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LAMPIRAN

Lampiran 1. Perhitungan hasil pengujian

Perhitungan rata – rata nilai kekerasan

a) Rata – rata nilai kekerasan spesimen pembanding JIS SUP9

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

247 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$247 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$1938,95(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{1938,95}$

=$2,5-\sqrt{6,25-\ d^2} = 0,1935$

=$2,5-0,1935 = \sqrt{6,25-\ d^2}$

=$2,3065^2 = \sqrt{6,25-\ d^2}$

=$5,3199 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-5,3199$

$d = \sqrt{0,9301}$

$d = 0,9644mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-0,9300}}$

= $\frac{375,2}{7,85(2,5-\sqrt{5,32}}$

= $\frac{375,2}{7,85(2,5-2,3065)}$

= $\frac{375,2}{7,85(0,1935)} = \frac{375,2}{1,5189} = 247HB$

b) Rata – rata nilai kekerasan variasi udara ke 1

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

123,67 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$123,67 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$970,80(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{970,80}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3864$

=$2,5-0,3864 = \sqrt{6,25-\ d^2}$

=$2,1136^2 = \sqrt{6,25-\ d^2}$

=$4,4673 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,4673$

$d = \sqrt{1,7827}$

$d = 1,3351mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,7824}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,4676}}$

= $\frac{375,2}{7,85(2,5-2,1136)}$

= $\frac{375,2}{7,85(0,3864)} = \frac{375,2}{3,0332} = 123,67HB$

c) Rata – rata nilai kekerasan variasi udara ke 2

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

124 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$124 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$973,4(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{973,4}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3854$

=$2,5-0,3854 = \sqrt{6,25-\ d^2}$

=$2,1146^2 = \sqrt{6,25-\ d^2}$

=$4,4715 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,4715$

d = $\sqrt{1,7785}$

$d = 1,3336mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,7784}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,4716}}$

= $\frac{375,2}{7,85(2,5-2,1146)}$

= $\frac{375,2}{7,85(0,3854)} = \frac{375,2}{3,0183} = 124HB$

d) Rata – rata nilai kekerasan variasi udara ke 3

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

124 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$124 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$973,4(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{973,4}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3854$

=$2,5-0,3854 = \sqrt{6,25-\ d^2}$

=$2,1146^2 = \sqrt{6,25-\ d^2}$

=$4,4715 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,4715$

$d = \sqrt{1,7785}$

$d = 1,3336mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,7784}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,4716}}$

= $\frac{375,2}{7,85(2,5-2,1146)}$

= $\frac{375,2}{7,85(0,3854)} = \frac{375,2}{3,0183} = 124HB$

e) Rata – rata nilai kekerasan variasi oli ke 1

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

133 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$133 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$1044,05(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{1044,05}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3593$

=$2,5-0,3593 = \sqrt{6,25-\ d^2}$

=$2,1407^2 = \sqrt{6,25-\ d^2}$

=$4,5825 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,5825$

$d = \sqrt{1,6675}$

$d = 1,2913mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,6674}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,5826}}$

= $\frac{375,2}{7,85(2,5-2,1407)}$

= $\frac{375,2}{7,85(0,3593)} = \frac{375,2}{2,8205} = 133HB$

f) Rata – rata nilai kekerasan variasi oli ke 2

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

131,67 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$131,67 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$1033,60(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{1033,60}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3630$

=$2,5-0,3630 = \sqrt{6,25-\ d^2}$

=$2,137^2 = \sqrt{6,25-\ d^2}$

=$4,5667 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,5667$

d = $\sqrt{1,6833}$

d = $1,2974mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,6832}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,5668}}$

= $\frac{375,2}{7,85(2,5-2,1370)}$

= $\frac{375,2}{7,85(0,363)} = \frac{375,2}{2,8495} = 131,67HB$

g) Rata – rata nilai kekerasan variasi oli ke 3

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

133 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$133 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$1044,05(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{1044,05}$

=$2,5-\sqrt{6,25-\ d^2} = 0,3593$

=$2,5-0,3593 = \sqrt{6,25-\ d^2}$

=$2,1407^2 = \sqrt{6,25-\ d^2}$

=$4,5825 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-4,5825$

d = $\sqrt{1,6675}$

d = $1,2913mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-1,6674}}$

= $\frac{375,2}{7,85(2,5-\sqrt{4,5826}}$

= $\frac{375,2}{7,85(2,5-2,1407)}$

= $\frac{375,2}{7,85(0,3593)} = \frac{375,2}{2,8205} = 133HB$

h) Rata – rata nilai kekerasan variasi air garam ke 1

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

295,67 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$295,67 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2321,00(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{2321,00}$

