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LAMPIRAN

Lampiran 1 Spesiment Benda Uji



Gambar Lampiran 1. 1 Spesimen Benda Uji Impact



Gambar Lampiran 1. 2 Spesimen Benda Uji Impact dan Bending

ANALISA KOMPOSISI KIMIA CHEMICAL COMPOSITION

Nomor : 014/LAB/PL/VII/2024
Tanggal : 18 Juli 2024

Pemakai : Galih Catur Febrian
Customer : UPS - Tegal

Bahan : Sample Plate
Material

Mesin : ARL Optic Emission Spectrometer
Machine : Switzerland QTD - 127

Obyek : Baja ST-37
Object

I. Chemical Composition

Unsur	Kandungan Unsur (%)	STD
Fe	Balance	Balance
C	0,236	-
Si	0,461	-
Mn	0,711	-
P	0,091	-
S	0,028	-
Cr	2,046	-
Ni	0,055	-
Mo	0,055	-
Cu	0,092	-
Al	0,0030	-
V	0,011	-
W	0,030	-
Co	0,0082	-
Nb	0,0050	-
Ti	0,0030	-
Mg	-	-

II. Mechanical Properties

	As Cast	After Hardened
1. Hardness Value Average	-	-
2. Tensile Strenght	-	-

Diperiksa/ Disetujui oleh
Checked/Approved by



Gambar Lampiran 1. 3 Hasi Uji Komposisi

Lampiran 2 Proses Heat Treatment



Gambar Lampiran 2.1 Heat Treatment dengan suhu 850°C



Gambar Lampiran 2.2 Heat Treatment dengan suhu 870°C





Gambar Lampiran 2.4 Proses
Penuangan Arang Tulang Sapi pada
Tengki



Gambar Lampiran 2.5 Proses
Pelapisan Arang Tulang Sapi pada
Material



Gambar Lampiran 2.6 Proses
Pelapisan Arang Tulang Sapi pada
Material



Gambar Lampiran 2.7 Proses
Pelapisan Arang Tulang Sapi pada
Material



Gambar Lampiran 2.8 Proses Pelapisan Arang Tulang Sapi pada Material



Gambar Lampiran 2.9 Proses Pelapisan Arang Tulang Sapi pada Material



Gambar Lampiran 2.11 Proses Pelapisan Arang Tulang Sapi pada Material

Lampiran 3 Proses Uji Bending



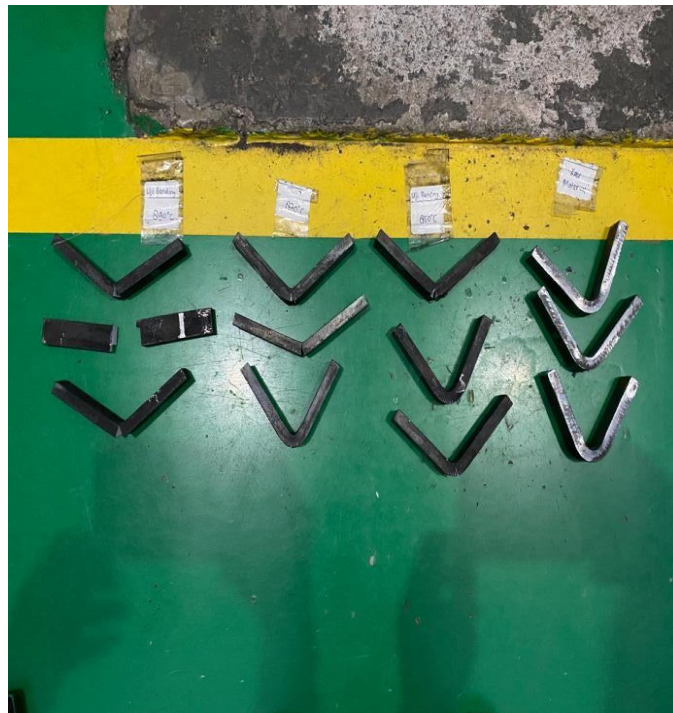
Gambar Lampiran 3.1 Spesimen Uji Bending



