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Modelling Between Propulsion Force, Speed and Blade Inclination, Radius and Rotation Parameters with Five Blades in Helicopter I

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Abstract

The modelling between propulsion force and speed has been built in this paper. With respect 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 rotational speed which affect the propulsion force at last. Thereby the big mass results in low rotational speed and high propulsion force and speed. On the other hand, the high rotational speed cause high propulsion 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 will increase.

Keywords: Propulsion modelling; Helicopter; Inclination; Angle ϕ; Blade radius; Propulsion speed; Time; rotational speed; Mass of helicopter.

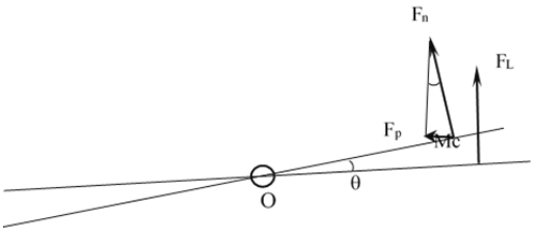
Introduction

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 propulsion speed which is important simulation. It is known that the force will incline the propulsion speed according to Newton mechanics. So the high rotation will be searched forwards because of its effectiveness to the high speed. The propulsion one determines the speed directly [1-21]. 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 and rotation speed & inclination. So as to incline the load and speed it is investigated three directions in this paper i.e. rotation, angle ϕ and radius. Through comparing with each other the advantage is searched in this study to further investigate later. On the other side, the speed of helicopter is also important one for us to search forwards in this paper because it is significant property to evaluate its function. The speed is a key factor to complete its task rapidly so here the detail situation is discussed to modelling its function. Overview, the propulsion force and speed of helicopter is important factor so its effect is needed to search in detail. The effective turn is concluded in total according to this model. In this paper the acceleration is computed in terms of theoretic dynamics to be used in this research. It is supposed that five blades exist in helicopter upper. The propulsion force is main factor to be considered because of its neglect role. The propulsion speed is another factor to model for finding the relation of them. That 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 center; θ is inclination, °; F_L is lift force, N; F_t is rotational force, N; F_n is normal force, N; F_p is propulsion force, N; M_c is the mass center. The model equation has been deduced as below. Here angle

$\phi = \alpha + \beta$ when the wind speed is small. Figure 2 shows the relationship between the propulsion force and rotational one in rotational plane of blades.



(a) Propulsion force

(b) Force in rotational plane

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

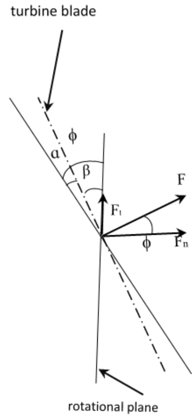


Figure 2: *The schematic of force and speed in turbine blade of helicopter.*

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. It is supposed that it has five blades in helicopter.

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

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

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

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

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

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

So it has

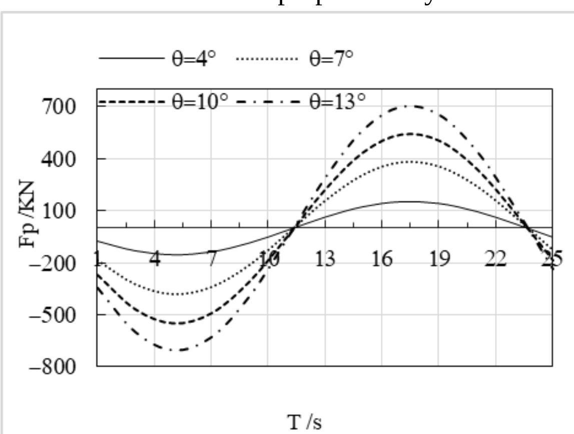
$$a_p = \frac{\pi n r}{30}\sqrt{\frac{1}{t^2} + \left(\frac{\pi n}{30}\right)^2} \cdot \text{tg}\,\theta \cdot \sin\phi \quad (11)$$

So it has $v_h = (F_1 + \ldots + F_n)t / m$ (12)

