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Modelling between Propulsion Force and Speed and Blade Inclination Radius Rotation and Angle ϕ Parameters of Five Blades in Helicopter

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Abstract

The modelling between propulsion force and speed has been built in this paper. With regard to different parameters it is found that the rotational speed is first factor to affect them and then the blade radius is the second factor to do. Therefore the right parameters is important in optimized design at helicopter turbine blades. The mass is one factor to influence the propulsion force mainly. So the big mass results in high propulsion and force change. On the other hand, low angle f causes the high rotational speed. With increasing the inclination the big propulsion force and speed has been attained in helicopter. With increasing blade radius R from 5m to 6.7m the propulsion force and speed will increase.

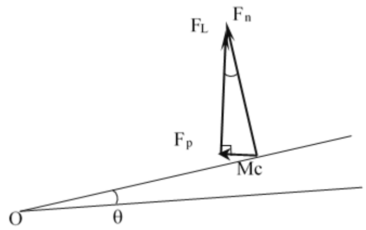
Keywords: Propulsion modelling; Blade; Helicopter; Inclination; Angleϕ; Radius; Propulsion speed and time; Rotation; Mass

Introduction

The helicopter is prevail in modern society because it has rapid flight than other usual vehicle. It accommodates more people to proceed transportation task in large helicopter. For example the injured one and substantial is needed rapidly arrangement. It can wield its effect in modern war due to its swiftness and mobile. It has attacking capacity in large scope. So it is investigated for the purpose of this utility. The propulsion of helicopter is studied to search its effect on speed which is important simulation. It is known that the speed will decline the propulsion. So the high rotation will be searched further because of its result of high speed. The propulsion determines the speed directly. On the other hand it will be affected by load so it is determined by a certain load. To promote the load it will be designed big for example the blade radius length and quantities and other like angle f and rotation speed & inclination [1-21]. So as to incline the load and speed it is investigated three directions in this paper i.e. rotation, angle f and radius. Through comparing with each other the advantage is searched in this study to further investigation later. On the other side, the speed of helicopter is also important one for us to search further in this paper because it is significant property to evaluate its function. Speed is a key factor to complete its task rapidly so here the detail situation is discussion to model its function. Overview, the propulsion and speed of helicopter is important factor so its effect is needed to search in detail. The turn is concluded in total according to this model. In this paper the acceleration is computed in terms of theory dynamics to use this research. It is supposed that five blades exist in. The lift force is second factor to consider because of its neglect role. The speed is a factor to model for finding the relation of them. It is to promote the property of helicopter through modelling is our destination finally.

Modelling and Equation

In the schematic graph as Figure 1 O is blade centre; θ is inclination, °; F_L is lift force, N; F_t is rotational force, N; F_p is propulsion force, N; M_c is the mass center. The model equation has been deduced as below. Figure 2 shows the relationship between the propulsion force and rotational one in rotational plane of blades.



(a) Propulsion and lift force

(b) Force in rotational plane

Figure 1: *The schematic of propulsion force in a blade of helicopter.*

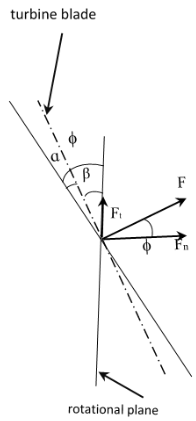


Figure 2: *The schematic of force and speed in turbine blade of helicopter.*

Meantime the force and speed relation is as seen in Figure 2. F is force, N; ϕ is angle $\alpha+\beta$, º; α is angle of attack, º; β is pitch angle, º.