=$2,5-\sqrt{6,25-\ d^2} = 0,1616$

=$2,5-0,1616 = \sqrt{6,25-\ d^2}$

=$2,3384^2 = \sqrt{6,25-\ d^2}$

=$5,4681 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-5,4681$

d = $\sqrt{0,7819}$

d = $0,8842mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-0,7818}}$

= $\frac{375,2}{7,85(2,5-\sqrt{5,4682}}$

= $\frac{375,2}{7,85(2,5-2,3384)}$

= $\frac{375,2}{7,85(0,1616)} = \frac{375,2}{1,2685} = 295,67HB$

i) Rata – rata nilai kekerasan variasi air garam ke 2

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

362,67 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$362,67 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2846,95(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{2846,95}$

=$2,5-\sqrt{6,25-\ d^2} = 0,1317$

=$2,5-0,1317 = \sqrt{6,25-\ d^2}$

=$2,3683^2 = \sqrt{6,25-\ d^2}$

=$5,6088 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-5,6088$

d = $\sqrt{0,6412}$

d = $0,8007mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-0,6411}}$

= $\frac{375,2}{7,85(2,5-\sqrt{5,6089}}$

= $\frac{375,2}{7,85(2,5-2,3683)}$

= $\frac{375,2}{7,85(0,1317)} = \frac{375,2}{1,0338} = 362,67HB$

j) Rata – rata nilai kekerasan variasi air garam ke 3

HB = $\frac{2F}{\pi.D(D-\sqrt{D^2-d^2}}$

298,33 = $\frac{2.187,6}{3,14.2,5(2,5-\sqrt{2,5^2-d^2}}$

=$298,33 \times 7,85(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2341,89(2,5-\sqrt{6,25-d^2}) = 375,2$

=$2,5-\sqrt{6,25-\ d^2} = \frac{375,2}{2341,89}$

=$2,5-\sqrt{6,25-\ d^2} = 0,1602$

=$2,5-0,1602 = \sqrt{6,25-\ d^2}$

=$2,3398^2 = \sqrt{6,25-\ d^2}$

=$5,4746 = \sqrt{6,25-\ d^2}$

$d^2 = 6,25-5,4746$

d = $\sqrt{0,7754}$

d = $0,8805mm$

= $\frac{375,2}{7,85(2,5-\sqrt{6,25-0,7752}}$

= $\frac{375,2}{7,85(2,5-\sqrt{5,4748}}$

= $\frac{375,2}{7,85(2,5-2,3398)}$

= $\frac{375,2}{7,85(0,1602)} = \frac{375,2}{1,2575} = 298,33HB$

Perhitungan rata – rata laju keausan

a) Rata – rata laju keausan material pembanding JIS SUP9

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}72^3}{12.13{,}6} = \frac{1{,}2877}{163{,}2} = 0{,}00789mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}72^3}{12.13{,}6.6.36.15} = 0{,}00008mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}67^3}{12.13{,}6} = \frac{1{,}0376}{163{,}2} = 0{,}00635mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}67^3}{12.13{,}6.6.36.15} = 0{,}00009mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}80^3}{12.13{,}6} = \frac{1{,}7664}{163{,}2} = 0{,}01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}80^3}{12.13{,}6.6.36.15} = 0{,}00011mm^3/\text{kg.m}$$

$$\frac{0{,}00008+0{,}00009+0{,}00011}{3} = 0{,}000093mm^3/\text{kg.m}$$

b) Rata – rata laju keausan variasi udara ke 1

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}77^3}{12.13{,}6} = \frac{1{,}5750}{163{,}2} = 0{,}00964mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}77^3}{12.13{,}6.6.36.15} = 0{,}00010mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}80^3}{12.13{,}6} = \frac{1{,}7664}{163{,}2} = 0{,}01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}80^3}{12.13{,}6.6.36.15} = 0{,}00011mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}77^3}{12.13{,}6} = \frac{1{,}5750}{163{,}2} = 0{,}00964 mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}77^3}{12.13{,}6.6.36.15} = 0{,}00010 mm^3/\text{kg.m}$$