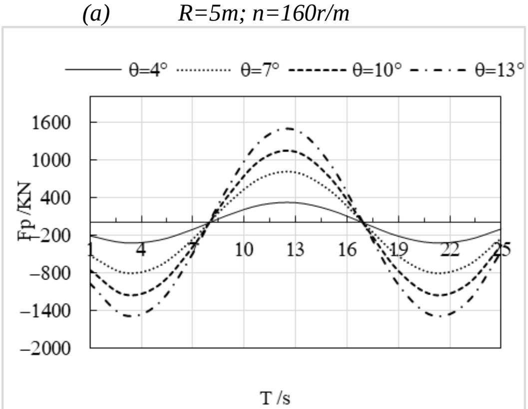
Here r is the radius of blade, m; n is the rotation, r/m; am is center of mass in blade, m/s^2; θ is inclination, º; ϕ is angle $\alpha+\beta$, º; v_p is the speed of helicopter, m/s^2; am is the circular acceleration, m/s^2; a_p is the propulsion acceleration, m/s^2; t is the time, s; m is the mass, Kg. Here it is supposed that the a_M is equal to a_N.

Discussions

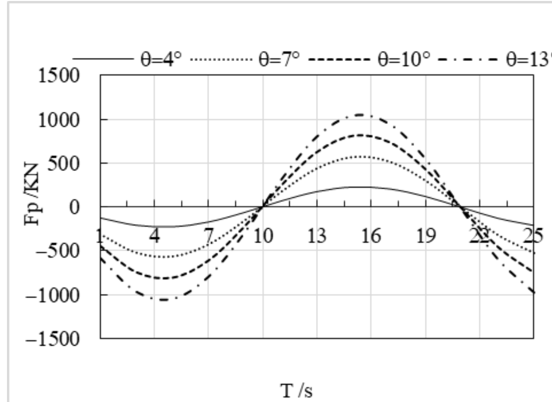
The propulsion and time is investigated as below with different constants. It is used three conditions of the rotation, angle ϕ and blade radius as correspond parameters to simulate for five helicopter's blades. It gains three groups of value to estimate theses. In this paper all the relational parameters 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 ϕ & 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 the blade rotation, angle ϕ, blade radius r & inclination θ are used to proceed as well. The detail is shown as below. As seen in Figure 2(a~d) it is shown that the relation of propulsion force and time changes with different θ when the blade radius R and rotation n is different under 11tons of helicopter. The maximum propulsion force is 1500kN i.e. 150 tons at R=5.7m and n=220r/m in Figure 2(b) while its periodical time is minimum with 9s because of its high rotation with 220r/m. It expresses that the high rotational movement will result in the short periodicity. It has fit to the logic well. The other has been 1400kN, 1000kN and 700kN with the rotation 200r/m, 180r/m and 160r/m respectively according to the declination value as seen in Figure 2(a, c&d). The whole decreasing change has become about 200kN~300kN with decreasing inclination θ 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.



