UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2004/2005
Second Semester Examination
2004/2005 Academic Session

Mac 2005
March 2005

ESA 474/3 – Elemen Rekabentuk Helikopter
Helicopter Design Element

Masa : [3 jam]
Hour : [3 hours]

ARAHAN KEPADA CALON :
INSTRUCTION TO CANDIDATES:

Sila pastikan bahawa kertas soalan ini mengandungi **EMPAT BELAS (14)** mukasurat dan **LIMA (5)** soalan sebelum anda memulakan peperiksaan.
*Please ensure that this paper contains **FOURTEEN (14)** printed pages and **FIVE (5)** questions before you begin examination.*

Jawab **EMPAT (4)** soalan sahaja.
*Answer **FOUR (4)** the questions only.*

Jawab semua soalan dalam Bahasa Malaysia.
Answer all questions in Bahasa Malaysia.

Setiap soalan mestilah dimulakan pada mukasurat yang baru.
*Each questions must begin from a new page.*

1.   (a)   Rajah 1.1 dan 1.2 menunjukkan satu sistem rotor helikopter yang disendikan sepenuhnya dan sistem pemutar separa tegar.   Terangkan istilah-istilah teknik yang terdapat dalam gambar.

Figure 1.1 and 1.2 shows a typical rotor system of the helicopter (fully articulated and semi rigid rotor system),   explain the technical terms are shown in that figure :
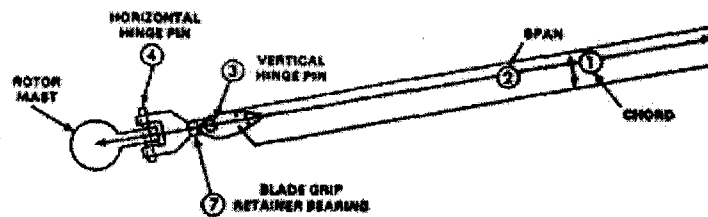
Rajah 1.1 : Fully Articulated rotor system
Figure 1.1 : Fully Articulated rotor system
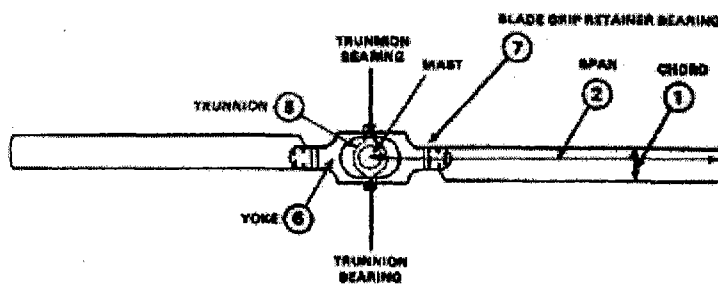
Rajah 1.2 : Semi rigid rotor system
Figure 1.2 : Semi rigid rotor system

Terangkan istilah teknik berikut:

Explain the following technical terms:

(i)   perentas bilah

        chord

                                        (2 markah/*marks*)

(ii)   rentang bilah

        the span

                                        (2 markah/*marks*)

(iii)   "vertical hinge pin" (drag hinge)

        "vertical hinge pin" (drag hinge)

                                        (2 markah/*marks*)

(iv)   "horizontal hinge pin"

        "horizontal hinge pin"

                                        (2 markah/*marks*)

(v)   trunnion

        the trunnion

                                        (2 markah/*marks*)

(vi)   yoke

        the yoke

                                        (2 markah/*marks*)

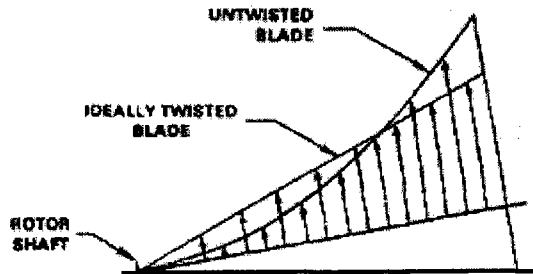(vii)   "blade twist"

        "the blade twist"

                                        (2 markah/*marks*)

(b)   Rajah 1.3 menunjukkan pengagihan beban antara rotor dengan bilah
       memiliki twist dan tanpa twist. Terangkan kegunaan sudut twist pada
       rotor bilah helikopter tersebut.

       *Figure 1.3 shows load distribution between twist and untwisted blade.
       Explain the function of the twisted angle on the blade.*

Rajah 1.3 : Distribution of lift on twisted and untwisted rotor blade
Figure 1.3 : Distribution of lift on twisted and untwisted rotor blade

(5 markah/*marks*)

(c)   Terangkan pengertian teknik dari

       (i)   sistem articulated rotor
       (ii)   sistem non articulated rotor

       Explain the technical terms of

       (i)   the articulated rotor
       (ii)   non articulated

(6 markah/*marks*)

2.   (a)   Helikopter dengan data data berikut:

Jejari bilah pemutar R_B = 6 m

Bilangan Bilah N_B = 4

Purata pekali geseran c_{do} = 0.008

Kelajuan tip $\Omega R_B = 200 \dfrac{m}{sec}$

Min perentas bilah $\bar{c}$ = 0.6 m

Jika berat helikopter ialah 4000 kg dan dalam keadaan penerbangan hover pada paras laut (anggap ketumpatan udara $\rho = 1.225 \dfrac{kg}{m^3}$) dan pecutan graviti $g = 10 \dfrac{m}{sec^2}$

A helicopter's data is given bellows :

Rotor blade radius R_B = 6 m

The blade number N_B = 4

The average drag coefficients c_{do} = 0.008

the tip speed $\Omega R_B = 200 \dfrac{m}{sec}$

the mean blade chord $\bar{c}$ = 0.6 m

If the helicopter has mass weight 4000 kg and in hover flight conditions at sea level (assume the air density $\rho = 1.225 \dfrac{kg}{m^3}$ *and the gravitational accelerations* $g = 10 \dfrac{m}{sec^2}$*)*

Dengan menggunakan teori momentum, kirakan:

Use a momentum theory to calculate:

(i)   Pembebanan cakera

        The disk loading

                                                    (3 markah/*marks*)

(ii)   Nisbah aliran masuk teraruh

        Induced inflow ratio

                                                    (3 markah/*marks*)

(iii)   Pekali kuasa teraruh unggul

        Ideal induced power coefficients

                                                    (4 markah/*marks*)

(iv)   Angka merit

        Figure of merit

                                                    (4 markah/*marks*)

(v)   Kesan nisbah bilah

        Effective blade ratio

                                                    (3 markah/*marks*)

(b)   (i)   Terangkan mengapa terjadi disimetri daya angkat di rotor bilah helikopter semasa helikopter terbang ke depan.

Explain why dissymmetry lift occurred on the rotor blade helicopter at the moment helicopter fly forward.

(2 markah/*marks*)

(ii)   Terangkan mengapa keadaan pegun terjadi pada bahagian belakang (retreating side) semasa helikopter melakukan terbang ke depan.

Explain why stall is occurred in retreating side when the helicopter in forward flight.

(2 markah/*marks*)

(iii)   Terangkan mengapa terjadi gelombang kejutan pada bahagian "advancing side" semasa helikopter terbang ke depan.

Explain why shock wave appeared in advancing side when the helicopter in forward flight.

(2 markah/*marks*)

(iv)   Terangkan apa yang dimaksudkan dengan persoalan "tip vortices interaction" di rotor bilah helikopter.

Explain what it is mean by tip vortices interaction on the rotor blade helicopter

(2 markah/*marks*)

3.   Diberikan data helikopter berikut:

Jejari bilah pemutar R_B = 6 m
Bilangan Bilah N_B = 4
Purata pekali geseran c_{do} = 0.008

Kelajuan tip $\Omega R_B = 200 \dfrac{m}{sec}$

Min perentas bilah $\bar{c}$ = 0.6 m
Berat helikopter : 20000 Newton

The helicopter's data is given as bellows:

Rotor blade radius R_B = 6 m
The blade number N_B = 4
The average drag coefficients c_{do} = 0.008

The tip speed $\Omega R_B = 200 \dfrac{m}{sec}$

The mean blade chord $\bar{c}$ = 0.6 m
Helicopter weight : 20000 Newton

Helikopter terbang di atas paras laut (ketumpatan udara $\rho = 1.225 \dfrac{kg}{m^3}$ dan

pecutan graviti $g = 10 \dfrac{m}{sec^2}$) . Dengan menggunakan teori momentum , kira:

Helicopter flies at sea level (air density $\rho = 1.225 \dfrac{kg}{m^3}$ *and gravity* $g = 10 \dfrac{m}{sec^2}$ *).*
Using momentum theory, calculate:

(i)   Pekali tujah

The thrust coefficient

(2 markah/*marks*)

(ii)   Nisbah aliran masuk teraruh semasa hover

The induced velocity at hover

(2 markah/*marks*)

(iii)   Halaju teraruh dengan halaju semasa mendaki 20 m/saat.

The induced velocity at climb with speed 20 m/sec.

(2 markah/*marks*)

(iv)   Halaju penurunan semasa terjadinya "vortex ring state"

Descent velocity at vortex ring state

(2 markah/*marks*)

(v)   Halaju penurunan semasa terjadinya "turbulent wake state"

Descent velocity at turbulent wake state

(2 markah/*marks*)

(vi)   Halaju penurunan semasa terjadinya "wind mill brake state"

Descent velocity at the wind mill brake state

(vii)   Angka merit semasa hover

Figure of merit at hover

(2 markah/*marks*)

(viii) Angka merit semasa mendaki dengan halaju 20 m/saat

Figure of merit at climb speed 20 m/sec

(2 markah/*marks*)

(ix) Jika helikopter tersebut menurun pada kelajuan sama dengan halaju teraruh, kirakan pekali kuasa teraruh unggul yang diperlukan.

If the helicopter descent with speed of descent equal to the induced velocity, calculate the ideal induced power coefficient.