$$\frac{0{,}00010+0{,}00011+0{,}00010}{3} = 0{,}000103 mm^3/\text{kg.m}$$

c) Rata – rata laju keausan variasi udara ke 2

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}80^3}{12.13{,}6} = \frac{1{,}7664}{163{,}2} = 0{,}01082 mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}80^3}{12.13{,}6.6.36.15} = 0{,}00011 mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}72^3}{12.13{,}6} = \frac{1{,}2877}{163{,}2} = 0{,}00789 mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}72^3}{12.13{,}6.6.36.15} = 0{,}00008 mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}67^3}{12.13{,}6} = \frac{1{,}0376}{163{,}2} = 0{,}00635 mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}67^3}{12.13{,}6.6.36.15} = 0{,}00009 mm^3/\text{kg.m}$$

$$\frac{0{,}00011+0{,}00008+0{,}00009}{3} = 0{,}000093 mm^3/\text{kg.m}$$

d) Rata – rata laju keausan variasi udara ke 3

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}61^3}{12.13{,}6} = \frac{0{,}7831}{163{,}2} = 0{,}00479 mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}61^3}{12.13{,}6.6.36.15} = 0{,}00005 mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}69^3}{12.13{,}6} = \frac{1{,}1334}{163{,}2} = 0{,}00694mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}69^3}{12.13{,}6.6.36.15} = 0{,}00007mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}64^3}{12.13{,}6} = \frac{0{,}9043}{163{,}2} = 0{,}00554mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}64^3}{12.13{,}6.6.36.15} = 0{,}00005mm^3/\text{kg.m}$$

$$\frac{0{,}00005+0{,}00007+0{,}00005}{3} = 0{,}000057mm^3/\text{kg.m}$$

e) Rata – rata laju keausan variasi oli ke 1

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}61^3}{12.13{,}6} = \frac{0{,}7831}{163{,}2} = 0{,}00479mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}61^3}{12.13{,}6.6.36.15} = 0{,}00005mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}80^3}{12.13{,}6} = \frac{1{,}7664}{163{,}2} = 0{,}01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}80^3}{12.13{,}6.6.36.15} = 0{,}00011mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}51^3}{12.13{,}6} = \frac{0{,}4576}{163{,}2} = 0{,}00280mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}51^3}{12.13{,}6.6.36.15} = 0{,}00002mm^3/\text{kg.m}$$

$\frac{0,00005+0,00011+0,00002}{3} = 0,000060mm^3$/kg.m

f) Rata – rata laju keausan variasi oli ke 2

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,64^3}{12.13,6} = \frac{0,9043}{163,2} = 0,00554mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,64^3}{12.13,6.6,36.15} = 0,00005mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,80^3}{12.13,6} = \frac{1,7664}{163,2} = 0,01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,80^3}{12.13,6.6,36.15} = 0,00011mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,69^3}{12.13,6} = \frac{1,1334}{163,2} = 0,00694mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,69^3}{12.13,6.6,36.15} = 0,00007mm^3/\text{kg.m}$$

$\frac{0,00005+0,00011+0,00007}{3} = 0,000077mm^3$/kg.m

g) Rata – rata laju keausan variasi oli ke 3

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,69^3}{12.13,6} = \frac{1,1334}{163,2} = 0,00694mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,69^3}{12.13,6.6,36.15} = 0,00007mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,80^3}{12.13,6} = \frac{1,7664}{163,2} = 0,01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_s} = \frac{3,45.0,80^3}{12.13,6.6,36.15} = 0,00011mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,37^3}{12.13,6} = \frac{0,1747}{163,2} = 0,00107mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_s} = \frac{3,45.0,37^3}{12.13,6.6,36.15} = 0,00001mm^3/\text{kg.m}$$

$$\frac{0,00007+0,00011+0,00001}{3} = 0,000063mm^3/\text{kg.m}$$

h) Rata – rata laju keausan variasi air garam ke 1

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,43^3}{12.13,6} = \frac{0,2742}{163,2} = 0,00168mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_s} = \frac{3,45.0,43^3}{12.13,6.6,36.15} = 0,00001mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,53^3}{12.13,6} = \frac{0,5136}{163,2} = 0,00315mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_s} = \frac{3,45.0,53^3}{12.13,6.6,36.15} = 0,00002mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,59^3}{12.13,6} = \frac{0,7085}{163,2} = 0,00434mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_s} = \frac{3,45.0,59^3}{12.13,6.6,36.15} = 0,00002mm^3/\text{kg.m}$$