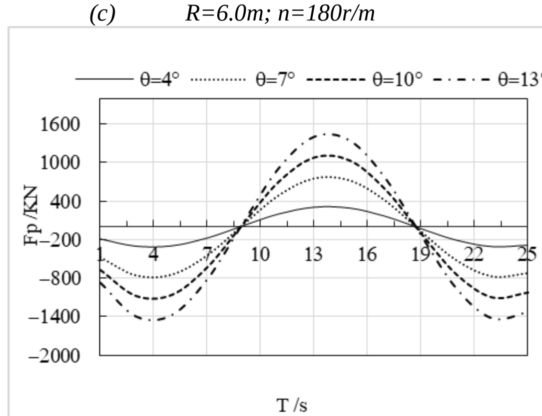
(a) R=5m; n=160r/m



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



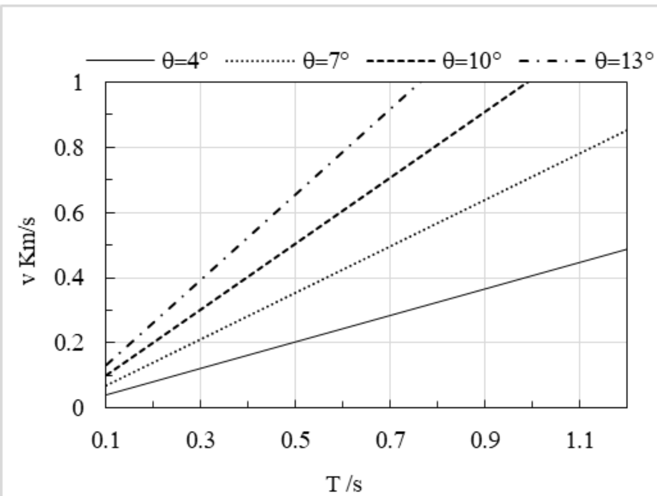
(c) R=6.0m; n=180r/m



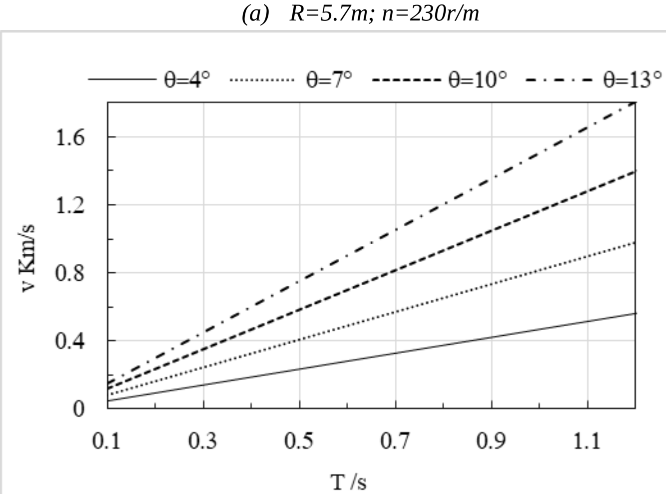
(d) R=6.7m; n=200r/m

Figure 2: *The propulsion force and time with different θ when the blade radius and rotation is different under 11tons of helicopter.*

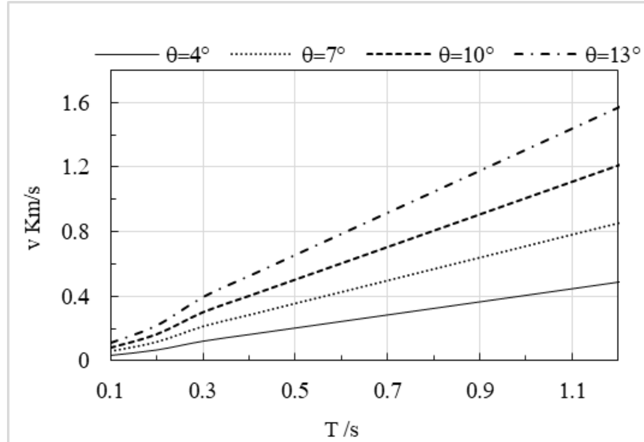
As seen in Figure 3(a~d) it is shown that the relation of the speed and time changes with different θ when blade radius and rotation n under ϕ=40° in helicopter. The maximum propulsion speed is 800m/s with 260r/m in Figure 3(b). The other is 650m/s, 600m/s and 570m/s with different rotational speed 230r/m, 220r/m and 200r/m respectively and radius in Figure(a, c &d). 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 maximum average change of propulsion speed is 500m/s and then 200m/s, 150m/s & 100m/s with different conditions of inclination from 13º. 10º, 7º to 4º respectively as seen in Figure 3(a, c &d) at the place of 0.5s. 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. 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). That means we can't maintain beyond several 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 as seen in Figure 3(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.