Gambar Lampiran 3.2 Alat Uji Bending



Gambar Lampiran 3.3 Proses Pengujian Bending



Gambar Lampiran 3.4 Hasi Spesiment Pengujian Bending



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UNIVERSITAS GADJAH MADA

HASIL PENGUJIAN BENDING

No.	Variasi Spesimen	Tebal	Lebar	Pmax	Defleksi	Tegangan
		(mm)	(mm)	(KN)	(mm)	Bending (MPa)
1	Raw_1	9.97	20.60	19.14	29.28	701.04
2	Raw_2	10.01	21.25	19.70	29.47	693.91
3	Raw_3	10.00	21.28	20.49	30.13	722.16
4	850°C_1	10.03	20.44	17.89	8.92	652.51
5	850°C_2	9.98	20.33	22.62	30.56	837.83
6	850°C_3	10.03	21.06	24.74	20.64	875.79
7	870°C_1	10.06	21.26	22.33	9.35	778.38
8	870°C_2	10.02	20.40	21.40	8.26	783.63
9	870°C_3	10.00	21.26	24.47	29.92	863.24
10	890°C_1	10.01	21.17	28.64	15.91	1012.62
11	890°C_2	10.02	20.73	29.10	11.67	1048.62
12	890°C_3	10.03	20.90	25.72	11.92	917.45

Lembar asli, tidak untuk digandakan

Keterangan:

1. Pengujian dilakukan tanggal 12 Juli 2024
2. Pengujian menggunakan Universal Testing Machine
3. Standar spesimen menggunakan ASTM D5942-92

Identitas Penguji :

Nama : Galih Catur Febrian
NPM : 6417500006
Institusi : Teknik Mesin Universitas Pancasakti Tegal

Yogyakarta, 12 Juli 2024
Staf Laboratorium Bahan Teknik
Pengujian & Material
Dr. Dik Dwi Setiawan, S.T., M.T.
NIP. 191703312002121002

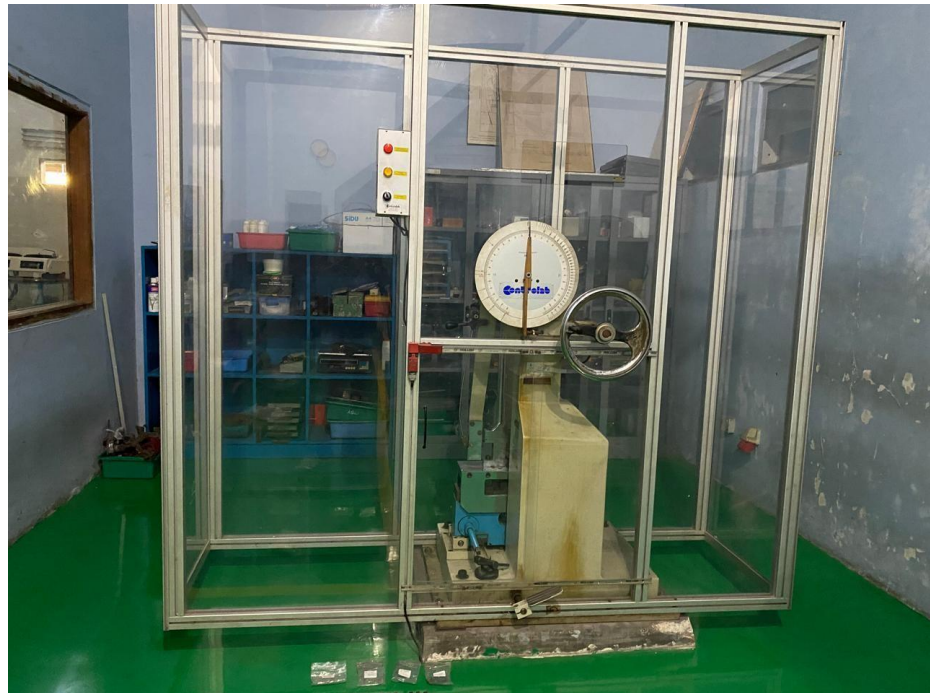
Kampus : Jl. Grafika 2A Yogyakarta 55281

