Appendix 8

**ANOVA – Impact Characteristics**

# Variance Due to Varying Drop Height

For each characteristic, ANOVA was performed using a 0.05 (5%) level of significance, i.e. if the *p*-value obtained was less than 0.05, there would be a significant level of variance.

# Maximum Force

Ho: There is no difference between the maximum forces produced as drop height is varied.

Ha: There is a difference between the maximum forces produced as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Peak Force** | 175.21 | 141.59 | 177.59 |
| 201.70 | 177.74 | 216.72 |
| 265.67 | 193.81 | 164.95 |
| 234.28 | 163.16 | 219.85 |
| 190.09 | 231.01 | - |
| **Average** | 213.39 | 181.46 | 194.78 |
| **SD** | 36.42 | 30.15 | 23.95 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| 5 cm | 5 | 1066.95 | 213.39 | 1326.712 |  |  |
| 4 cm | 5 | 907.31 | 181.462 | 1136.518 |  |  |
| 3 cm | 4 | 779.11 | 194.7775 | 765.0645 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 2568.535 | 2 | 1284.267 | 1.162892 | 0.348217 | 3.982298 |
| Within Groups | 12148.11 | 11 | 1104.374 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 14716.65 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the maximum forces as drop height is varied.

# Peak Pressure

Ho: There is no difference between the peak pressures produced as drop height is varied.

Ha: There is a difference between the peak pressures produced as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Peak Pressure** | 557.72 | 450.69 | 565.29 |
| 642.02 | 565.77 | 689.85 |
| 845.66 | 616.92 | 525.04 |
| 745.73 | 519.36 | 699.79 |
| 605.08 | 735.31 | - |
| **Average** | 679.242 | 577.61 | 619.99 |
| **SD** | 115.94 | 95.98 | 76.25 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| 5 cm | 5 | 3396.21 | 679.242 | 13442.17 |  |  |
| 4 cm | 5 | 2888.05 | 577.61 | 11514.13 |  |  |
| 3 cm | 4 | 2479.97 | 619.9925 | 7752.017 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 26025.87 | 2 | 13012.93 | 1.16299 | 0.348188 | 3.982298 |
| Within Groups | 123081.2 | 11 | 11189.2 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 149107.1 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the peak pressures as drop height is varied.

# Time to Maximum Force From Point of Contact

Ho: There is no difference between the time to maximum force as drop height is varied.

Ha: There is a difference between the time to maximum force as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Time to Maximum Force From Point of Contact** | 0.045 | 0.061 | 0.057 |
| 0.055 | 0.061 | 0.037 |
| 0.041 | 0.049 | 0.031 |
| 0.031 | 0.053 | 0.039 |
| 0.051 | 0.035 | - |
| **Average** | 0.045 | 0.050 | 0.041 |
| **SD** | 0.01 | 0.01 | -0.01 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| 5 cm | 5 | 0.223 | 0.0446 | 8.68E-05 |  |  |
| 4 cm | 5 | 0.259 | 0.0518 | 0.000115 |  |  |
| 3 cm | 4 | 0.164 | 0.041 | 0.000125 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 0.000278 | 2 | 0.000139 | 1.290058 | 0.313827 | 3.982298 |
| Within Groups | 0.001184 | 11 | 0.000108 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 0.001462 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the times taken to reach maximum force as drop height is varied.

# Skin Displacement

Ho: There is no difference between the level of skin displacement as drop height is varied.

Ha: There is a difference between the skin displacement as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Skin Displacement** | -5.87 | -7.00 | -8.63 |
| -13.66 | -3.09 | -5.36 |
| -5.84 | -5.97 | -2.55 |
| -2.37 | -7.77 | -7.12 |
| -7.66 | -4.7 | - |
| **Average** | -7.08 | -5.71 | -5.92 |
| **SD** | 4.15 | 1.66 | 2.26 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| 5 cm | 5 | -35.4 | -7.08 | 17.20465 |  |  |
| 4 cm | 5 | -28.53 | -5.706 | 3.46493 |  |  |
| 3 cm | 4 | -23.66 | -5.915 | 6.818167 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 5.372501 | 2 | 2.686251 | 0.286512 | 0.756314 | 3.982298 |
| Within Groups | 103.1328 | 11 | 9.375711 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 108.5053 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the levels of skin displacement as drop height is varied.

# Work Done

Ho: There is no difference between the work done as drop height is varied.

Ha: There is a difference between the word done as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Word Done** | -292.44 | -432.30 | -240.27 |
| -28.99 | -181.96 | -534.93 |
| 501.81 | -398.52 | -197.93 |
| -313.13 | -473.29 | -564.69 |
| -379.16 | -450.15 | - |
| **Average** | -303.12 | -387.24 | -386.71 |
| **SD** | 173.65 | 117.96 | 194.48 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| Column 1 | 5 | -1515.53 | -303.106 | 30155.33 |  |  |
| Column 2 | 5 | -1936.22 | -387.244 | 13914.95 |  |  |
| Column 3 | 4 | -1546.82 | -386.705 | 37825.86 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 22625.84 | 2 | 11312.92 | 0.429468 | 0.661315 | 3.982298 |
| Within Groups | 289758.7 | 11 | 26341.7 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 312384.5 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the levels of work done as drop height is varied.

# Impulse of the Force

Ho: There is no difference between the impulse of the force produced as drop height is varied.

Ha: There is a difference between the impulse of force produced as drop height is varied.

Dataset Used For Calculation:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Drop Height** | | |
| **5 cm** | **4 cm** | **3cm** |
| **Impulse of Force** | 1.70 | 2.66 | 0.66 |
| 0.09 | 2.54 | 2.56 |
| 2.60 | 2.56 | 1.60 |
| 2.56 | 2.35 | 2.02 |
| 1.82 | 2.33 | - |
| **Average** | 1.75 | 2.49 | 1.71 |
| **SD** | 1.02 | 0.14 | 0.80 |

**Results:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Anova: Single Factor |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| SUMMARY |  |  |  |  |  |  |
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |  |  |
| 5 cm | 5 | 8.77 | 1.754 | 1.03538 |  |  |
| 4 cm | 5 | 12.44 | 2.488 | 0.02037 |  |  |
| 3 cm | 4 | 6.84 | 1.71 | 0.6444 |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 1.829521 | 2 | 0.914761 | 1.63451 | 0.239052 | 3.982298 |
| Within Groups | 6.1562 | 11 | 0.559655 |  |  |  |
|  |  |  |  |  |  |  |
| Total | 7.985721 | 13 |  |  |  |  |

**Conclusion:**

As the *p­* > 0.05, H0 is accepted and Ha rejected. Therefore there is no significant difference between the observed impulses of force as drop height is varied.