21

ISE 2211 • Exam VII • 8 December 2017 NAME SOLUTION

Tungsten-copper (WCu) is an alloy often used in applications requiring high strength, high melting temperature, and good electrical conductivity, such as welding rods. It is believed that there is a relationship between the proportion of tungsten and bending-mode strength. Fifteen welding rods were tested at five different proportions of tungsten in random order and the results presented below:

W	Bending-Mode Strength (MPa)			totals	averages
	Sample 1	Sample 2	Sample 3		
0.70	770	792	799	2361	787
0.75	882	894	873	2649	883
0.80	922	936	977	2835	945
0.85	1050	1088	1104	3242	1081
0.90	1161	1091	1240	3492	1164
				14579	972

(+1) (+1)

Use Analysis of Variance (ANOVA) to test the null hypothesis that the treatment means are equal at the $\alpha = 0.05$ level of significance. Fill in the ANOVA table and state your final conclusion regarding the significance of tungsten content in the bending-mode strength of WCu welding rods.

$SS_T = 770^2 + 882^2 + \ldots - \frac{14579^2}{15} = 14459425 - 62985.6 = 289608.9$ (+1)

$an - 1 = 5 \cdot 3 - 1 = 14$ (+1)

$SS_{Treatments} = \frac{2361^2 + 2649^2 + \ldots}{3} - \frac{14579^2}{15} = 14444458.3 - 62985.6 = 274642.267$ (+1)

$a - 1 = 5 - 1 = 4$ (+1)

$SS_E = SS_T - SS_{treatments} = 14966.67$ (+1)

$a(n-1) = 5 \cdot 2 = 10$ (+1)

$MS_{Treatments} = \frac{274642.3}{4} = 68660.567$ (+1)

$MS_E = \frac{14966}{10} = 1497$ (+1)

$f_0 = \frac{68660.567}{1497} = 45.87$ (+1)

$f_{critical} = f_{.05,4,10} = 3.48$ (+1)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	f_0
Treatments	274642.3	4	68660.6	45.87
Error	14966.7	10	1497	-
Total	289608.9	14	-	-

filled in (+1)

$f_0 \gg f_{critical}$; strongly reject H_0 (+1)

The proportion of W IS significant to bending-mode strength (+1) @ W=20!

15

Write a 95% confidence interval on bending-mode strength at the 0.75 tungsten level. Include a unit with your answer.

μ_2 : $\bar{y}_{2\cdot} \pm t_{.025,10}\sqrt{\frac{1497}{3}}$

μ_2 ↑ .75 level

$\bar{y}_{2\cdot} = 883$

$t_{.025,10} = 2.228$ (+1) (Table)

$833 < \mu_2 < 938$ (+1)

MPa (+1)

Use Fisher's Least Significant Difference to determine which, if any, pairs of treatment means show significant difference at $\alpha = 0.05$. (Hint: 12 23 34 45 13 24 35 14 25 15)

$LSD = 2.228\sqrt{\frac{2 \cdot 1497}{3}} = 70.39$ (+1)

$\lvert \bar{y}_{1\cdot} - \bar{y}_{2\cdot} \rvert$	=	96
$\lvert \bar{y}_{2\cdot} - \bar{y}_{3\cdot} \rvert$	=	62
$\lvert \bar{y}_{3\cdot} - \bar{y}_{4\cdot} \rvert$	=	136
$\lvert \bar{y}_{4\cdot} - \bar{y}_{5\cdot} \rvert$	=	83
$\lvert \bar{y}_{1\cdot} - \bar{y}_{3\cdot} \rvert$	=	158 (+1)
$\lvert \bar{y}_{2\cdot} - \bar{y}_{4\cdot} \rvert$	=	198
$\lvert \bar{y}_{3\cdot} - \bar{y}_{5\cdot} \rvert$	=	219
$\lvert \bar{y}_{1\cdot} - \bar{y}_{4\cdot} \rvert$	=	294
$\lvert \bar{y}_{2\cdot} - \bar{y}_{5\cdot} \rvert$	=	281
$\lvert \bar{y}_{1\cdot} - \bar{y}_{5\cdot} \rvert$	=	377

all differences > LSD except .75 vs. .80

ALL pairs show significant differences (+1) $\alpha = 0.05$ except 0.75 vs. 0.80 (+1)