Mass center M_c's orbit equation is

$$x^2+y^2=r^2 \quad (1)$$

Here it has

$$\begin{cases} x=r\cos\theta \\ y=r\sin\theta \end{cases} \quad (2)$$

It has been derived, it is

$$\begin{cases} \dot{x}=-r\dot{\theta}\sin\theta \\ \dot{y}=r\dot{\theta}\cos\theta \end{cases} \quad (3)$$

It has been secondly derived, it has

$$\begin{cases} \ddot{x}=-r\ddot{\theta}\sin\theta-r\dot{\theta}^2\cos\theta \\ \ddot{y}=r\ddot{\theta}\cos\theta-r\dot{\theta}^2\sin\theta \end{cases} \quad (3)$$

Since

$$a_M=\sqrt{\ddot{x}^2+\ddot{y}^2} \quad (4)$$

It has

$$a_M=\frac{\pi nr}{30}\sqrt{\frac{1}{t^2}+\left(\frac{\pi n}{30}\right)^2} \quad (5)$$

Here $\dot{\theta}=\frac{\pi n}{30}$ (6) and $\ddot{\theta}=\frac{\pi n}{30t}$ (7)

$$\begin{cases} \sin\theta_1=F_1/N_1 \\ \dots \\ \sin\theta_n=F_n/N_n \end{cases} \quad (8)$$

$$\begin{cases} N_1=F_{i1}\sin\phi \\ \dots \\ N_n=F_{in}\sin\phi \end{cases} \quad (9)$$

$$F_p=F_1+\dots+F_n=(F_{i1}+\dots+F_{in})tg\theta\cdot\sin\phi \quad (10)$$

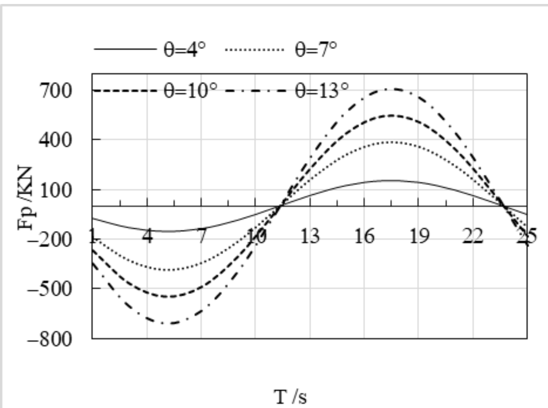
So it is $v_p=(F_1+\dots+F_n)t/m$ (11)

Here r is the radius of blade, m; n is the rotation, r/m; am is center of mass in blade, m/s^2; θ is inclination, º; ϕ is angle $\alpha+\beta$, º; v_p is the speed of helicopter， m/s^2; t is the time, s; m is the mass, Kg.

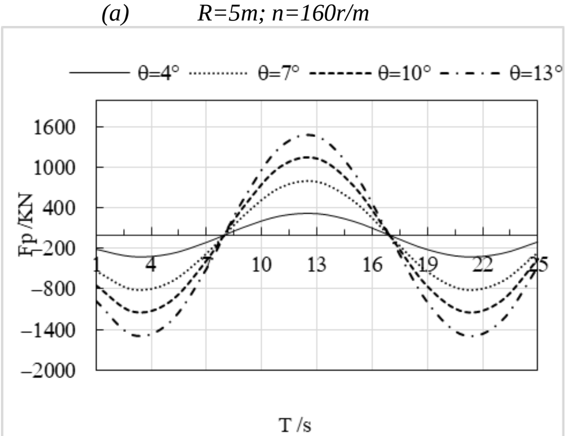
Discussions

The propulsion and time is investigated as below with different constants. It is used three conditions of rotation, angle f and blade radius as correspond parameters to simulate and compute for helicopter's blade. It gains three groups of value to estimate theses. In this paper all the relational parameters have been calculated on the helicopter and its blades. It is tried out that finding intrinsic relationships happens in helicopter flight in order to simulate the data changing conditions. The propulsion force and time is searched here according to different rotation、angle f & blade radius in helicopter while the speed and time is in research of the rotation of blade and mass of helicopter with different inclinations. The main task has grasped the force and propulsion speed with the time. The other parameters like blade rotation、angle f、blade radius r & inclination q are used to proceed as well. The detail is shown as below. As seen in Figure 3(a~d) the relationship between propulsion force and time has been exhibited with different q when the blade radius R and rotation n is different under 11tons of helicopter. The maximum propulsion is 1,500kN and its general change is 200kN with n=220r/m and R=5.7m in Figure 3(a) and with n=220r/m and R=6.7m in Figure 3(b) respectively. The propulsion with 1,000kN and 700kN has been formed with 180r/m and R=6.0m & 160r/m and R=5m in Figure 2(c &a) respectively.

