International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 4 [April. 2023] PP: 01-10

The Modeling between Propulsion Force & Speed and Blade Rotation, Radius & Inclination in Helicopter

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Abstract: *As the blade inclination increases the propulsion speed and force has increased, which has been proven through modeling in this study. With increasing the inclination the propulsion will increase, while increasing the time it will maintain a constant. At different rotation of 220 r/m, 270r/m and 320 r/m the force will increase at the high later. At high angle ϕsuch as 50º propulsion will decrease. The effect turn is n (rotation) >ϕ (angle α+β) >r (blade radius). The speed of helicopter will incline when the rotation and the inclination increase respectively. Meantime the speed will decline when the mass of helicopter increases from 11tons to 38tons. That's saying the speed per time incline steeply in the former which is caused by light weight. It has been controlled through inclination、rotation and mass too.*

Keywords: *Propulsion modeling; vertex axis blade; helicopter; inclination; angleϕ; radius; speed and time; rotation; mass*

Date of Submission: 18-03-2023 Date of acceptance: 03-04-2023

I. 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. [1~5] 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 ϕ 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 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 modeling is our destination finally.

II. Modeling and equation

In the schematic graphy as Figure 1 O is blade center; θ is inclination; F_L is lift force; N_n is normal force; F_n is level force; M_c is the mass center. The model equation has been deduced as below.

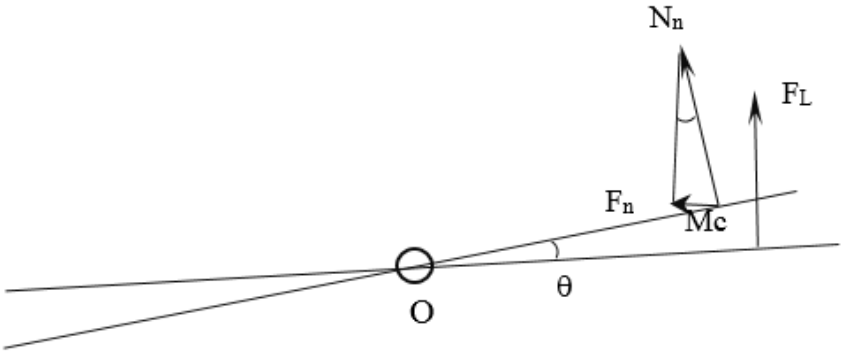


Figure 1 The schematic of propulsion and lift force in blade.

Mass center M_c*'s* orbit equation is

$x^2 + y^2 = r^2$ (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

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

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

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

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

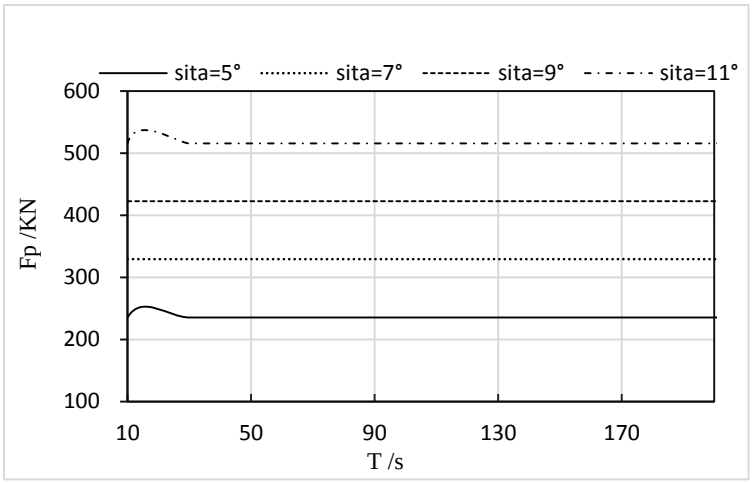
So it has $v_h = (F_1 + \ldots + F_n)t/m$ (11)

Here r is the radius of blade, m; n is the rotation, r/m; am is center of mass in blade, m/s^2; F_p is propulsion, N; F_n is the nth propulsion, N; N is the pressure wind speed, N; F_{in} is the produced natural wind speed, N; θ is inclination, º; ϕ is angle $\alpha+\beta$, º; v_h is the speed of helicopter， m/s^2; t is the time, s; m is the mass, Kg.