$$\frac{0,00001+0,00002+0,00002}{3} = 0,000017mm^3/\text{kg.m}$$

i) Rata – rata laju keausan variasi air garam ke 2

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,72^3}{12.13,6} = \frac{1,2877}{163,2} = 0,00789mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,72^3}{12.13,6.6,36.15} = 0,00008mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,69^3}{12.13,6} = \frac{1,1334}{163,2} = 0,00694mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,69^3}{12.13,6.6,36.15} = 0,00007mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,67^3}{12.13,6} = \frac{1,0376}{163,2} = 0,00635mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,67^3}{12.13,6.6,36.15} = 0,00009mm^3/\text{kg.m}$$

$$\frac{0,00008+0,00007+0,00009}{3} = 0,000080mm^3/\text{kg.m}$$

j) Rata – rata laju keausan variasi air garam ke 3

Titik ke 1

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,67^3}{12.13,6} = \frac{1,0376}{163,2} = 0,00635mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,67^3}{12.13,6.6,36.15} = 0,00009mm^3/\text{kg.m}$$

Titik ke 2

$$w = \frac{B.b^3}{12.r} = \frac{3,45.0,72^3}{12.13,6} = \frac{1,2877}{163,2} = 0,00789mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3,45.0,72^3}{12.13,6.6,36.15} = 0,00008mm^3/\text{kg.m}$$

Titik ke 3

$$w = \frac{B.b^3}{12.r} = \frac{3{,}45.0{,}80^3}{12.13{,}6} = \frac{1{,}7664}{163{,}2} = 0{,}01082mm^3$$

$$ws = \frac{B.b^3}{12.r.P.L_o} = \frac{3{,}45.0{,}80^3}{12.13{,}6.6{,}36.15} = 0{,}00011mm^3/\text{kg.m}$$

$$\frac{0{,}00009+0{,}00008+0{,}00011}{3} = 0{,}000093mm^3/\text{kg.m}$$

Perhitungan rata – rata laju keausan

a) Rata – rata tegangan tarik variasi udara ke 1

Pmax = $13{,}57\ KN$

= $13{,}57x1000$

= $13570N$

Lebar = $14{,}91$

Tebal = $3{,}33$

Ao = $Tebal\ x\ Lebar$

= $3{,}33x14{,}91$

= $49{,}6503mm^2$

σ = $\frac{Pmax}{Ao}$

= $\frac{13570N}{49{,}6503mm^2}$

= $273{,}31N/mm^2$

b) Rata – rata tegangan tarik variasi udara ke 2

Pmax = $13{,}97\ KN$

= $13{,}97x1000$

= $13970N$

Lebar = $15{,}19$

Tebal = $3{,}37$

Ao $= Tebal\ x\ Lebar$

$= 3{,}37x15{,}19$

$= 51{,}1903mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{13970N}{51{,}1903mm^2}$

$= 272{,}90N/mm^2$

c) Rata – rata tegangan tarik variasi udara ke 3

Pmax $= 13{,}62\ KN$

$= 13{,}62x1000$

$= 13620N$

Lebar $= 14{,}85$

Tebal $= 3{,}39$

Ao $= Tebal\ x\ Lebar$

$= 3{,}39x14{,}85$

$= 50{,}3415mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{13620N}{50{,}3415mm^2}$

$= 270{,}55N/mm^2$

$\frac{273{,}31+272{,}90+270{,}55}{3} = 272{,}3MPa$

d) Rata – rata tegangan tarik variasi oli ke 1

Pmax $= 15{,}77\ KN$

$= 15{,}77x1000$

$= 15770N$

Lebar $= 15{,}69$

Tebal $= 3{,}36$

Ao $= Tebal\ x\ Lebar$

$= 3{,}36x15{,}69$

$= 52{,}7184mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{15770N}{52{,}7184mm^2}$

$= 299{,}14N/mm^2$

e) Rata – rata tegangan tarik variasi oli ke 2

Pmax $= 14{,}61\ KN$

$= 14{,}61x1000$

$= 14610N$

Lebar $= 14{,}88$

Tebal $= 3{,}35$

Ao $= Tebal\ x\ Lebar$

$= 3{,}35x14{,}88$

$= 49{,}848mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{14610N}{49{,}848mm^2}$