Gambar Lampiran 3.5 Hasil Pengujian Bending

Lampiran 4 Proses Uji Impact



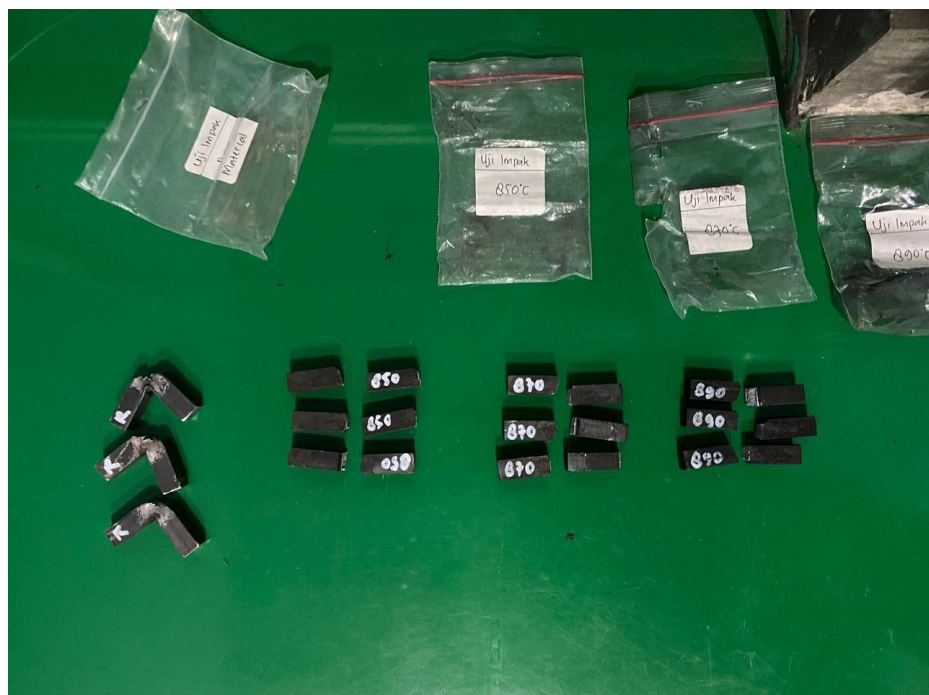
Gambar Lampiran 4.1 Spesimen Uji Impact



Gambar Lampiran 4.2 Alat Uji Impact



Gambar Lampiran 4.3 Proses Pengujian Impact



Gambar Lampiran 4.4 Hasil Spesiment Pengujian Impact



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HASIL PENGUJIAN IMPACT

No.	Variasi Spesimen	Sudut α (°)	Energi (J)	Sudut β (°)	Energi Terserap (J)	Luas (mm ²)	Harga Impact (J/mm ²)
1	Raw_1	151	300	10	297.5	88.5	3.363
2	Raw_2	151	300	18	292.1	86.7	3.370
3	Raw_3	151	300	15	294.5	90.8	3.243
4	850°C_1	151	300	135	26.8	91.5	0.293
5	850°C_2	151	300	132	32.9	93.9	0.350
6	850°C_3	151	300	123	52.8	93.3	0.566
7	870°C_1	151	300	113	77.4	91.9	0.842
8	870°C_2	151	300	116	69.8	91.4	0.764
9	870°C_3	151	300	122	55.2	88.5	0.623
10	890°C_1	151	300	115	72.3	90.2	0.802
11	890°C_2	151	300	117	67.3	92.4	0.728
12	890°C_3	151	300	116	69.8	93.1	0.750

Keterangan :

1. Menggunakan metode Charpy
2. Standar Spesimen menggunakan ASTM E23
3. Panjang lengan 0,8 meter
4. Berat palu 20 kilogram

