UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2009/2010

SUBJECT NAME	:	ENGINEERING MATERIALS SELECTION
SUBJECT CODE	:	BDA 2042
COURSE	:	2 BDD / 3 BDD
EXAMINATION DATE	:	APRIL/MEI 2010
DURATION	:	2 HOURS
INSTRUCTION	:	ANSWER FOUR (4) QUESTION ONLY FROM FIVE (5) QUESTIONS

THIS EXAMINATION PAPER CONTAIN FOURTEEN (14) PAGES

Q1 (a) (i) Define classical selection method.

(ii) State the characteristics of classical selection method.

(iii) Point out the advantages of classical selection method.

(8 Marks)

(b) Discuss the approach of materials selection in each design stages. Sketch an appropriate diagram if necessary.

(12 Marks)

(c) Based on Figure Q1, Datuk Lee Chong Wei has proposed Ni-Cu alloys type I, II and III for his badminton racquet frame application. Give a comment on the alloy selection.

(5 Marks)

Q2 (a) Sketch the stress-strain graph for metal. From the graph, label and define the following properties;

(i) Yield strength (σ_y)

(ii) Ultimate strength (σ_u)

(iii) Young's modulus (E)

(10 marks)

(b) Describe briefly the composite material including their applications.

(5 marks)

c) Give five (5) comparisons between elastomer and glasses.

(10 marks)

Q3 (a) State the complete procedures to derive the materials index. (6 Marks)

(b) Derive the materials index for beam which has a light weight and stiff criteria, $M = \frac{E^{1/2}}{\rho}$. Refer to Figure Q3 (b). If the beam has a cross sectional area , b × b and length, l with applied load, F. The constraint is stiffness, S.

$$S \approx \frac{F}{\delta} \approx \frac{C_1 EI}{l^3}$$

which, S = Stiffness

δ = Deflection

E = Young Modulus

C_1= Constant which is refer to the load

F = Load

$I = \frac{b^4}{12}$ = Second Moment

l = Length

(10 Marks)

(c) For a materials index of $M = \frac{\sigma^{3/2}}{\rho^{1/3}}$, what slope will the decision line be for a materials selection chart of log σ (Y axis) versus log ρ (X axis)? (3 Marks)

(d) By using the materials selection chart in Figure Q3 (d). Determine the region which the strength, σ_f is less than 3 MPa and materials index, $M = \frac{\sigma_f^{\ 2}}{\rho}$, greater than 20 Mg.m^{-3}.

(6 Marks)

Q4 (a) Stainless Steel (SS) consists of at least minimum of 10.5 wt% of Chromium.

(i) List the classes of the Stainless Steel (SS) material. (3 Marks)

(ii) What is Duplex Stainless Steel? Give the properties of this material. (5 Marks)

(b) Titanium is one of the non-ferrous metals. Its extraordinary properties lead to the applications in an aircraft and aerospace industries.

(i) Explain the crystalline (allotropes) forms in the pure Titanium. (3 Marks)

(ii) Briefly discuss the types and properties of Titanium alloys. (6 Marks)

(c) Ahmad, Ah Tong and Kumar would like to determine the suitable steel to be used for their design on a mini bridge. The design requires a 75 mm diameter with a minimum hardness of 1500 MPa tensile strength at about a 1/2 –radius position in the cross section. Then the steel will be heat treated in non-scaling atmosphere and will be quenched in an agitated water bath at velocity of 200ft/min. **Note**: Please refer Figures Q4 (c) and Table 1.

(i) What is the value of as-quenched hardness? (3 Marks)

(ii) What is the Jominy equivalent cooling rate, J_{ec}? (2 Marks)

(iii) List the possible alloy steels that can fulfill their requirement. (3 Marks)

Q5 (a) What are biopolymer, bioceramics and biocomposites? Give one example of the starting material for each of these class of engineering materials. (6 marks)

(b) Bioceramics need to have a low Young's modulus to help prevent cracking of the material and commonly subdivided into their bioactivity and bioinert materials. The materials requirements are; to be long lasting, not be prone to structural failure, and corrosion resistant. Why the above mentioned criteria are important as primary medical procedures such as designing bone, joint, artificial teeth or dental.(5 marks)

(c) Explain the mechanism involved in polymeric materials deformation under constant strain which results in decrease in the stress with time. (6 marks)

(d) A stress of 8 MPa is applied to an elastomeric material at constant strain. After 55 days at 30 °C, the stress decreases to 5.5 MPa.