$= 293{,}09N/mm^2$

f) Rata – rata tegangan tarik variasi oli ke 3

Pmax $= 16{,}18\ KN$

$= 16{,}18x1000$

$= 16180N$

Lebar $= 15{,}76$

Tebal $= 3{,}36$

Ao $= Tebal\ x\ Lebar$

$= 3{,}36x15{,}76$

$= 52{,}9536mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{16180N}{52{,}9536mm^2}$

$= 305{,}55N/mm^2$

$\frac{299{,}14+293{,}09+305{,}55}{3} = 299{,}3MPa$

g) Rata – rata tegangan tarik variasi air garam ke 1

Pmax $= 16{,}21\ KN$

$= 16{,}21x1000$

$= 16210N$

Lebar $= 15{,}00$

Tebal $= 3{,}24$

Ao $= Tebal\ x\ Lebar$

$= 3{,}24x15{,}00$

$= 48{,}6mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{16210N}{48{,}6mm^2}$

$= 333{,}54N/mm^2$

h) Rata – rata tegangan tarik variasi air garam ke 2

Pmax $= 16{,}73\ KN$

$= 16{,}73x1000$

$= 16730N$

Lebar $= 15{,}88$

Tebal $= 3{,}25$

Ao $= Tebal\ x\ Lebar$

$= 3{,}25x15{,}88$

$= 51{,}61mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{16730N}{51{,}61mm^2}$

$= 324{,}16N/mm^2$

i) Rata – rata tegangan tarik variasi air garam ke 3

Pmax $= 16{,}19\ KN$

$= 16{,}19x1000$

$= 16190N$

Lebar $= 15{,}64$

Tebal $= 3{,}19$

Ao $= Tebal\ x\ Lebar$

$= 3{,}19x15{,}64$

$= 49{,}8916mm^2$

$\sigma = \frac{Pmax}{Ao}$

$= \frac{16190N}{49{,}89{,}16mm^2}$

$= 324{,}50N/mm^2$

$\frac{333{,}54+324{,}16+324{,}50}{3} = 327{,}4MPa^3$

Lampiran 2. Sertifikat pengujian

DINAS PERINDUSTRIAN, TRANSMIGRASI DAN TENAGA KERJA
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Email : labperintgl@gmail.com website : lab.disperinnaker.tegalkab.go.id

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LAPORAN UJI KEKERASAN

Laporan No.	:	06/2024.184/H/25	Benda Uji	:	Sesuai JIS Z 2243 : 2008
Pemakai Jasa	:	MISBAHUL FALAH	Objek uji	:	**AISI 1020 Quenching Udara**
Alamat	:	Universitas Pancasakti Tegal	Metode Uji	:	JIS Z 2243 : 2008
Suhu	:	27 °C	Mesin Uji	:	Affri 206 RT
Tgl. Terima	:	26 Juni 2024	Jml. Specimen	:	3 Pcs
Tgl. Pengujian	:	26 Juni 2024	Halaman	:	1 dari 1

HASIL UJI :

No.	Kode Sampel uji	Parameter uji	Hasil uji		Satuan	Keterangan
			Daerah Uji	Nilai Kekerasan		
1.	25.7	Kekerasan Brinell	Titik 1	123	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 1**
			Titik 2	125		
			Titik 3	123		
			Rata-rata	123,67		
2.	25.8	Kekerasan Brinell	**Titik 1**	124	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 2**
			Titik 2	124		
			Titik 3	124		
			Rata-rata	124		
3.	25.9	Kekerasan Brinell	**Titik 1**	124	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 3**
			Titik 2	123		
			Titik 3	125		
			Rata-rata	124		

Keterangan :
1) U_{95} = 123,67 ± 1,75
2) U_{95} = 124 ± 1,13
3) U_{95} = 124 ± 1,62

U_{95} / Ketidakpastian pengukuran tersebut diukur pada tingkat kepercayaan 95% dengan faktor cakupan (k) = 2

Tegal, 2 Juli 2024
Manajer Teknis

DINAS PERINDUSTRIAN TRANSMIGRASI DAN TENAGA KERJA UPTD LABORATORIUM PERINDUSTRIAN KABUPATEN TEGAL

EKO SUPRIYANTO, S.T.
NIP. 19741230 200604 1 093

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LAPORAN UJI KEKERASAN

Laporan No.	:	06/2024.184/H/25	Benda Uji	:	Sesuai JIS Z 2243 : 2008
Pemakai Jasa	:	MISBAHUL FALAH	Objek uji	:	**AISI 1020 Quenching Air Garam**
Alamat	:	Universitas Pancasakti Tegal	Metode Uji	:	JIS Z 2243 : 2008
Suhu	:	27 °C	Mesin Uji	:	Affri 206 RT
Tgl. Terima	:	26 Juni 2024	Jml. Specimen	:	3 Pcs
Tgl. Pengujian	:	26 Juni 2024	Halaman	:	1 dari 1