Identitas Penguji :

Nama : Galih Catur Febrian
NPM : 6417500006
Institusi : Teknik Mesin Universitas Pancasakti Tegal

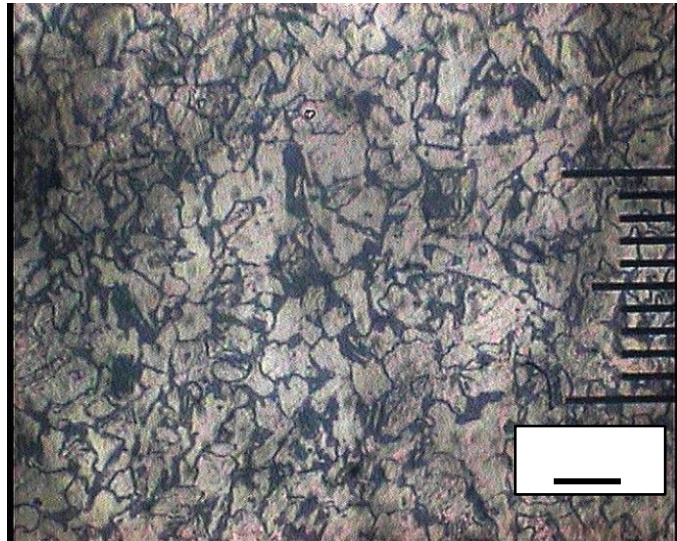
Yogyakarta, 12 Juli 2024
Staf Laboratorium Bahan Teknik

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

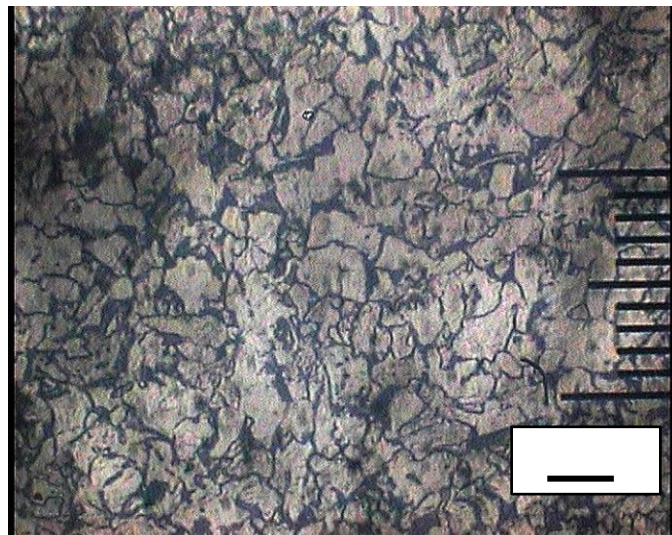
Kampus : Jl. Grafika 2A Yogyakarta 55281