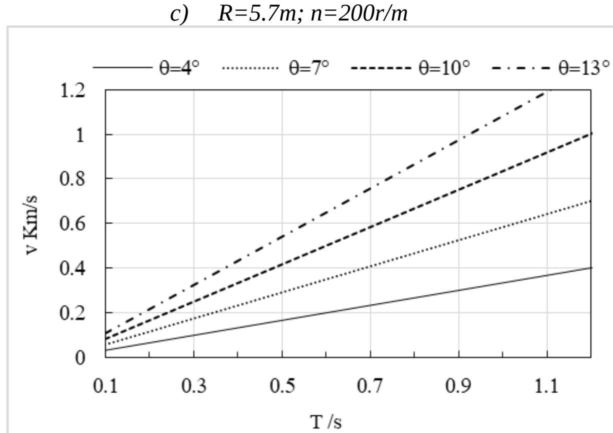
(a) R=5.7m; n=230r/m



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



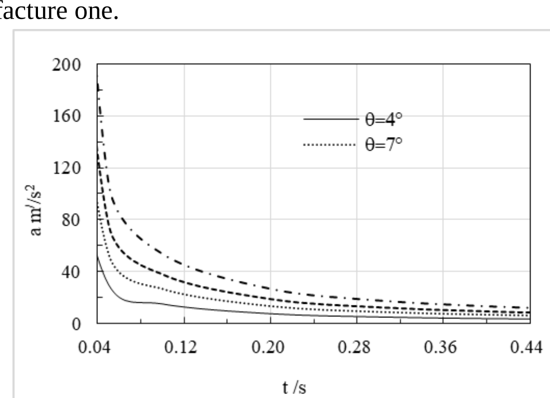
c) R=5.7m; n=200r/m



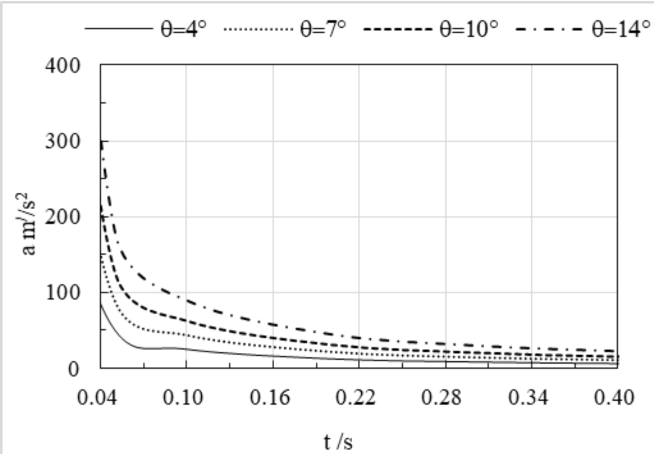
d) R=4.7m; n=220r/m

Figure 4: *The speed and time with different q when blade radius R and rotation n under ϕ=40°.*

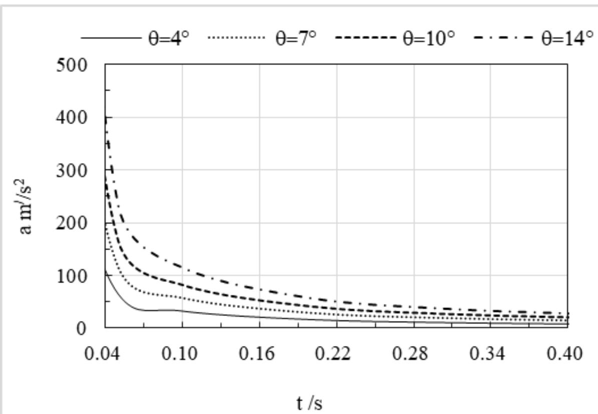
On the other hand, the cost control will be necessary and important mostly so we combine the parameters to manufacture cost for the sake of decreasing it which is essential and core in the end. That is the wisdom and task for our engineers and technicians to do in the manufacture course. We shall not waste materials、transportation & manufacture process too. Decreasing manufacture cost and increasing production quantity will be under control for guaranteeing quality and quantity from initial design process to manufacture one.