(i) What is the relaxation time constant for this material? (3 marks)

(ii) What will be the stress after 100 days at 30 °C? (2 marks)

(e) A reaction-bonded silicon nitride has strength of 238 MPa and fracture toughness of 4.0 MPa$\sqrt{m}$. What is the maximum size of internal crack that this material can support without fracturing? Use Y = 1 in the fracture toughness equation. (3 marks)

S1 (a) (i) Definisikan kaedah pemilihan klasik.

(ii) Nyatakan ciri-ciri kaedah pemilihan klasik.

(iii) Nyatakan kelebihan kaedah pemilihan klasik.

(8 Markah)

(b) Bincangkan pendekatan dalam pemilihan bahan di dalam setiap tahap rekabentuk. Lakarkan rajah yang sesuai jika perlu.

(12 Markah)

(c) Berpandukan kepada Rajah S1, Datuk Lee Chong Wei telah mencadangkan aloi Ni-Cu jenis I, II dan III untuk kegunaan kerangka raket badminton beliau. Beri komen terhadap pemilihan aloi tersebut.

(5 Markah)

S2 a) Lakarkan graf tegasan-terikan untuk metal. Daripada graf, label dan takrifkan sifat-sifat bahan berikut;

(i) Kekuatan alah (σ_y)

(ii) Kekuatan muktamad (σ_u)

(iii) Modulus young (E)

(10 markah)

b) Huraikan secara ringkas tentang bahan komposi termasuk aplikasinya.

(5 markah)

c) Berikan Lima (5) perbandingan di antara elastomer dan kaca. (10 markah)

S3 (a) Nyatakan prosedur untuk menerbitkan indeks bahan dengan lengkap. (6 Markah)

(b) Terbitkan indek bahan bagi rasuk yang ringan dan kaku, $M = \frac{E^{1/2}}{\rho}$. Lihat Rajah S2. Sekiranya rasuk mempunyai keratan rentas, b × b dan panjang, l serta dikenakan beban, F. Diberikan juga, kekangannya adalah sifat kekakuan, S.

$$S \approx \frac{F}{\delta} \approx \frac{C_1 EI}{l^3}$$

Di mana,
S = Kekakuan
δ = Pesongan
E = Modulus Young
C_1= Pemalar yang bergantung pada beban
F = Beban
$I = \frac{b^4}{12}$ = Momen luas kedua
l = Panjang

(10 Markah)

(c) Bagi indeks bahan $M = \frac{\sigma^{3/2}}{\rho^{1/3}}$, apakah kecerunan garisan bagi carta pemilihan bahan dengan log σ (paksi Y) melawan log ρ (paksi X).

(3 Markah)

(d) Dengan menggunakan carta pemilihan bahan dalam Rajah S3. Tentukan kawasan yang mematuhi nilai kekuatan, σ_f yang lebih kecil daripada 3 MPa dan indeks bahan, $M = \frac{\sigma_f^{\,2}}{\rho}$, yang lebih besar daripada 20 Mg.m^{-3}.

(6 Markah)

S4 (a) Keluli Tahan KArat mengandungi Kromium sekurang-kurangnya sebanyak minimum 10.5 wt%

(i) Senaraikan pengkelasan bagi bahan Keluli Tahan Karat (3 Markah)

(ii) Apakah Keluli Tahan Karat Duplex? Berikan sifat-sifat bahan ini. (5 Markah)

(b) Titanium merupakan salah satu daripada logam bukan ferus. Sifatnya yang luar biasa menbolehkan ia digunakan di dalam industri kapal terbang dan kapal angkasa.