Gambar Lampiran 4.5 Hasil Pengujian Impact

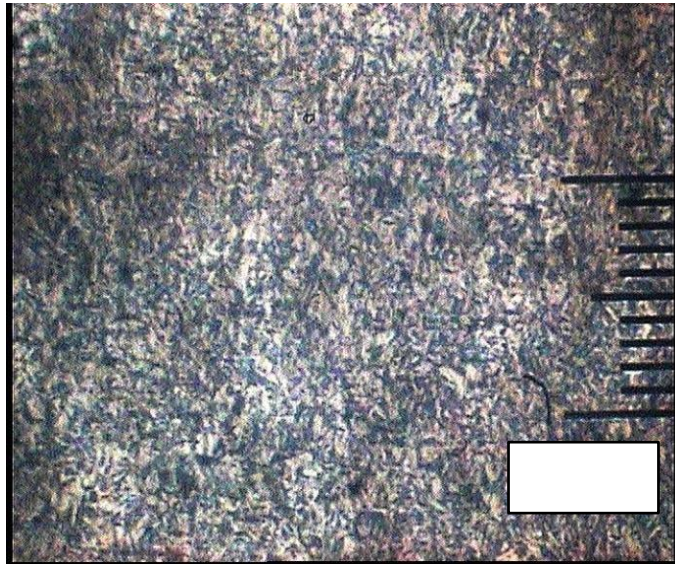
Lampiran 5 Hasil Uji Mikro



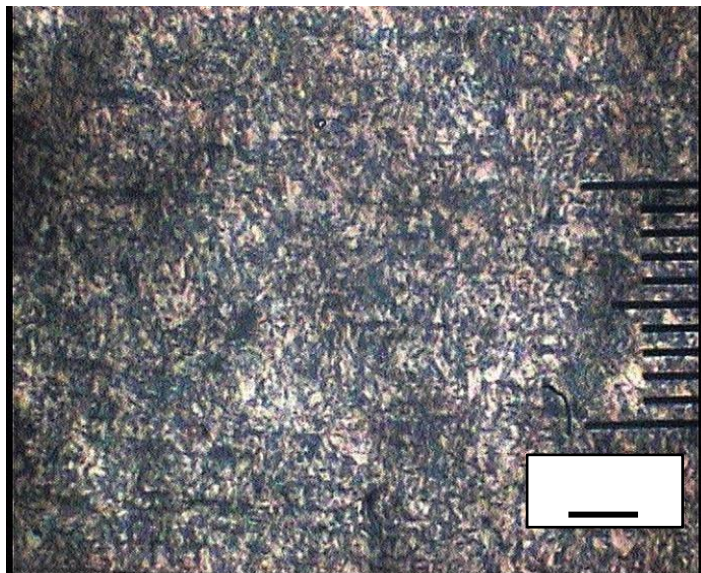
Gambar Lampiran 5. 2 Hasil Uji Mikro
Raw Material_Lokasi 1_Perbesaran 200x



Gambar Lampiran 5. 1 Hasil Uji Mikro
Raw Material_Lokasi 2_Perbesaran 200x



Gambar Lampiran 5. 4 Hasil Uji Mikro pada
Suhu 890°C_Lokasi 1_Perbesaran 200x



Gambar Lampiran 5. 3 Hasil Uji Mikro pada
Suhu 890°C_Lokasi 2_Perbesaran 200x

Lampiran 6 Perhitungan Hasil Uji Bending

Raw Material_2

Diketahui :

$$P = 19,70 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,25 \text{ mm}$$

$$d = 10,01 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (19,70 \cdot 1000) \cdot 50}{2 \cdot 21,25 \cdot (10,01)^2} \\&= \frac{3 \cdot 19700 \cdot 50}{2 \cdot 2,25 \cdot 100,2} \\&= \frac{2955000}{4258,5} \\&= 693,91 \text{ MPa}\end{aligned}$$

Raw Material_3

Diketahui :

$$P = 20,49 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,28 \text{ mm}$$

$$d = 10,00 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (20,49 \cdot 1000) \cdot 50}{2 \cdot 21,28 \cdot (10,00)^2} \\&= \frac{3 \cdot 20490 \cdot 50}{2 \cdot 21,28 \cdot 100} \\&= \frac{3073500}{4256} \\&= 722,16 \text{ MPa}\end{aligned}$$

Suhu 850°C_2

Diketahui :

$$P = 22,62 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 20,33 \text{ mm}$$

$$d = 9,98 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (22,62 \cdot 1000) \cdot 50}{2 \cdot 20,33 \cdot (9,98)^2} \\&= \frac{3 \cdot 22620 \cdot 50}{2 \cdot 20,33 \cdot 99,6} \\&= \frac{3393000}{4049,73} \\&= 837,83 \text{ MPa}\end{aligned}$$

Suhu 850°C _3

Diketahui :

$$P = 24,74 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,06 \text{ mm}$$

$$d = 10,03 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (24,74 \cdot 1000) \cdot 50}{2 \cdot 21,06 \cdot (10,03)^2} \\&= \frac{3 \cdot 24740 \cdot 50}{2 \cdot 21,06 \cdot 100,6} \\&= \frac{3711000}{4237,27} \\&= 875,79 \text{ MPa}\end{aligned}$$

