**Project Analysis**

Group Project on Knocking

Contributors:

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(All participate in each section. Assignments are what we are in charge of and then we lead the others in knowing what to do.)

**Model Specification**

Yij = μ + αᵢ + βj+γij , ϵijk ~ N(0,σ)

Yij = Amount of knocking.

μ = sample mean.

αᵢ = Factor 1 : Air/Fuel Ratio.

i = Levels: Regular, Booster#1, Booster #2. And their 3 replicates.

βj= Factor 2: Octane Booster.

j = Levels: Stoichiometric, lean, Rich. And their 3 replicates.

γij = interaction of air/fuel ratio and octane booster main effects

ϵijk = collective effects of all other factors, normally distributed

σ = Standard Deviation.

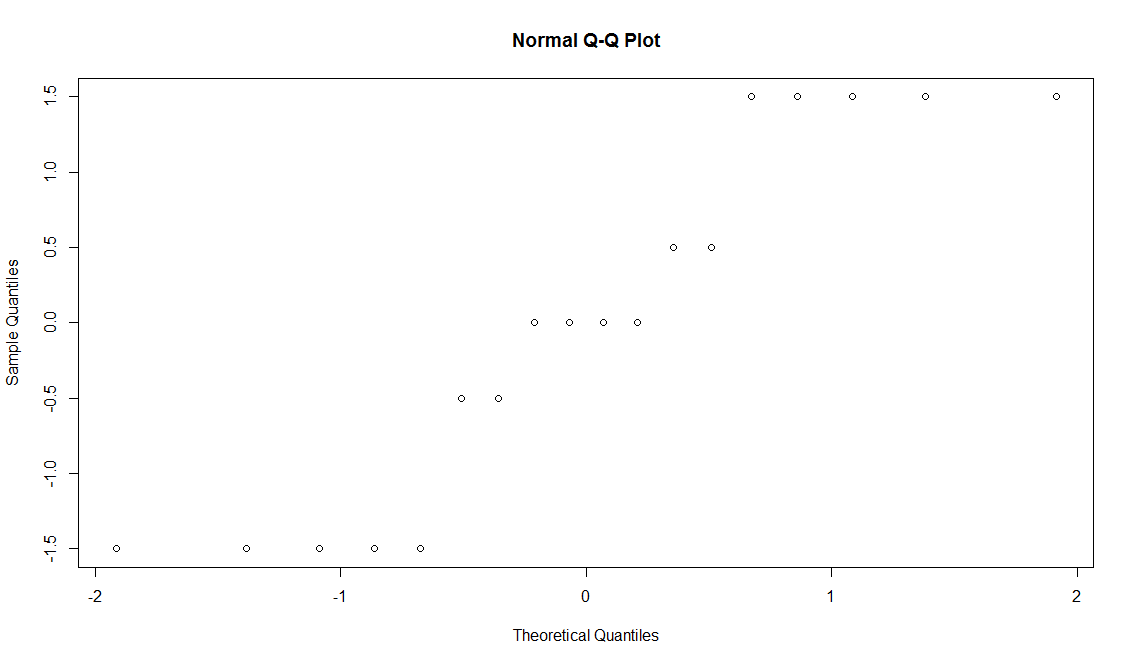
N(0,σ) = Normal distribution.

**ANOVA Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
| Air-Fuel Ratio | 2 | 1987.0 | 993.50 | 380.489 | < 0.0005 |
| Octane | 2 | 1900.0 | 950.00 | 363.830 | < 0.0005 |
| Air-Fuel Ratio:Octane | 4 | 552.0 | 138.00 | 52.851 | < 0.0005 |

**Table 1. ANOVA Table**

**Regression Diagnostics**

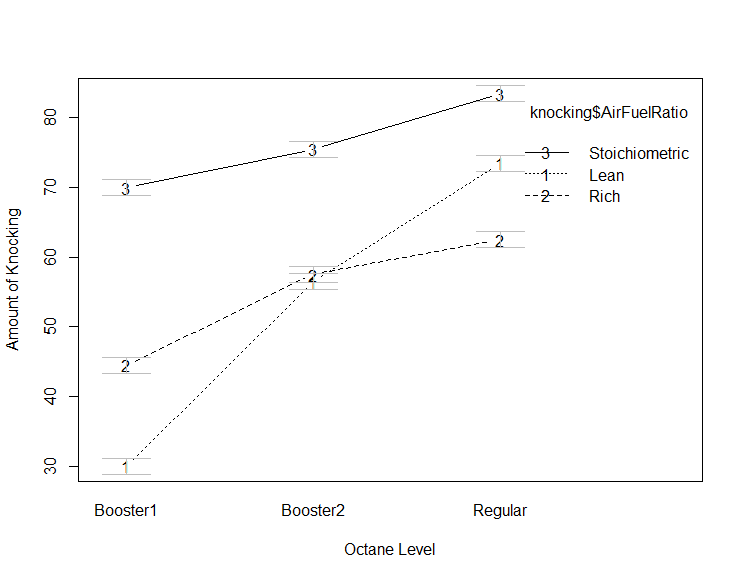


**Figure 1. Q-Q plot of residuals**

The plot is generally linear; therefore, the normality assumption is valid.

**Inference**

The null hypothesis H0 is that there there is no interaction effect. According to Table 1, the *p*-value of the interaction is < 0.0005, so there is a statistically significant interaction between all the factors. This can plainly be seen in the graph below:



**Figure 2. Interaction of factors**

As can be seen in the Figure 2, the performance of regular fuel improves as the air-fuel ratio goes from lean to rich, while the performance of both booster 1 and 2 decrease as they go from lean to rich. This shows that there is an interaction between the octane level and the air-fuel ratio.

|  |  |  |
| --- | --- | --- |
| 95% Confidence Intervals | | |
|  | Lower Bound | Upper Bound |
| Rich - Lean | -1.104 | 4.104 |
| Stoichiometric - Lean | 20.395 | 25.604 |
| Stoichiometric - Rich | 18.895 | 24.104 |
| Booster 2 - Booster 1 | 12.395 | 17.604 |
| Regular - Booster 1 | 22.395 | 27.604 |
| Regular - Booster 2 | 7.395 | 12.604 |

**Table 2. 95% confidence intervals of main effects**

All but one of the confidence intervals do not include 0, therefore there is a statistically significant difference between nearly every combination. This reflects the fact that the interaction effect is statistically significant, and corroborates the conclusion based on the *p*-value. This table also parallels the results shown in Figure 2, namely that the “bigger” differences in confidence intervals parallel the differences on the chart. For example, the table shows 95% confidence of regular fuel having between 22.395 and 27.604 more knocks in one cycle than booster #1. On the chart (Figure 2), the various tests for regular fuel knock about 20-30 more times than for booster #1.