(i) Terangkan bentuk hablur (allotropi) di dalam Titanium tulen (3 Markah)

(ii) Terangkan secara ringkas jenis dan sifat Titanium aloi. (6 Markah)

(c) Ahmad, Ah Tong and Kumar ingin mengenalpasti keluli yang sesuai untuk merekabentuk sebuah jambatan mini. Rekabentuk ini memerlukan rod yang mempunyai 75 mm ukuran diameter dengan kekerasan minimum sebanyak 1500 MPa kekuatan terikan pada kedudukan 1/2 jejari daripada garisan pusat keluli tersebut. Kemudian, keluli akan dirawat haba di dalam keadaan *non-scaling atmosphere* dan dilindap kejut secara pengadukan dalam larutan air pada halaju setara 200ft/min. **Nota :** Sila rujuk **Rajah S4-S7** dan **Jadual 1.**

(i) Apakah nilai as-quenched hardness? (3 Markah)

(ii) Apakah kadar penyejukan setaraan Jominy, J_{ec}? (2 Markah)

(iii) Senaraikan kemungkinan keluli aloi yang memenuhi kehendak mereka. (3 Markah)

S5 (a) Apakah biopolimer, bioseramik dan biokomposik? Berikan satu contoh bahan permulaan bagi setiap bahan kejuruteraan yang dinyatakan. (6 markah)

(b) Bioceramik adalah satu bahan yang mempunyai Young Modulus yang rendah untuk mengelakkan daripada berlakunya rekahan dan biasanya ia terdiri daripada bahan yang mempunyai bioaktiviti dan "bioinert". Bahan ini perlulah; tahan lama, tidak mudah mengalami kecacatan struktur, dan tahan karat. Kenapakah kriteria ini penting sebagai bahan perubatan yang utama seperti rekabentuk tulang, joint, gigi tiruan atau pergigian. (5 markah)

(c) Terangkan dengan jelas mekanisma kecacatan yang terlibat bagi bahan polimerik dibawah keterikan malar yang menyebabkan pengurangan ketegasan dengan masa. (6 markah)

(d) Tegasan sebanyak 8 MPa dikenakan keatas bahan elastomer pada keterikan malar. Selepas 55 hari pada 30 °C, ketegasan telah berkurangan kepada 5.5 MPa.

(i) Apakah pemalar bagi "relaxation time" bahan ini? (3 markah)

(ii) Apakah nilai tegasan bagi bahan ini selepas 100 hari pada 30 °C? (2 markah)

(e) Silicon Nitrat mempunyai kekuatan sebanyak 238 MPa dan K_{IC} sebanyak 4.0 MPa√m. Apakah saiz maximum kecacatan dalaman yang dibolehkan bagi membenarkannya untuk menampung beban dari pecah? Gunakan Y = 1 dalam "fracture toughness equation" (3 markah)

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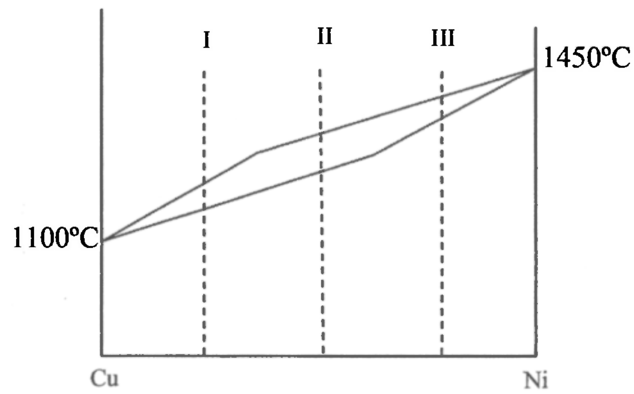