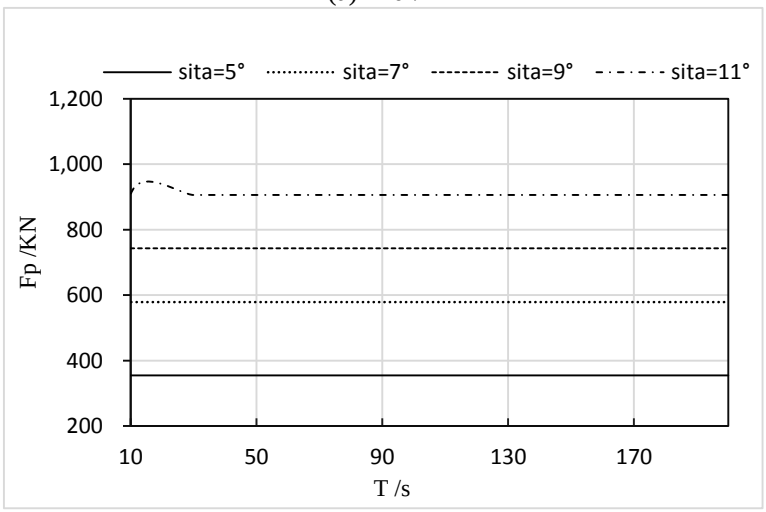
III. Discussions

The propulsion and time is investigated as below with different constants. It is used three conditions of rotation, angle ϕ 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.

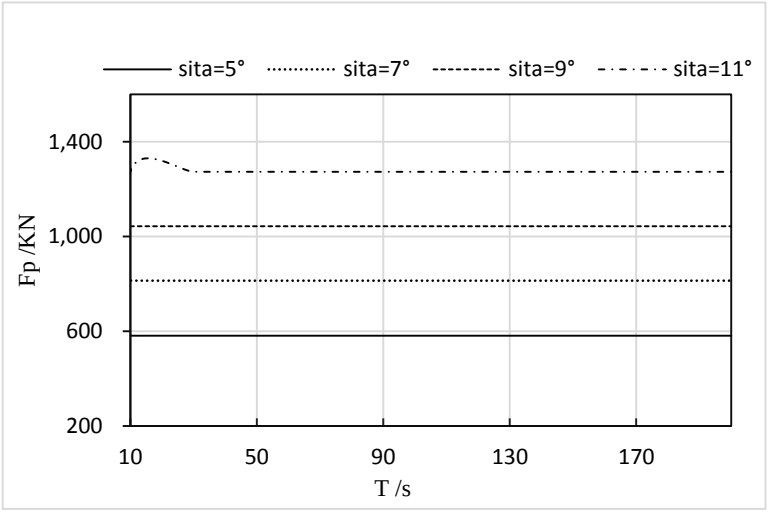
The propulsion force and time is searched here according to different rotation、angle ϕ & blade radius in helicopter while the speed and time is in research of the rotation of blade and mass of helicopter with different inclinations. The main task has grasped the force and propulsion speed with the time. The other parameters like blade rotation、angle ϕ、blade radius r & inclination θ are used to proceed as well. The detail is shown as below.