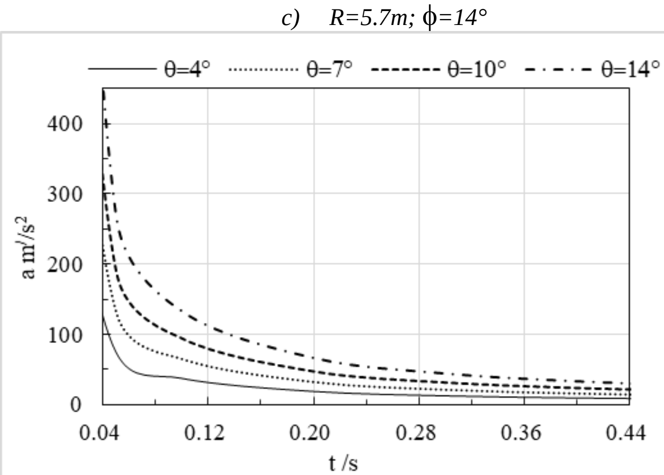
(a) R=6.7m; ϕ=60



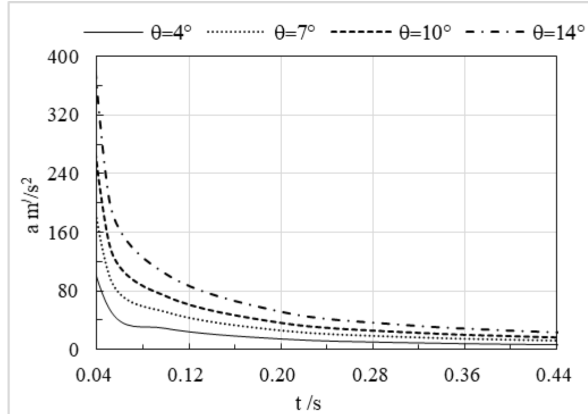
b) R=6.7m; ϕ=10°



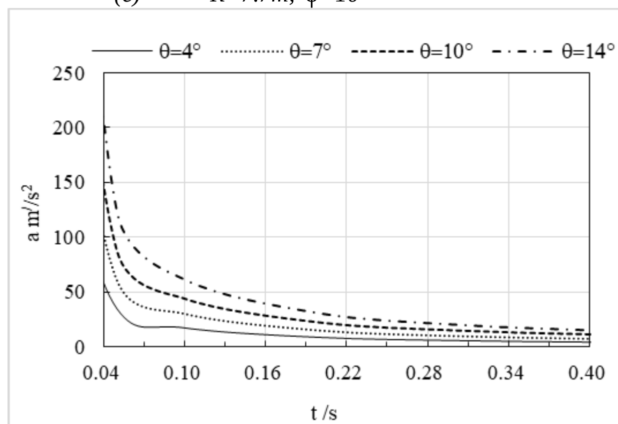
c) R=5.7m; ϕ=14°



d) R=7.7m; ϕ=14°



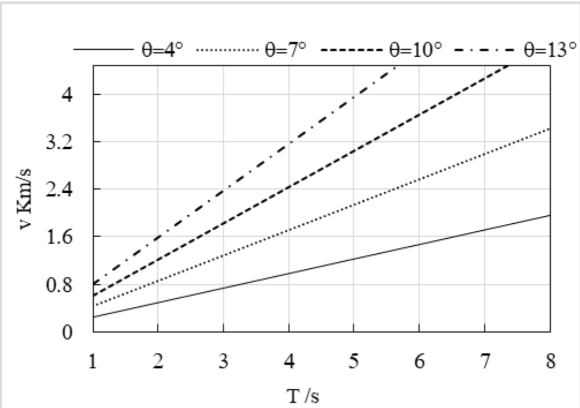
(e) R=7.7m; ϕ=10°



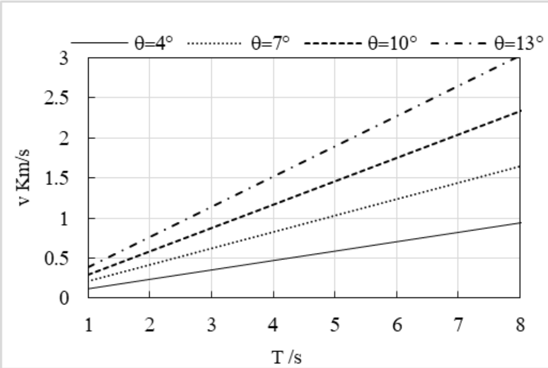
(f) R=7.7m; ϕ=6°

Figure 5: *The propulsion speed and time with different q when blade radius R=6.7m~7.7m and rotation n=420r/m under ϕ=6°~14°.*

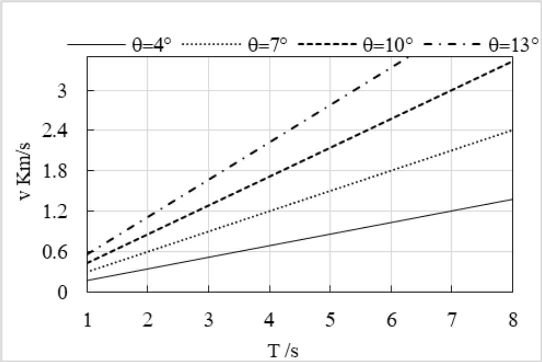
In Figure 4(a) the acceleration has decreased with time while it is bigger with raising inclination θ as parameters is radius R=6.7m, rotation speed n=420r/m and angle ϕ=6°. The acceleration changes from 160m/s^2 to 16m/s^2 with time from 0.04s to 0.4s at the inclination θ=14°. It has decreased from 70 m/s^2, 50m/s^2, 35m/s^2 to 20m/s^2 as the inclination reduced from 4°, 7°, 10° and 14° at the moment 0.08s. As seen in Figure 4(a~f) the acceleration will decrease with decreasing the angle ϕ meanwhile it will increase about 40m/s^2 with increasing radius from 6.7m to 7.7m in one helicopter. In short the rotational speed will affect the propulsion force and speed firstly that is the main factor to consider. Then the second parameter is blade radius which may affect them too. Therefore whether they can be chosen right is the optimized design. On the other side, the angle ϕ is another factor to consider because of its certain value supposed here. If the angle f is changed the results exhibition will be dominant too. According to increasing the blade radius R the propulsion speed and force will increase too. So if the big helicopter is to be built the big radius and rotation will be necessary. In addition to, the big mass and angle should be adopted for helicopter design. Certainly that the detail data and curve is checked to observe the optimum parameter is important like sophisticated parameters combination. It is corrective method to confirm and design task for us to do. Therein the total parameters is needed to consider and design optimum the blade in helicopter that can enhance load its burden and promote the mobility. That is the final destination in this study. It is found that regulating the detail parameters like speed, force and rotation etc. can acquire optimum property applied to helicopter.