FIGURE Q1 / RAJAH S1

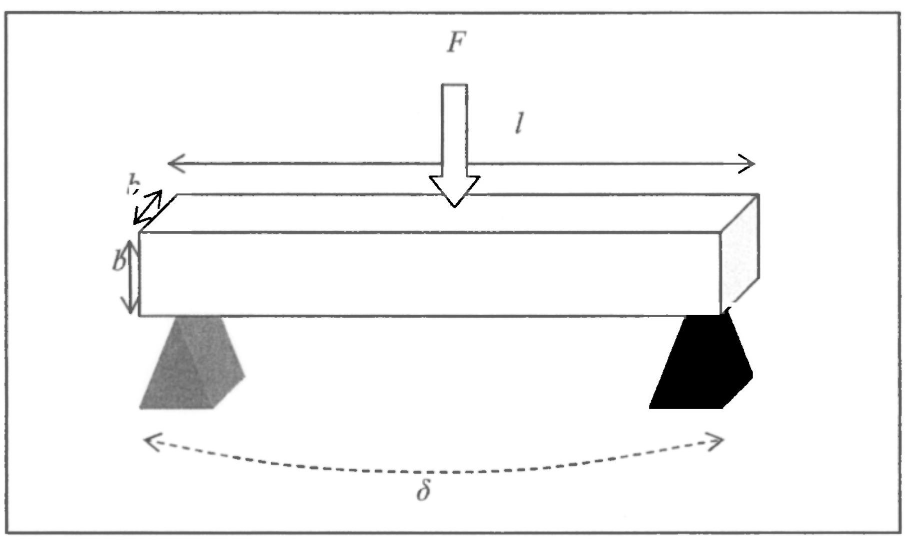

FIGURE Q3 (b) / RAJAH S2

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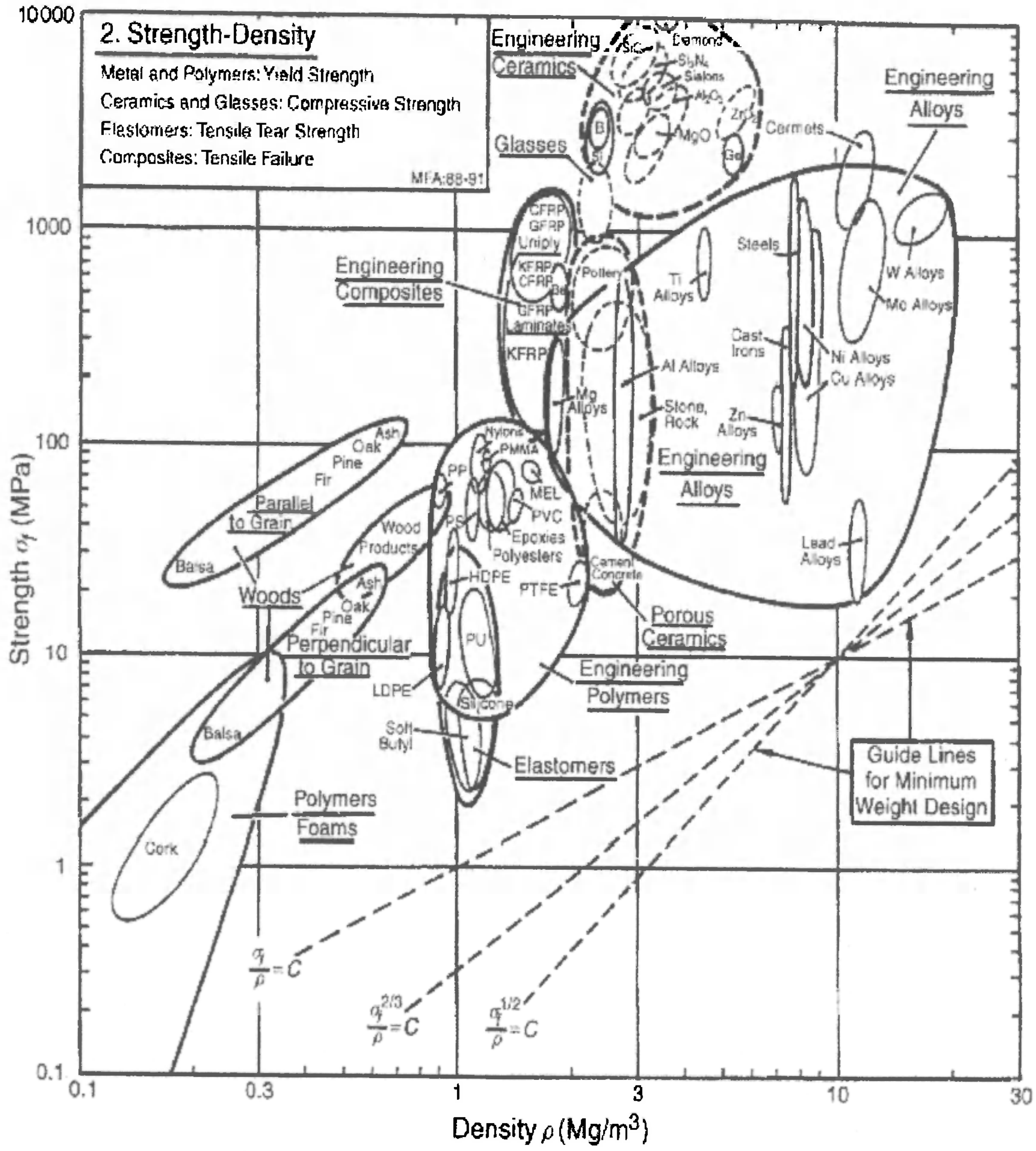