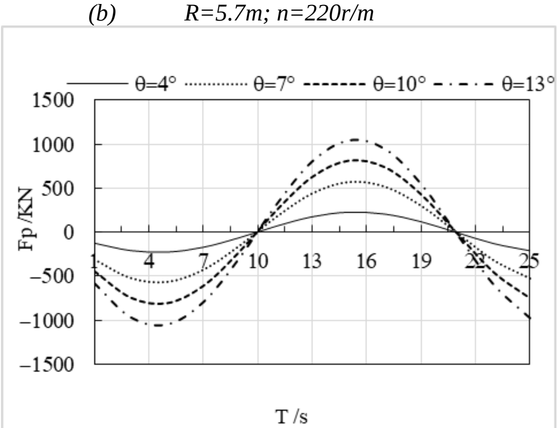
It expresses that with increasing rotation and blade radius may raise the propulsion both. Meantime the former is first factor and the latter is second facor to affect the propulsion according to data and formula. It fits to the logic well. In other words, the whole decreasing change has become about 200kN~250kN with decreasing inclination q from 13º、10º、7º to 4º. It means that increasing inclination will increase the propulsion force as well. It fits to the logic too. With increasing blade radius R from 5m、5.7m、6m to 6.7m the propulsion force will increase proportionally. The periodical time of propulsion is from 12s and then 11s、10s to 8s with different conditions of rotation speed from 160r/m, 180r/m, 200r/m to 220r/m respectively. It corresponds to the logic well.



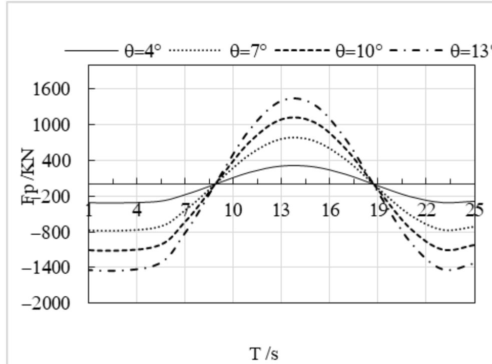
(a) R=5m; n=160r/m



(b) R=5.7m; n=220r/m



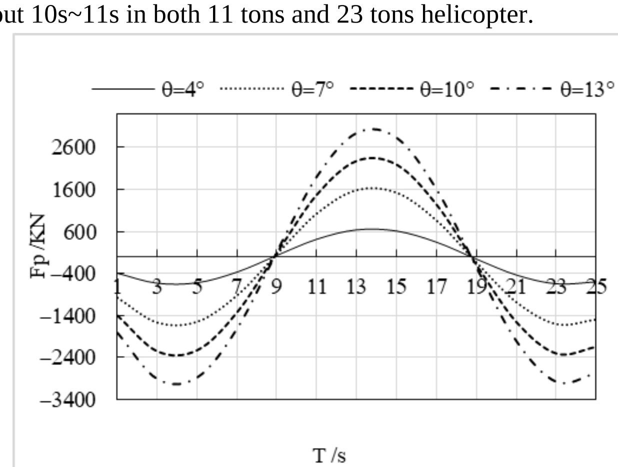
(c) R=6.0m; n=180r/m



(d) R=6.7m; n=200r/m

Figure 3: *The propulsion force and time with different q when the blade radius and rotation is different under 11tons of helicopter.*

As seen in Figure 4(a~c) it is shown that the relation of propulsion force and time changes with different q when the blade radius R and rotation n is different under 23tons of helicopter. The maximum propulsion force is 3,000kN at R=6.7m and n=200r/m in Figure 4(a) while its periodical time is minimum with 11s because of its rotation with 200r/m. It expresses that the rotational movement will result in the certain periodicity. It has fit to the logic well. On the other side, the other has been 2,600kN and 2,000kN with the rotation 200r/m and 180r/m respectively according to the declination value as seen in Figure 4(b &c). The average propulsion change has been 500kN when inclination changes from 13º、10º、7º to 4º commonly as seen in Figure 4(a~c). It means that increasing inclination will increase the propulsion force as well. It corresponds to the logic too. To compare with 11 tons in 23 tons helicopter the propulsion has been bigger about 2 times. The inclination effect to propulsion has been bigger 2 times than Figure 2 with 11 tons in Figure 3 with 23 tons helicopter. It corresponds to logic very well. The periodical time is maintaining certain value about 10s~11s in both 11 tons and 23 tons helicopter.