HASIL UJI :

No.	Kode Sampel uji	Parameter uji	Hasil uji		Satuan	Keterangan
			Daerah Uji	Nilai Kekerasan		
1.	25.1	Kekerasan Brinell	Titik 1	293	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 1**
			Titik 2	301		
			Titik 3	293		
			Rata-rata	295,67		
2.	25.2	Kekerasan Brinell	Titik 1	370	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 2**
			Titik 2	370		
			Titik 3	348		
			Rata-rata	362,67		
3.	25.3	Kekerasan Brinell	Titik 1	301	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 3**
			Titik 2	293		
			Titik 3	301		
			Rata-rata	298,33		

Keterangan :
1) U_{95} = 295,67 ± 5,45
2) U_{95} = 362,67 ± 14,71
3) U_{95} = 298,33 ± 5,45

U_{95} / Ketidakpastian pengukuran tersebut diukur pada tingkat kepercayaan 95% dengan faktor cakupan (k) = 2

Tegal, 3 Juli 2024
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NIP. 19741231 200604 1 093

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Email : labperintgl@gmail.com website : lab.disperinnaker.tegalkab.go.id

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LAPORAN UJI KEKERASAN

Laporan No.	:	06/2024.184/H/25	Benda Uji	:	Sesuai JIS Z 2243 : 2008
Pemakai Jasa	:	MISBAHUL FALAH	Objek uji	:	**AISI 1020 Quenching Oli**
Alamat	:	Universitas Pancasakti Tegal	Metode Uji	:	JIS Z 2243 : 2008
Suhu	:	27 °C	Mesin Uji	:	Affri 206 RT
Tgl. Terima	:	**26 Juni 2024**	Jml. Specimen	:	**3 Pcs**
Tgl. Pengujian	:	**26 Juni 2024**	Halaman	:	**1 dari 1**

HASIL UJI :

No.	Kode Sampel uji	Parameter uji	Hasil uji		Satuan	Keterangan
			Daerah Uji	Nilai Kekerasan		
1.	25.4	Kekerasan Brinell	Titik 1	135	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 1**
			Titik 2	133		
			Titik 3	131		
			Rata-rata	133		
2.	25.5	Kekerasan Brinell	Titik 1	131	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 2**
			Titik 2	131		
			Titik 3	133		
			Rata-rata	131,67		
3.	25.6	Kekerasan Brinell	Titik 1	133	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm - **Benda 3**
			Titik 2	135		
			Titik 3	131		
			Rata-rata	133		

Keterangan :
1) U_{95} = 133 ± 2,57
2) U_{95} = 131,67 ± 1,75
3) U_{95} = 133 ± 2,57

U_{95} / Ketidakpastian pengukuran tersebut diukur pada tingkat kepercayaan 95% dengan faktor cakupan (k) = 2

Tegal, 2 Juli 2024
Manajer Teknis

DINAS PERINTRANSNAKER UPTD LABORATORIUM PERINDUSTRIAN KABUPATEN TEGAL

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LAPORAN UJI KEKERASAN

Laporan No.	: 06/2024.184/H/24	Benda Uji	: Sesuai JIS Z 2243 : 2008
Pemakai Jasa	: MISBAHUL FALAH	Objek uji	: Baja JIS SUP 9
Alamat	: Universitas Pancasakti Tegal	Metode Uji	: JIS Z 2243 : 2008
Suhu	: 27 °C	Mesin Uji	: Affri 206 RT
Tgl. Terima	: 26 Juni 2024	Jml. Specimen	: 1 Pc
Tgl. Pengujian	: 26 Juni 2024	Halaman	: 1 dari 1

HASIL UJI :

No.	Kode Sampel uji	Parameter uji	Hasil uji		Satuan	Keterangan
			Daerah Uji	Nilai Kekerasan		
1.	24	Kekerasan Brinell	Titik 1	249	HB	- Beban penekanan F = 1840 N - Waktu penekanan 15 detik - Indentor Ø 2,5 mm
			Titik 2	243		
			Titik 3	249		
			Rata-rata	247		