(a) 220r/m



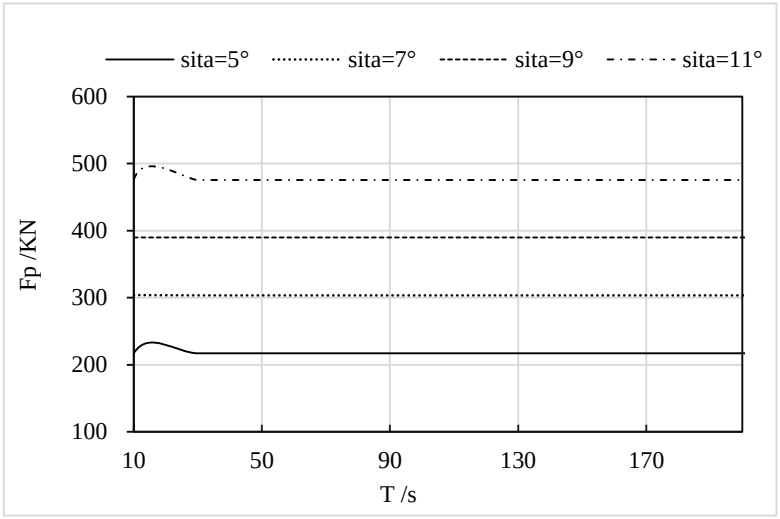
(b) 270r/m



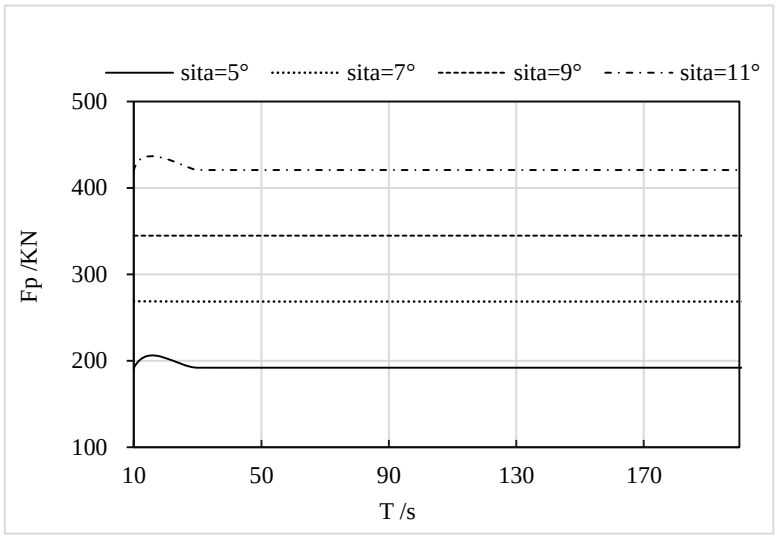
(c) 320r/m

Figure 2 The relation in force of push and time with different dip angle at different rotation at 20º of angle ϕ in helicopter turbine blade.

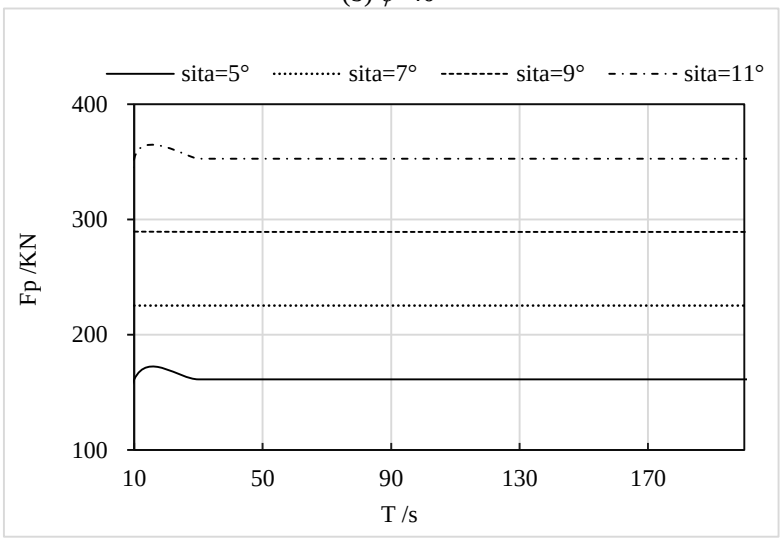
As seen in Figure 2 it is better that increasing inclination and rotation to raise propulsion. The maximum propulsion attains 120 tons at 11º of inclination at 320r/m. Then 95 tons and 52 tons is attained as blade rotation attains 270 r/m and 220 r/m respectively while decreasing θ causes the propulsion force decreases too. The propulsion force change is 100kN~200kN when the θ changes 5°~7° at 20º of angle ϕ. With increasing time the propulsion force will maintain a certain value.