FIGURE Q3 (d) / RAJAH S3

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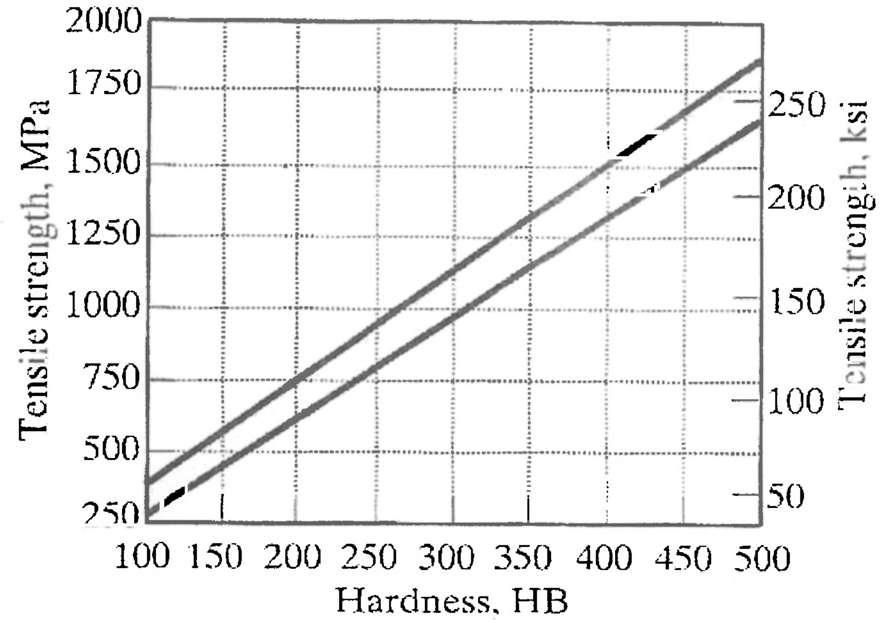