(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

The relationship between propulsion force and speed has been searched in this paper. With 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. Thereby the right parameters is important in optimized design at helicopter turbine blades. The mass is one factor to influence the rotational speed which affect the propulsion force at last. So the big mass results in low rotational speed and high propulsion force and speed. On the other side the high rotational speed cause high propulsion speed. With increasing the inclination the big propulsion force and speed has been attained in helicopter. With increasing blade radius from 5m, 5.7m, 6m to 6.7m the propulsion speed will increase proportionally. With increasing blade radius from 6.7m to 7.7m the acceleration will increase about 40m/s^2.

References

1. Wensheng W. Kinematics analysis of blade length mechanism of internal combustion engine for vehicle. Internal Combustion Engine Accessories. 2019; 5: 72.
2. Liu S, Zhou L. The internal combustion Engine to Learn. China Machine Press. 2017; 115-116.
3. Xu R. The relationship of properties with variable mass of block on crank linkage mechanism in multibody system. SunText Review Material Sci. 2021; 105.
4. Chen K. Helicopter structure and systems. Tsinghua University Press. 2020; 4.
5. Xingjia Y. Principle and Application of Wind Turbines. China Machine Press. 2020; 42
6. Xu R, Hur B. A simulation between torque and angle with speed on five freedoms of robot mechanical arm in multibody systems. Saudi J Civil Engg. 2021; 5: 91-93.
7. Xu R. The relationship between force and time with lagrange equation by regul ating piston mass on crankshaft of vehicle. Saudi J Engg Technology. 2021; 6: 73-76.
8. Xu R, Liu J. The kinematics model establishment of crank and linkage with time under low speed in vehicle. Saudi J Engg Technology. 2021; 6: 67-72.
9. Zhihao Y. Calculation and analysis of rotor structure vibration load based on fluid-structure coupling. J Vibration Engg. 2020; 33: 285-293.
10. Guopu S, Pusun C, Xiaotian C. Load analysis of rotor hub in helicopter sling flight. Helicopter Technol. 2021; 25-31.
11. Weizhong G, Baolong G, Hao C. Research on dynamic bending moment measurement of blade

based on optical fiber sensing technology. Integrated Circuit Applications. 2020; 37: 18-20.
12. Mingjie C. Research on distributed optical fiber intelligent monitoring technology for helicopter rotor blade bending moment and deformation. Nanjing: Nanjing University of Aeronautics Astronautics. 2019.
13. Guangxin C, Yong Z. Analysis on the development trend of high speed helicopter. J Anhui University Technol. 2019; 8.
14. Jun Y, Hui Z. Study on the Statistical Method of Helicopter Index. J Anhui University Sci Technol. 2019.
15. Baocheng Y, Weihong Z, Zhe W, Jianzheng H, Kuixing D, Lixing Z, et al. Study on the Sleep Quality of Helicopter Pilots. J Anhui University Technology. 2007.
16. Xu R, Hur B. The Relationship between force and time with lagrange equation by regulating piston mass on crankshaft of vehicle. Saudi J Engg Technol. 2021; 6: 73-76.
17. Mingming L, Bingkun L, Qiang D. Measurement Method of Helicopter Rotor Blade Load. Electronic Technol Software Engg. 2022; 97-99.
18. Zixian S, Dong H, Zhao C. Helicopter rotor blade model based on sensitivity analysis Correction method. J Aerospace Power. 2023.
19. Kaiyin Z, Can X, Bin Z, Wen F. Sensitivity analysis based on design parameters. J Wuhan University of Technology. 2021; 45: 1128-1132.
20. Nelson RB. Simplified calculation of eigenvector derivatives. Asia J. 2015; 24: 823-832.
21. Miao Z. Research on model correction method based on modal parameter sensitivity. Changchun J Institute Engg. 2019; 20: 118-125.