Keterangan :
1) $U_{95} = 247 \pm 4{,}16$
U_{95} / Ketidakpastian pengukuran tersebut diukur pada tingkat kepercayaan 95% dengan faktor cakupan (k) = 2

Tegal, 2 Juli 2024
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EKO SUDIYANTO, S.T.
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HASIL PENGUJIAN TARIK

No.	Variasi Spesimen	Tebal (mm)	Lebar (mm)	Pmax (KN)	ΔL (mm)	Tegangan (MPa)	Regangan (%)
1	Udara_1	3.33	14.91	13.57	21.42	273.31	42.84
2	Udara_2	3.37	15.19	13.97	23.28	272.90	46.56
3	Udara_3	3.39	14.85	13.62	20.18	270.55	40.36
4	Oli_1	3.36	15.69	15.77	20.53	299.14	41.06
5	Oli_2	3.35	14.88	14.61	22.38	293.09	44.76
6	Oli_3	3.36	15.76	16.18	26.13	305.55	52.26
7	Air Garam_1	3.24	15.00	16.21	17.14	333.54	34.28
8	Air Garam_2	3.25	15.88	16.73	20.48	324.16	40.96
9	Air Garam_3	3.19	15.64	16.19	13.36	324.50	26.72

Keterangan:

1. Pengujian dilakukan tanggal 28 Juni 2024
2. Pengujian menggunakan Universal Testing Machine
3. Standar spesimen menggunakan JIS Z 2201

Identitas Penguji :

Nama : Mishbahul Falah
NPM : 6420600022
Institusi : Teknik Mesin Universitas Pancasakti Tegal

Yogyakarta, 28 Juni 2024
Staf Laboratorium Bahan Teknik

Pengujian & Analisa Material
Lab. Bahan Teknik Departemen Teknik Mesin Sekolah Vokasi UGM

Dr. Ir. Dwi Setyaka, S.T., M.T
NIP. 197703312002121002

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HASIL PENGUJIAN KEAUSAN

Variasi Spesimen	Titik Uji	Tebal Disc (B;mm)	Jari-jari Disc (r;mm)	Panjang Wear (b;mm)	Volume Tergores (W;mm³)	Keausan (Ws; mm³/kg.m)	Keausan rata-rata (Ws; mm³/kg.m)
Pembanding	1	3.45	13.6	0.72	0.00789	0.00008	0.000093
	2	3.45	13.6	0.67	0.00635	0.00009	
	3	3.45	13.6	0.80	0.01082	0.00011	
Udara_1	1	3.45	13.6	0.77	0.00964	0.00010	0.000103
	2	3.45	13.6	0.80	0.01082	0.00011	
	3	3.45	13.6	0.77	0.00964	0.00010	
Udara_2	1	3.45	13.6	0.80	0.01082	0.00011	0.000093
	2	3.45	13.6	0.72	0.00789	0.00008	
	3	3.45	13.6	0.67	0.00635	0.00009	
Udara_3	1	3.45	13.6	0.61	0.00479	0.00005	0.000057
	2	3.45	13.6	0.69	0.00694	0.00007	
	3	3.45	13.6	0.64	0.00554	0.00005	
Oli_1	1	3.45	13.6	0.61	0.00479	0.00005	0.000060
	2	3.45	13.6	0.80	0.01082	0.00011	
	3	3.45	13.6	0.51	0.00280	0.00002	
Oli_2	1	3.45	13.6	0.64	0.00554	0.00005	0.000077
	2	3.45	13.6	0.80	0.01082	0.00011	
	3	3.45	13.6	0.69	0.00694	0.00007	
Oli_3	1	3.45	13.6	0.69	0.00694	0.00007	0.000063
	2	3.45	13.6	0.80	0.01082	0.00011	
	3	3.45	13.6	0.37	0.00107	0.00001	
Air Garam_1	1	3.45	13.6	0.43	0.00168	0.00001	0.000017
	2	3.45	13.6	0.53	0.00315	0.00002	
	3	3.45	13.6	0.59	0.00434	0.00002	
Air Garam_2	1	3.45	13.6	0.72	0.00789	0.00008	0.000080
	2	3.45	13.6	0.69	0.00694	0.00007	
	3	3.45	13.6	0.67	0.00635	0.00009	
Air Garam_3	1	3.45	13.6	0.67	0.00635	0.00009	0.000093
	2	3.45	13.6	0.72	0.00789	0.00008	
	3	3.45	13.6	0.80	0.01082	0.00011	