(a) ϕ=30º



(b) ϕ=40º

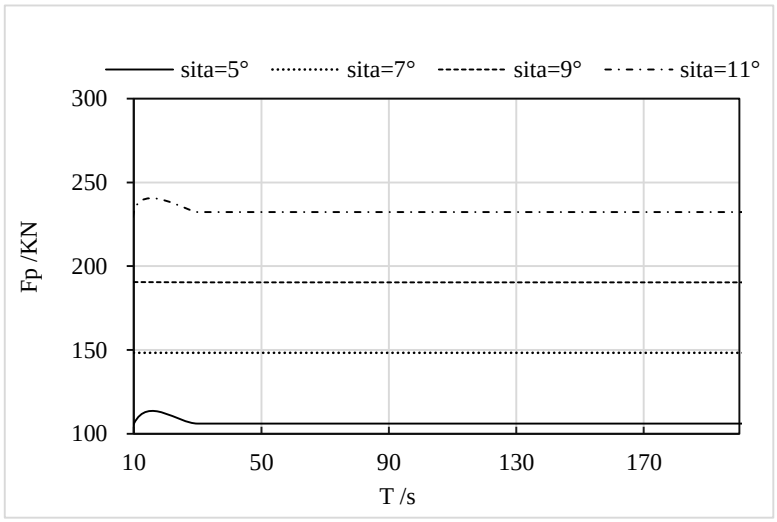


(c) ϕ=50º

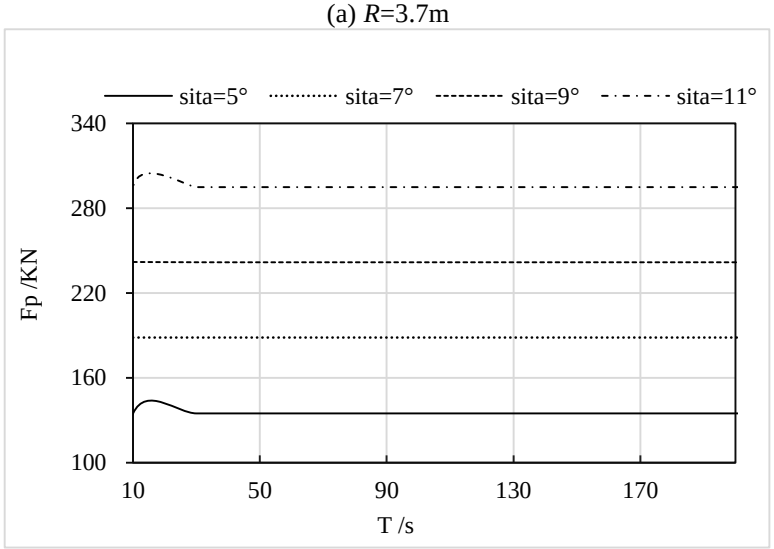
Figure 3 The relation in force of push and time with different angle ϕ at 220 r/m of rotation in helicopter turbine blade.

In Figure 3 with the increasing inclination propulsion will increase, meantime with the declining angle ϕ it will incline. It is noted that it is not better to adopt big angle ϕ for promote propulsion, on the contrary it is better to use less angle ϕ.

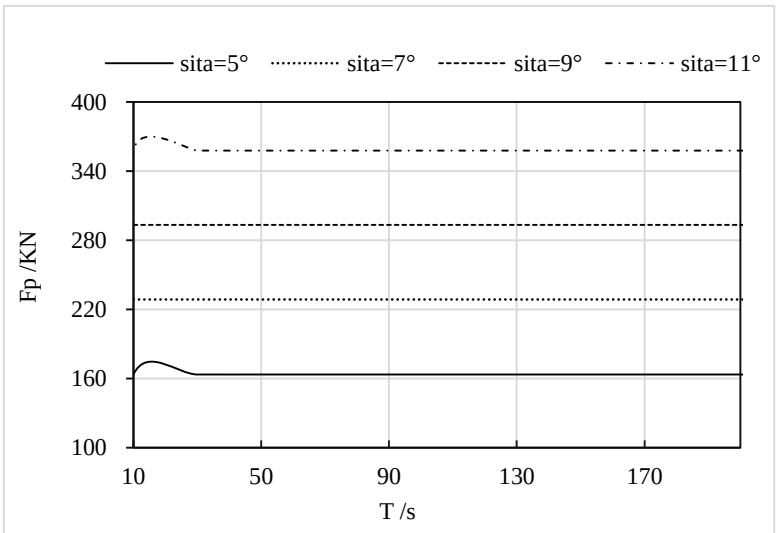
The maximum propulsion force is 48 tons、42 tons & 36 tons with the angle ϕ to be 30°、40° & 50° at blade rotation 220 r/m. The propulsion force change is 80kN with the angle θ to be 5°~7°. There is evident difference with the adjacent angle θ. The whole propulsion force will maintain a certain one with increasing time from 10s to 200s.