(a) R=6.7m; n=200r/m

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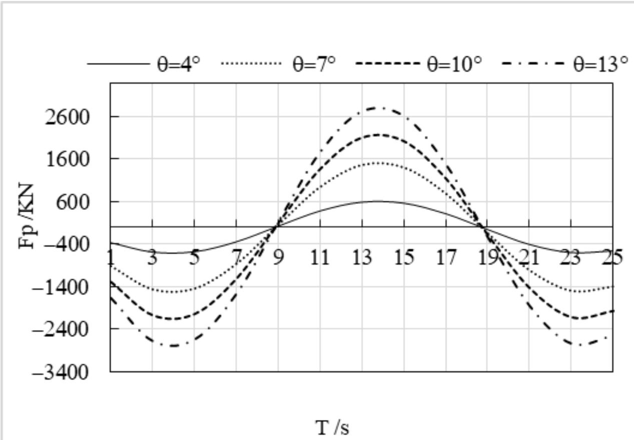
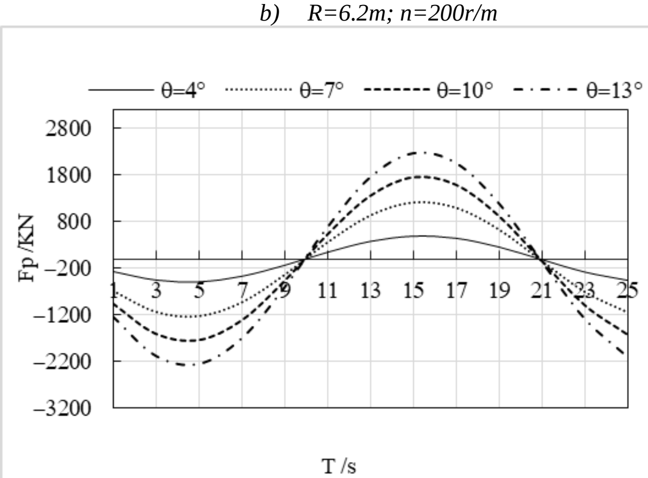


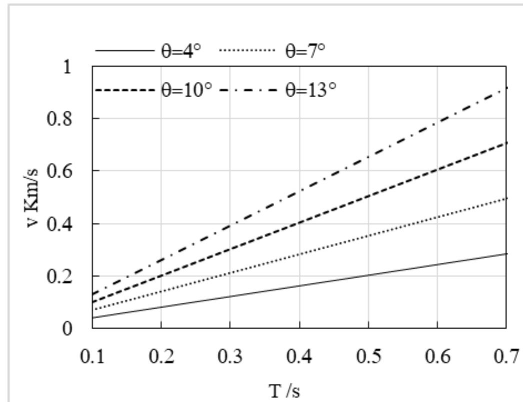
b) R=6.2m; n=200r/m



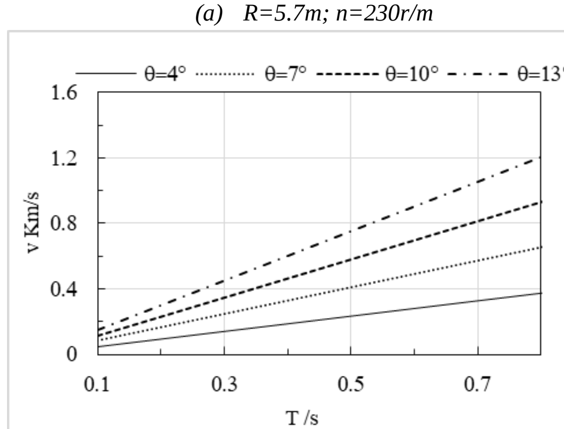
c) R=6.2m; n=180r/m

***Figure 4:** The propulsion force and time with different θ when the blade radius and rotation is different under 23tons of helicopter.*