Pengujian & Analisa Material
Lab Material
Departemen Teknik Mesin
Sekolah Vokasi UGM

Kampus : Jl. Grafika 2A Yogyakarta 55281

LABORATORIUM BAHAN TEKNIK
DEPARTEMEN TEKNIK MESIN SEKOLAH VOKASI
UNIVERSITAS GADJAH MADA

Keterangan:

1. Pengujian dilakukan tanggal 25 Juni 2024
2. Pengujian menggunakan universal wear
3. Jarak pengausan 15 m, Beban pengujian 6,36 kg

Identitas Penguji :

Nama : Mishbahul Falah
NPM : 6420600022
Institusi : Teknik Mesin Universitas Pancasakti Tegal

Yogyakarta, 25 Juni 2024
Staf Laboratorium Bahan Teknik

Dr. Lilik Dwi Setyana, S.T., M.T
NIP. 197703312002121002

Lembar asli, tidak untuk digandakan

SeAH Besteel Corp.
1-6, SORYONG-DONG,KUNSAN,
CHEONBUK, KOREA(573-711)

TEL : +82-(0)63-460-8572, 8318(QA)
+82-(0)63-460-8114(Repres.)
FAX : +82-(0)63-460-8423

MILL CERTIFICATE

Date : 2020-12-25
Cert. No. : 202008-383190
Customer :
Heat No. : 338575

Steel Grade : AISI 1020
Shape of Product : PLATE SHEET
Delivery Condition : Plate Bar

Size (mm) : 1-100
Length (mm) : 6000
Weight (kg) :
Quantity(pcs) : 1

Inspection Items		Chemical Composition (wt. %)				
		C	SI	MN	P	S
		x 100	x 100	x 100	x 1000	x 1000
Spec.	Min.	15	20	0.85		
	Max.	20	24	1.067	0.016	0.021
	Result	20	24	1.067	0.025	0.024

Inspection Items	Product Hardness (HB)		
	SURFACE	110-121 HB	20-25 HRC

Mechanical Properties AISI 1020

Mechanical Properties	Symbol	Amount
Density (kg/m³)	ρ	7870
Tensile Strength (MPa)		420
Yield Strength (MPa)		350
Elongation at Break (%)		15
Reduction of Area (%)		40
Modulus of Elasticity (GPa)		186
Bulk Modulus (GPa)		148
Poissons Ratio		0.29
Machinability		65.0

<<Remarks>>

B/DS : 4

End of report

We hereby certify that the material described herein has been made in accordance with the rules of the contract.

Certified by O.Y. Cho

Manager of Quality Assurance Dept

SeAH Besteel Corp.
1-6, SORYONG-DONG,KUNSAN,
CHEONBUK, KOREA(573-711)

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FAX : +82-(0)63-460-8423

MILL CERTIFICATE

Date : 2021-01-12
Cert. No. : 202101-410918
Customer :
Heat No. : 489026

Steel Grade : SUP 9
Shape of Product : PLATE SHEET
Delivery Condition : PLATE ROLLED

Size (mm) : 6 - 30
Length (mm) : 6,000
Weight (kg) :
Quantity(pcs) :

Inspection Items		Chemical Composition (wt. %)					
		C	SI	MN	P	S	CR
		x1000	x1000	x1000	x1000	x1000	x1000
Spec.	Min.	5.2	1.5	6.5			6.5
	Max.	6.0	3.5	9.5	0.35	0.45	9.5
	Result						

Inspection Items	Product Hardness (HB)
	SURFACE

Mechanical Properties SUP 9

Mechanical Properties	Symbol	Steel
Ultimate tensile strength (MPa)		1226
0.2% Proof stress (MPa)		1080
Elongation (%)		9

<<Remarks>>

B/DS : 4

End of report

We hereby certify that the material described herein has been made in accordance with the rules of the contract.

Certified by O.Y.Cho

Manager of Quality Assurance Dept

Lampiran 3. Pembuatan spesimen

No.	Gambar	Keterangan
1.		Spesimen sebelum dilakukan proses perlakuan panas
2.		Media pendingin menggunakan Oli mesin bekas dan air garam dengan jumlah garam 10%/liter air

3.		Spesimen setelah dilakukan proses perlakuan panas dan pendinginan cepat
4.		Hasil pengujian kekerasan

5.		Hasil pengujian keausan
6.		Hasil pengujian tarik