(a) *R*=3.7m



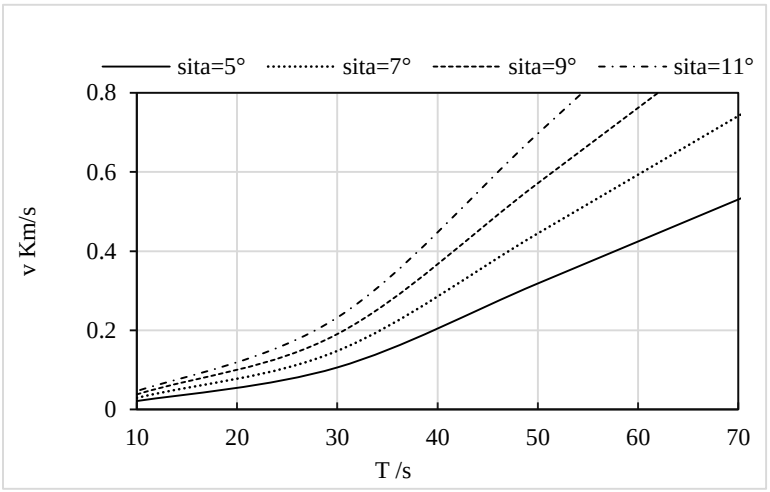
(b) *R*=4.7m



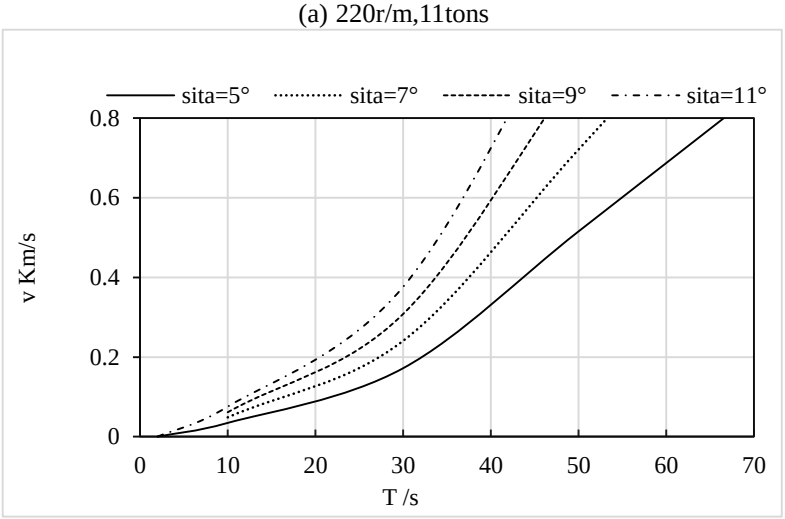
(c) *R*=5.7m

Figure 4 The relation in force of push and time with different radius、ϕ= 40º & inclination at 220r/m of rotation in helicopter turbine blade.

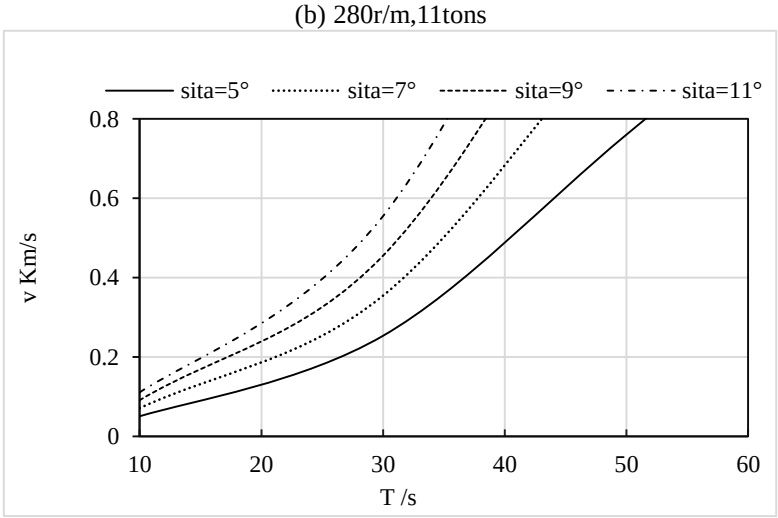
As seen in Figure 4 the propulsion will increase when the radius increases in the ϕ=40º. Meantime when the inclination increases the force will increase as well. The force attains 367kN=36.7tons at θ=11º and R=5.7m as seen in Figure 4(c). Since the rotation is constant the force will maintain a certain value with time increasing. Here it is used 170kg as a blade mass and 5 blades so the value has been bigger. As seen in Figure 4(a) the lowest one is about 100kN at R=3.7m which is equal to 10tons helicopter. It means that with increasing blade radius to be R=5.7m the propulsion force will increase to the maximum 36 tons at angle θ to be 11°. The whole propulsion will maintain a certain value with increasing time from 10s to 200s.