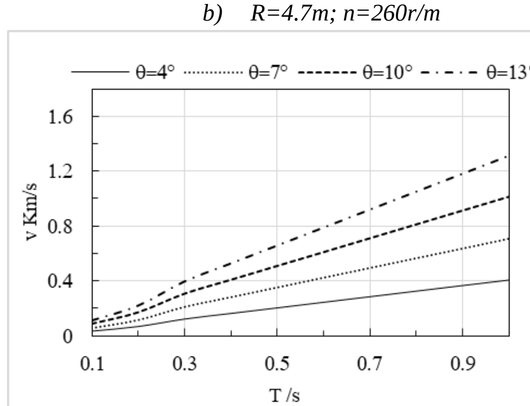
As seen in Figure 5(a~d) it is shown that the relation of the speed and time changes with different q when blade radius R and rotation n under ϕ=40° in helicopter. The maximum propulsion speed is 450m/s with 260r/m in Figure 5(b). The other is 400m/s、400m/s and 300m/s with different rotational speed 230r/m, 200r/m and 220r/m and radius 5.7m, 5.7m and 4.7m in Figure (a、c &d) respectively at the moment of 0.3s. Here the rotational speed is main factor to compare with blade radius. Both of them are effective to propulsion speed found in this study. The average change of propulsion speed is about 100m/s with conditions of inclination from 13º, 10º, and 7 º to 4º as seen in Figure 5(a、b、c &d) at the place of 3s. With passing time the propulsion speed will increase. It is also the rotational speed to be first factor and then the radius. So it is known that the decreasing inclination from 13º, 10º, and 7 º to 4º has decreased the propulsion speed too as mentioned above. On the other side, the angle ϕ is another factor to consider because of its certain value defined here. If the angle ϕ is changed the results exhibition will be dominant as well which is considered here. The rotational speed is low in this study because it has heavy mass 11 tons which is big loaded flight. If the light mass is adopted the rotational speed will increase according to our determination. So the mass of flight is main parameter to evaluate its swift and mobile property. We need to choose fit mass to design their property not beyond its limited value which can affect its property on the contrary if we randomly design big and heavy one. Sometimes its cost will dramatically increase which produces large waste money. If it's manufacturing cost and property will be thought firstly then do design that is good one. As the blade radius increases from 4.7m, 5m, 6m to 6.7m the propulsion speed will enhance proportionally according to the formula. So we shall use the big radius to promote its speed here.