Suhu 870°C _1

Diketahui :

$$P = 22,33 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,26 \text{ mm}$$

$$d = 10,06 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (22,33 \cdot 1000) \cdot 50}{2 \cdot 21,26 \cdot (10,06)^2} \\&= \frac{3 \cdot 22330 \cdot 50}{2 \cdot 21,26 \cdot 101,2} \\&= \frac{3349500}{4303,02} \\&= 778,38 \text{ MPa}\end{aligned}$$

Suhu 870°C _2

Diketahui :

$$P = 21,40 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 20,40 \text{ mm}$$

$$d = 10,02 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (21,40 \cdot 1000) \cdot 50}{2 \cdot 20,40 \cdot (10,02)^2} \\&= \frac{3 \cdot 21400 \cdot 50}{2 \cdot 20,40 \cdot 100,4} \\&= \frac{3210000}{4096,32} \\&= 783,63 \text{ MPa}\end{aligned}$$

Suhu 870°C _3

Diketahui :

$$P = 24,47 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,26 \text{ mm}$$

$$d = 10,00 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (24,47 \cdot 1000) \cdot 50}{2 \cdot 21,26 \cdot (10,00)^2} \\&= \frac{3 \cdot 24470 \cdot 50}{2 \cdot 21,26 \cdot 100} \\&= \frac{3670500}{4252} \\&= 863,24 \text{ MPa}\end{aligned}$$

Suhu 890°C _1

Diketahui :

$$P = 28,64 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 21,17 \text{ mm}$$

$$d = 10,01 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (28,64 \cdot 1000) \cdot 50}{2 \cdot 21,27 \cdot (10,01)^2} \\&= \frac{3 \cdot 28640 \cdot 50}{2 \cdot 21,17 \cdot 100,2} \\&= \frac{4296000}{4242,46} \\&= 1012,62 \text{ MPa}\end{aligned}$$

Suhu 890°C _2

Diketahui :

$$P = 29,10 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 20,73 \text{ mm}$$

$$d = 10,02 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (29,10 \cdot 1000) \cdot 50}{2 \cdot 20,73 \cdot (10,02)^2} \\&= \frac{3 \cdot 29100 \cdot 50}{2 \cdot 20,73 \cdot 100,4} \\&= \frac{4365000}{4162,58} \\&= 1048,62 \text{ MPa}\end{aligned}$$

Suhu 890°C _3

Diketahui :

$$P = 25,72 \text{ N}$$

$$L = 50 \text{ mm}$$

$$b = 20,90 \text{ mm}$$

$$d = 10,03 \text{ mm}$$

Jawab :

$$\begin{aligned}fb &= \frac{3PL}{2bd^2} \\&= \frac{3 \cdot (25,72 \cdot 1000) \cdot 50}{2 \cdot 20,90 \cdot (10,03)^2} \\&= \frac{3 \cdot 25720 \cdot 50}{2 \cdot 20,90 \cdot 100,6} \\&= \frac{3858000}{4205,08} \\&= 917,45 \text{ MPa}\end{aligned}$$

Lampiran 7 Perhitungan Hasil Uji Impact

Raw Material_2

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 18^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 18^\circ - \cos 151^\circ) \\ &= 160 (0,951 - (-0,874)) \\ &= 160 \cdot 1,825\end{aligned}$$

$$= 292,1 \text{ J}$$

dengan demikian Harga Impact dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 292,1 \text{ J}$$

$$A = 86,7 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{292,1}{86,7}\end{aligned}$$

$$= 3,370 \text{ J/mm}^2$$

Raw Material_3

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 15^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 15^\circ - \cos 151^\circ) \\ &= 160 (0,966 - (-0,874)) \\ &= 160 \cdot 1,840\end{aligned}$$

$$= 294,5 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 294,5 \text{ J}$$

$$A = 90,8 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{294,5}{90,8}\end{aligned}$$

$$= 3,243 \text{ J/mm}^2$$

Suhu 850°C_2

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 132^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 132^\circ - \cos 151^\circ) \\ &= 160 (-0,669 - (-0,874)) \\ &= 160 \cdot 0,205\end{aligned}$$

$$= 32,9 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 32,9 \text{ J}$$

$$A = 93,9 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{32,9}{93,9} \\ &= 0,350 \text{ J/mm}^2\end{aligned}$$