FIGURE Q4 (c) / RAJAH S4

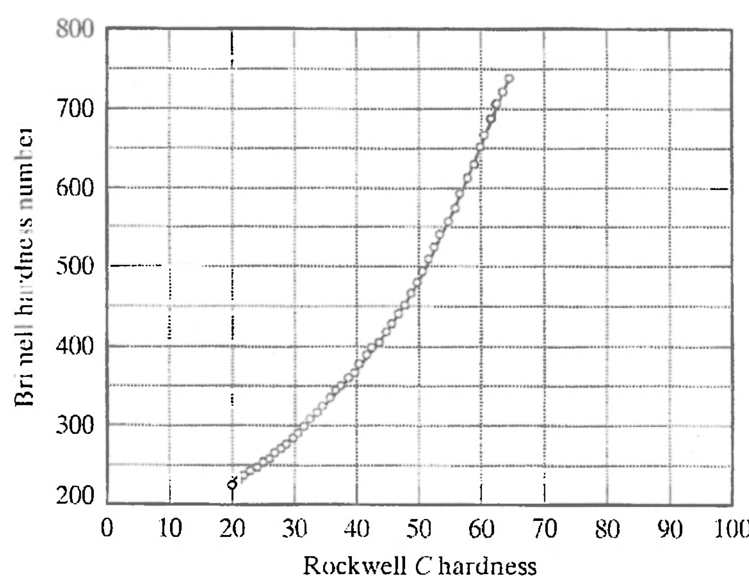

FIGURE Q4 (c) / RAJAH S5

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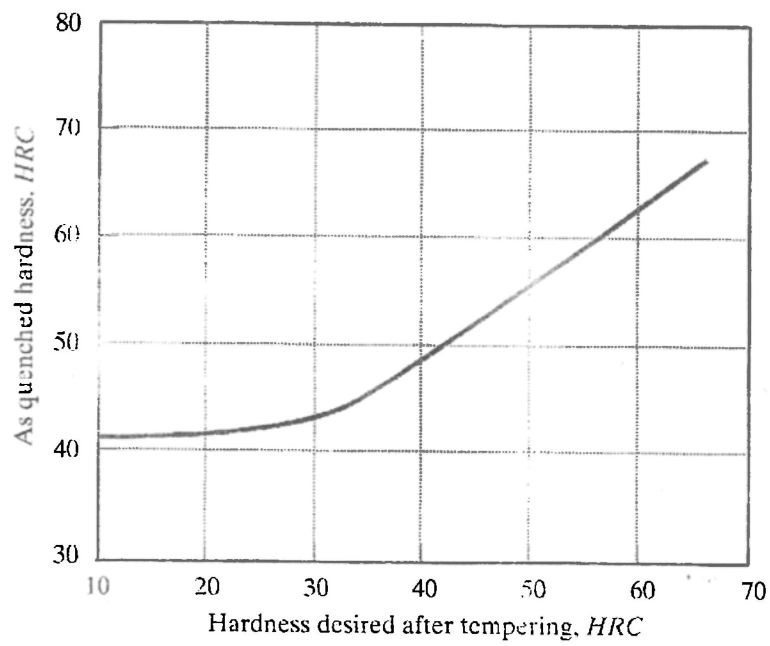