(3 markah/*marks*)

(x) Jika laju tip menjadi 180 m/saat semasa helikopter terbang mendaki 20 m/saat, kirakan penurunan peratus penurunan pekali kuasa teraruh unggul bila dibandingkan laju tip 200 m/saat

If the tip speed becomes 180 m/sec at the time helicopter fly climb at speed of 20 m/sec, Calculate the percentage of the decrease of the ideal power coefficient compared to the helicopter at tip speed 200 m/sec.

(3 markah/*marks*)

(xi) Terangkan anggapan yang digunakan dalam analisis aerodinamik pemutar bilah helikopter dengan kaedah teori Momentum.

Explain the assumptions had been used in the aerodynamic analysis of rotor blade helicopter with the Momentum Theory Method.

(5 markah/*marks*)

4. Diberikan data helikopter berikut:

Jejari bilah pemutar R_B = 6 m

Bilangan Bilah N_B = 4

Purata pekali geseran c_{do} = 0.008

Kelajuan tip ΩR_B = $200 \dfrac{m}{sec}$

Min perentas bilah $\bar{c}$ = 0.6 m

Berat helikopter : 20000 Newton

Luasan plat datar setara 30% (luasan rotor bilah)

The helicopter's data is given as bellows:

Rotor blade radius R_B = 6 m

The blade number N_B = 4

The average drag coefficients c_{do} = 0.008

The tip speed ΩR_B = $200 \dfrac{m}{sec}$

The mean blade chord $\bar{c}$ = 0.6 m

Helicopter weight : 20000 Newton

Equivalent flat plate area 30 % (Rotor blade area)

Helikopter terbang di atas paras laut (ketumpatan udara $\rho = 1.225 \dfrac{kg}{m^3}$ dan

pecutan graviti $g = 10 \dfrac{m}{sec^2}$). Bila helikopter ini sedang melakukan terbang ke arah depan (forward) dengan haluju 30 m/sec dan sudut serang Tip Path Plane α_{TPP} = 5^0.

Kirakan:

Helicopter flies at sea level (air density $\rho = 1.225 \dfrac{kg}{m^3}$ and gravity $g = 10 \dfrac{m}{sec^2}$).
When the helicopter move forward with velocity 30 m/sec and Tip Path Plane angle of attack α_{TPP} = 5^0, calculate:

(i)   Dengan menggunakan kaedah iterasi Newton (3 iterasi) tentukan nisbah aliran masuk λ_i

Using Iteration Newton's Iteration method (up to 3th iterations) determine the inflow ratio λ_i

(6 markah/*marks*)

(ii)   pekali kuasa teraruh unggul Cp_i

Ideal induced power coefficients Cp_i

(2 markah/*marks*)

(iii)   pekali kuasa seretan parasit Cp_p

parsite drag power coefficients Cp_p

(2 markah/*marks*)

(iv)   pekali kuasa seretan profil Cp_{do}

profile drag power coefficients Cp_{do}

(2 markah/*marks*)

(v)   Bila sudut serang Tip Path Plane $\alpha_{TPP} = 10^0$, dengan kaedah iterasi Newton (3 iterasi). Tentukan nisbah aliran masuk λ_i

If the angle of attack Tip Path Plane $\alpha_{TPP} = 10^0$ Using Iteration Newton's Iteration method (up to 3th iterations). Determine the inflow ratio λ_i

(6 markah/*marks*)

(vi)   Jumlah pekali kuasa untuk no soalan 4 (iv)

Total power coefficient for the problem No 4(iv)

(4 markah/*marks*)

(vii)   Terangkan mengapa halaju operasi helikopter memiliki kecepatan terbang ke depan tidak dapat melebihi nilai nisbah lanjut $\mu > 0.4$

Explain why the operational speed of the helicopter can not exceed for the advance ratio $\mu > 0.4$

(3 markah/*marks*)

5.   (a)   Terangkan konsep Kaedah Elemen bilah dalam analisis aerodinamik pemutar bilah helikopter.

Explain the concept of Blade Element Method in the aerodynamic analysis of the rotor blade helicopters

(6 markah/*marks*)

(b)   Terangkan konsep "Prescribed Wake Method" dalam analisis aerodinamik pemutar bilah helikopter.

Explain the concept of Free Wake Method in the aerodynamic analysis of the rotor blade helicopters.

(6 markah/*marks*)

(c)   Terangkan konsep "Free Wake Method" dalam analisis aerodinamik pemutar bilah helikopter.

Explain the concept of Free Wake Method in the aerodynamic analysis of the rotor blade helicopters.

(6 markah/*marks*)

(d)   Terangkan mengapa di dalam analisis aerodinamik pemutar bilah helikopter dengan ketiga teori di atas memerlukan data pekali tujah sebagai data masukan.

Explain why on the use of three method as mentioned as above in their aerdynamics analysis of rotor blade helicopter need the thrust power coefficient as an input data.

(4 markah/marks)

(e)   Terangkan mengapa model dinamik pegun perlu disertakan dalam analisis aerodinamik pemutar bilah helikopter.

Explain why the dynamics stall model need to be implemented in the aerodynamics analysis of the rotor blade helicopter

(3 markah/*marks*)

ooo000ooo