Suhu 850°C_3

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 123^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 123^\circ - \cos 151^\circ) \\ &= 160 (-0,545 - (-0,874)) \\ &= 160 \cdot 0,33\end{aligned}$$

$$= 52,8 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 52,8 \text{ J}$$

$$A = 93,3 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{52,8}{93,3} \\ &= 0,566 \text{ J/mm}^2\end{aligned}$$

Suhu 870°C_1

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 113^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 113^\circ - \cos 151^\circ) \\ &= 160 (-0,390 - (-0,874)) \\ &= 160 \cdot 0,484\end{aligned}$$

$$= 77,4 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 77,4 \text{ J}$$

$$A = 91,9 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{77,4}{91,9} \\ &= 0,842 \text{ J/mm}^2\end{aligned}$$

Suhu 870°C_2

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 116^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 116^\circ - \cos 151^\circ) \\ &= 160 (-0,438 - (-0,874)) \\ &= 160 \cdot 0,436\end{aligned}$$

$$= 69,8 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 69,8 \text{ J}$$

$$A = 91,4 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{69,8}{91,4} \\ &= 0,764 \text{ J/mm}^2\end{aligned}$$

Suhu 870°C_3

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 122^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 122^\circ - \cos 151^\circ) \\ &= 160 (-0,529 - (-0,874)) \\ &= 160 \cdot 0,345\end{aligned}$$

$$= 55,2 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 55,2 \text{ J}$$

$$A = 88,5 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{55,2}{88,5} \\ &= 0,623 \text{ J/mm}^2\end{aligned}$$

Suhu 890°C_1

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 115^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 115^\circ - \cos 151^\circ) \\ &= 160 (-0,422 - (-0,874)) \\ &= 160 \cdot 0,452\end{aligned}$$

$$= 72,3 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 72,3 \text{ J}$$

$$A = 90,2 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{72,3}{90,2} \\ &= 0,802 \text{ J/mm}^2\end{aligned}$$

Suhu 890°C_2

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 117^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 117^\circ - \cos 151^\circ) \\ &= 160 (-0,453 - (-0,874)) \\ &= 160 \cdot 0,421\end{aligned}$$

$$= 67,3 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 67,3 \text{ J}$$

$$A = 92,4 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{67,3}{92,4} \\ &= 0,728 \text{ J/mm}^2\end{aligned}$$

Suhu 890°C_3

Diketahui :

$$W = 20 \text{ kg} = 200 \text{ N}$$

$$L = 0,8 \text{ m}$$

$$\alpha = 151^\circ$$

$$\beta = 116^\circ$$

Jawab :

$$\begin{aligned}\Delta E &= W \cdot L (\cos \beta - \cos \alpha) \\ &= 200 \cdot 0,8 (\cos 116^\circ - \cos 151^\circ) \\ &= 160 (-0,438 - (-0,874)) \\ &= 160 \cdot 0,436\end{aligned}$$

$$= 69,8 \text{ J}$$

dengan demikian Harga Impack dapat di ketahui sebagai berikut :

$$HI = \frac{AE}{A}$$

Diketahui :

$$AE = 69,8 \text{ J}$$

$$A = 93,1 \text{ mm}^2$$

Jawab :

$$\begin{aligned}HI &= \frac{AE}{A} \\ &= \frac{69,8}{93,1}\end{aligned}$$

$$\begin{aligned} &= 93,1 \\ &= 0,750 \text{ J/mm}^2 \end{aligned}$$