FIGURE Q4 (c) / RAJAH S6

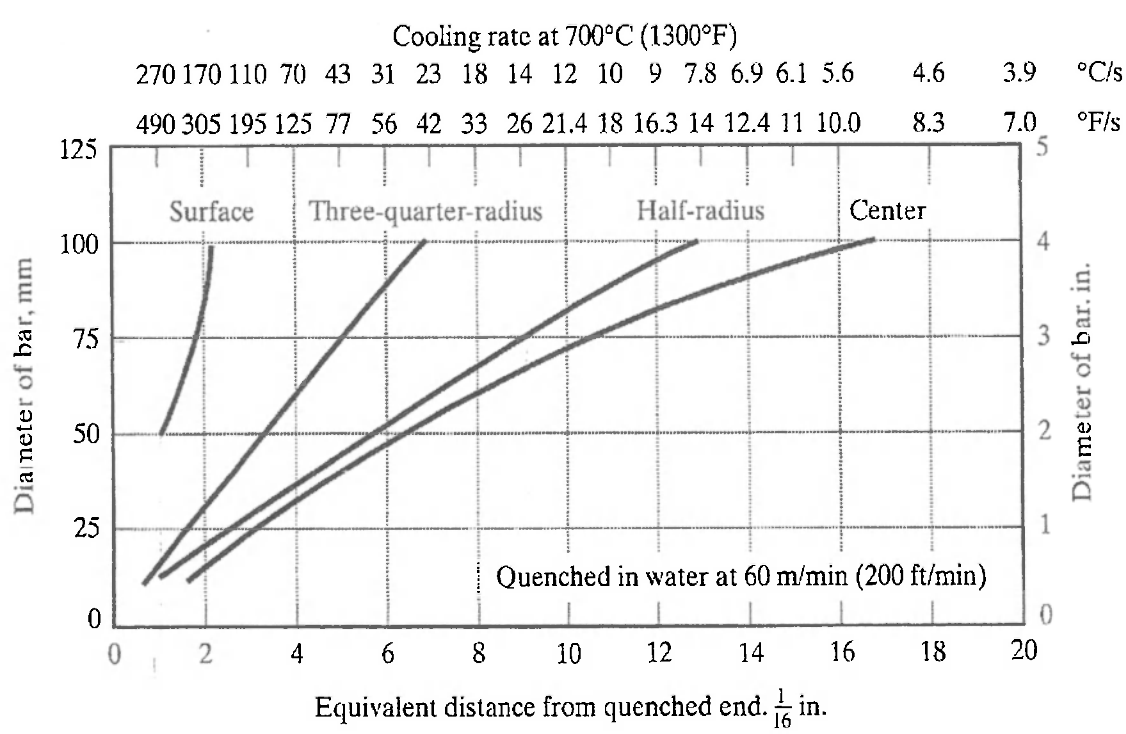

FIGURE Q4 (c) / RAJAH S7

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Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
40 HRC (Continued)	
10 1/2	6150, 50B60
11	4140
11 1/2	81B45, 8650, 5152
12	86B30
13	51B60
.14	8655
15	4142
15 1/2	8750
18	4145, 8653, 8660
19	9840, 86B45
20	4147
24	4337, 4150
32	4340
36+	E4340, 9850
45 HRC	
1	4027, 4028, 8625
1 1/2	8627, 1038
2	4032, 1042, 1146, 1045
2 1/2	4130, 5130, 8630, 4037, 1050, 5132
3	1330, 5046, 1541
3 1/4	1050
3 1/2	1335, 5135, 4042, 4047
4	8635, 1141
5	8637, 1340, 5140, 50B46, 4053, 9260, 15B37
5 1/2	5145, 4063
6	4135, 4640, 4068, 1345
6 1/2	8640, 8740, 5150, 94B30
7	4137, 8642, 6145, 9261, 50B40
7 1/2	8742, 50B44, 5155
8	8645, 5147
8 1/2	4140, 6150, 5160, 9262, 50B50
9	50B60
9 1/2	81B45, 8650, 86B30
10	5152
11	51B60, 8655
11 1/2	4142
12	8750

Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
45 HRC (Continued)	
13	8653, 8660
14	9840, 4145
16	85B45, 4147
17	4337
18	4150
22	4340
26	4161
30	E4340
36	9850
50HRC	
1	4032, 5132, 1038
1 1/2	1335, 5135, 8635, 4037, 1042, 1146, 1045
2	4135, 1541, 15B35, 15B37
2 1/4	1050
2 1/2	4042
3	8637, 5140, 5046, 4047
3 1/2	4137, 1141, 1340
4	4640, 5145, 50B46
4 1/2	8640, 8740, 4053, 9260
5	8642, 4063, 1345, 50B40
5 1/2	8742, 6145, 5150, 4068
6	4140, 8645
6 1/2	9261, 50B44, 5155
7	5147, 6150
7 1/2	5160, 9262, 50B50
8	4142, 81B45, 8650
8 1/2	5152, 50B60
9 1/2	4337, 8750, 8655
10	4145, 51B60
10 1/2	9840
11	8653, 8660
11 1/2	8645
12	85B45
13	4340, 4147
14	4150
20	E4340
22	9850, 4161

(Continued)

Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
55HRC	
1	1141, 1042, 4042, 4142, 1045, 1146, 1050, 8642
1 1/2	50B46
2	8742, 5046, 4047, 5145
2 1/2	6145
3	4145, 8645, 1345
3 1/2	86B45, 5147, 4053, 9260
4 1/2	5150, 40635
5	81B45, 6150, 9261, 5155

Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
55HRC (Continued)	
5 1/2	8650, 5152, 4068
6	50B50
6 1/2	5160, 9262
7	4147, 8750, 8655
7 1/2	50B60
9	8653, 51B60, 8660
9 1/2	4150
17	9850

TABLE O4 (c) / JADUAL 1