the test design, statistics significancy and believing level are ignored. In this paper, the randomized block test for additives’ oil saving is designed and the statistics significancy and believing level are analyzed. The mathematic performance and process are presented. The content of this paper can be adopted in other fields of test design and data analysis.

2. Randomized block design

2.1. Foundation principle

In test design, the selection of test object, the factor level’s combination, the proces of test should all been randomized. In the random block design, all the objects are divided to some blocks as to the objects’ character. The number of object in every block is same to the factor level. The randomized block design can resolv a test factor and a block fator. In fact, the randomized block design consider another block factor based on single factor design. Through random block desing, the disturbing of non-test factor can be removed and the influence of test factor can be scientific gained. The block fator can be object’s some character or the character’s synthesis. The selecting of the block factor is the key
of the randomized block design. If the block factor is significant to the result and complete randomized design is not good, the randomized block design is certainly better than single factor design [8].

2.2. Calculating process
The standard data table of the randomized block design is as table 1.

| block index(unit) | process: 1 | 2 | ... | a |
|-------------------|------------|---|-----|---|
| 1                 | y11        | y12 | ... | y1a|
| 2                 | y21        | y22 | ... | y2a|
| :                 | :          | :  |     | : |
| b                 | yb1        | yb2 | ... | yba|

The variance analysis result is as table 2.

| source         | SS        | DF | MS         | F value |
|----------------|-----------|----|------------|---------|
| process        | SSHandle  | a-1| SSHandle/(a-1) | MSHandle/MSerror |
| block          | SSBlock group | b-1| SSBlock group/(b-1) | MSBlock group/MSerror |
| error          | SSerror   | (a-1)(b-1)| SSerror/(a-1)(b-1) |
| total          | SSTotal   | N-1 |             |         |

The calculating formula of every statistic value is as bellow.

\[ SS_{error} = SSTotal - SS_{Handle} - SS_{Block group} \]

\[ y_i = \sum_{j=1}^{b} y_{ij}, \quad i = 1, 2, \ldots, a \]

\[ y_j = \sum_{i=1}^{a} y_{ij}, \quad j = 1, 2, \ldots, b \]

2.3. The result of calculating
The oil saving level of 3 kinds of motor additive will been researched. Firstly, the 15 vehicles are divided to 5 blocks as to the brand and the vehicle status in every block is similar. Secondly, 3 kinds of motor additive are added to 3 vehicles by random. Thirdly, oil saving mass in 100 kilometre is taken as the index and the test data is as table 3. Fourthly, the statisticas significance of different additive’s oil saving effect will be checked.

| block | oil saving mass(kg) |
|-------|---------------------|
|       | additive A | B | C |
| 1     | 0.8610      | 0.6825 | 0.5355 |
| 2     | 0.7665      | 0.5670 | 0.2415 |
| 3     | 0.4515      | 0.3570 | 0.2940 |
| 4     | 0.4305      | 0.2205 | 0.3255 |
| 5     | 0.7140      | 0.4515 | 0.2520 |
In this test, the test factor is additive with 3 levels for A, B, C. The test object is vehicle. The test index is oil saving mass. The brand is block factor. In order to check the statistic significance of different additive’s oil saving effect, variance analysis and Friedman check can be used through SAS program.

In the SAS program, the data content is realized by 2 cycle sentences. The normal and homogeneity of variance of 2 factors are checked. The levels in factor are compared. The variance analysis is realized through glm function and Friedman way.

The result of normal and homogeneity of variance check is as table 4.

| a  | b   | the statistics variable of y | the P value of y |
|----|-----|-----------------------------|-----------------|
| 1  | .   | 0.9969                      | 0.8934          |
| 2  | .   | 0.9812                      | 0.7370          |
| 3  | .   | 0.9868                      | 0.7804          |
| 4  | .   | 1                           | 1               |
| 5  | .   | 0.9938                      | 0.8499          |
| .  | 1   | 0.8765                      | 0.2939          |
| .  | 2   | 0.9929                      | 0.9887          |
| .  | 3   | 0.7906                      | 0.0678          |

The result of covariance check is as table 5.

| source | F value | Pr>F    |
|--------|---------|---------|
| a      | 1.76    | 0.2140  |
| b      | 1.06    | 0.3782  |

The variance analysis result is as table 6. The P value of 2 factor is 0.0158 and 0.0040. The 2 factors’ influence to the result all have statistics significance. Different brands and different additives all have different influences to oil saving.

| Source | DF  | Type III SS | Mean Square | F Value | Pr>F  |
|--------|-----|-------------|-------------|---------|-------|
| a      | 4   | 0.25176690  | 0.06294173  | 5.98    | 0.0158|
| b      | 2   | 0.25137000  | 0.12568500  | 11.94   | 0.0040|

The rule of comparison of factor b’s level is as table 7. From table 7, the additive A is better than additive B and C.

| SNK Grouping | Mean | N | b |
|--------------|------|---|---|
| A            | 0.64470 | 5 | 1 |
| B            | 0.45570 | 5 | 2 |
| B            | 0.32970 | 5 | 3 |

The result of Friedman check is as table 8. The every level of factor b have statistics significance.
### Table 8. The result of Friedman check

| variable                     | H for choice       | DF  | value | probability |
|------------------------------|--------------------|-----|-------|-------------|
| 1 nonzero correlation        | 8.1000             | 1   | 0.0044|             |
| 2 difference of row average  | 8.4000             | 2   | 0.0150|             |

#### 3. Conclusion

Through randomized block design, the oil saving level and the difference in different additive are gained by variance analysis and Friedman check in this paper. The mathematic principle and the calculating process are also presented. The randomized block design is practicable and can be widely used in logisticas and test.

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