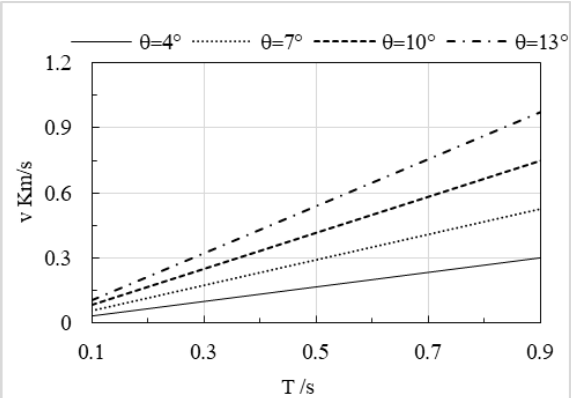
(a) R=5.7m; n=230r/m



b) R=4.7m; n=260r/m



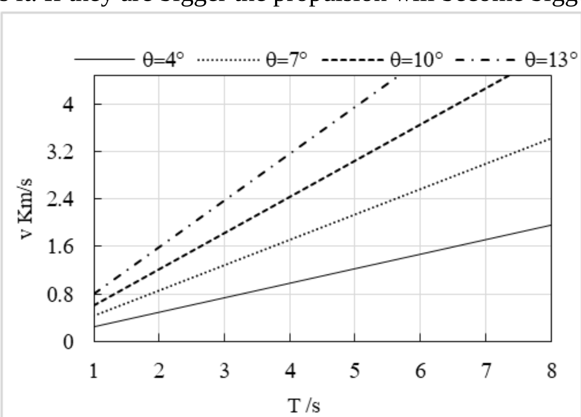
c) R=5.7m; n=200r/m



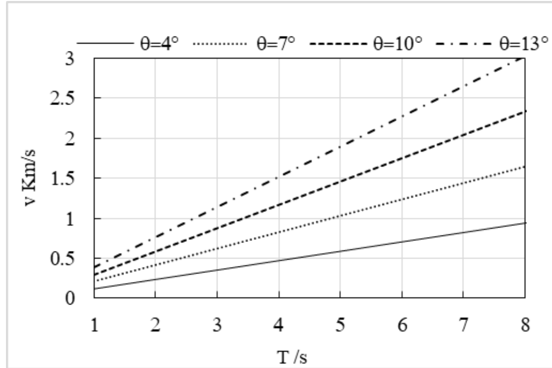
d) R=4.7m; n=220r/m

Figure 5: *The speed and time with different θ when blade radius and rotation under ϕ=40°.*

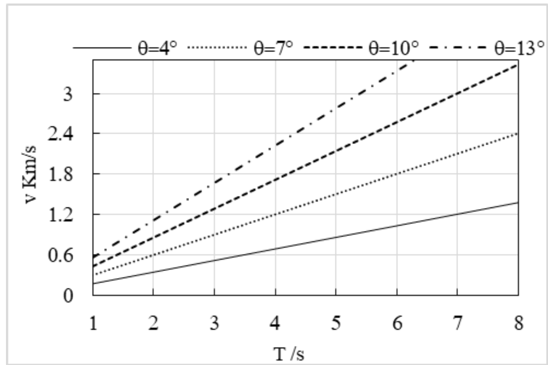
At the same time if the inclination maintains a certain value the propulsion will become bigger so it will last for no longer than maximum time as seen in Figure 3(a~d) &4(a~c). That means we can't maintain beyond ten seconds because of its high propulsion speed like inclination 13º whose limited speed is supposed 800km/h to be 288m/s that means the maximum time is about 0.2s like as seen in Figure 6(a). Thereby when the small inclination like 4º has been used the time has been 0.8s in the same figure at R=5.7m and n=230r/m. In Figure 6(a~c) the speed and time changes with different θ when blade radius R and rotation n under ϕ=30°. The propulsion speed has been 2,500m/s, 1,700m/s and 1,200m/s with the R=6.7m & n=400r/m, R=4.7m &400r/m and R=5.7m &300r/m respectively in Figure 6(a, b &c). The big difference happens to here. It is because the rotation and radius affects it. If they are bigger the propulsion will become bigger too.



(a) R=6.7m; n=400r/m



b) R=5.7m; n=300r/m



c) R=4.7m; n=400r/m

Figure 6: *The speed and time with different q when blade radius R and rotation n under ϕ=30°.*

If it is compared to ϕ=30° in ϕ=40° it has smaller propulsion speed with bigger rotation in helicopter. The main factor is the big rotation and then the small angle ϕ. The rapid rotational speed causes the high propulsion speed and the small angle does the same. Then the blade radius affects the speed finally. It says that the long blade radius will cause the big propulsion speed. Thereby all the parameters like rotation、angle、propulsion speed、propulsion force and blade radius will wield their roles on the propulsion property in helicopter.

Conclusions

As for the modeling between propulsion force and speed their relationship has been built in this paper. With regard to different parameters it is found that the rotational speed is first factor to affect them and then the blade radius is the second factor to do. Therefore the right parameters is important in optimized design at helicopter turbine blades. The mass is one factor to influence the propulsion force mainly. So the big mass results in high propulsion and force change. On the other hand, low angle ϕ causes the high rotational speed. With increasing the inclination the big propulsion force and speed has been attained in helicopter. With increasing blade radius R from 5m to 6.7m the propulsion force and speed will increase. The rapid rotational speed causes the high propulsion speed and the small angle does the same. Then the blade radius affects the speed finally. It says that the long blade radius will cause the big propulsion speed.

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