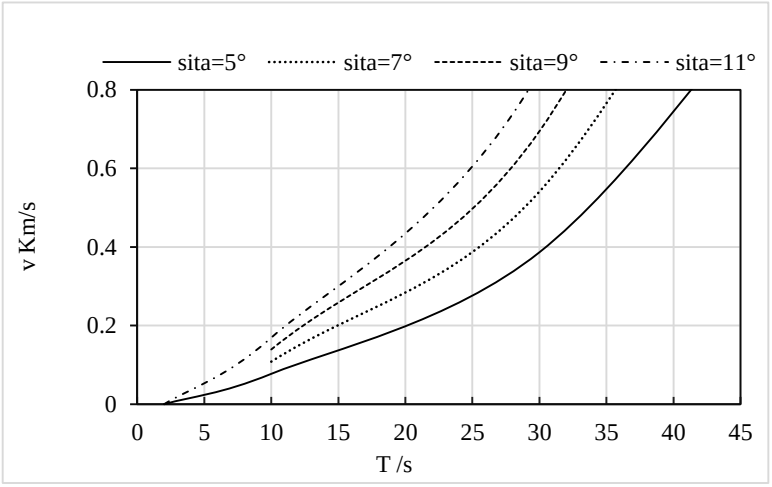
(a) 220r/m,11tons



(b) 280r/m,11tons

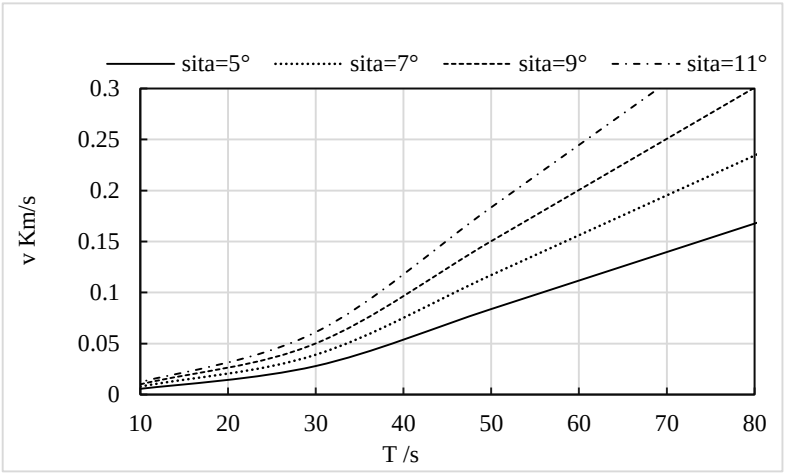


(c) 340r/m,11tons

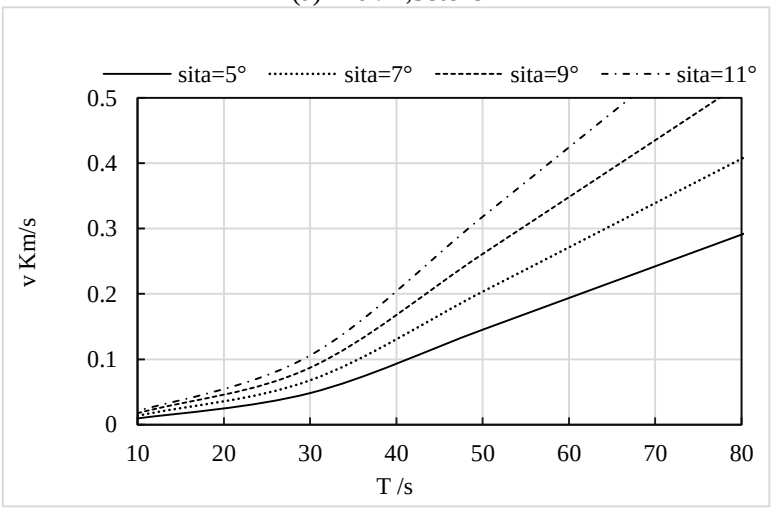


(d) 420r/m,11tons

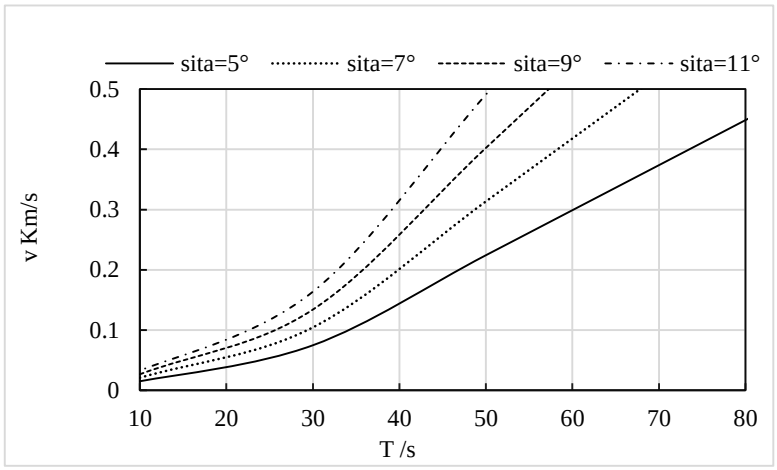
Figure 5 The relation of speed and time with various inclinations and ϕ= 40º when different rotation and mass in helicopter.



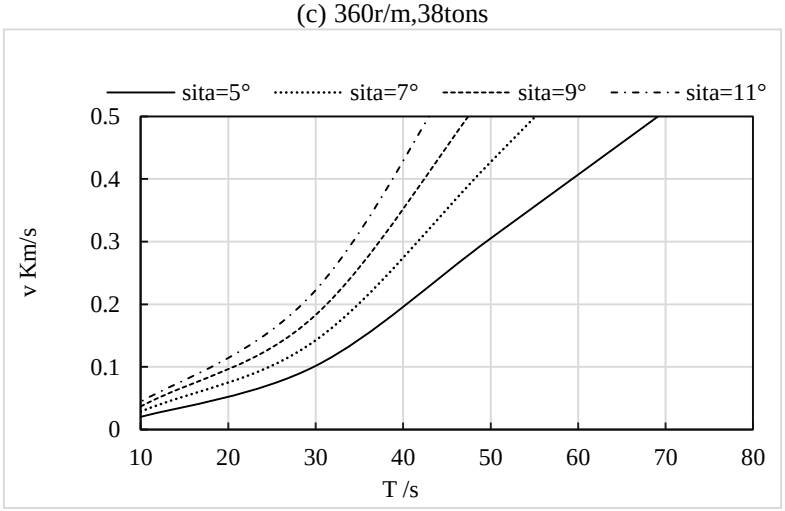
(a) 220r/m,38tons



(b) 290r/m,38tons



(c) 360r/m,38tons



(d) 420r/m,38tons

Figure 6 The relation of speed and time with various inclination and ϕ= 40º when the different rotation and times in helicopter.

In Figure 5(a~d) and 6(a~d) It is used that 11tons and 38tons is mass in helicopter respectively with the various rotation from 220Km/s to 420Km/s in the ϕ= 40º. It is found that the speed of helicopter will incline when the rotation and the inclination increase respectively. Meantime the speed will decline when the mass of helicopter increases from 11tons to 38tons. That's saying the speed per time incline steeply in the former which is caused by light weight. There is big difference in here which expresses the speed is changed with inclination from 5º to 11º. It expresses the speed is been controlled easily through inclination. The speed at 0.2km/s is 360Km/h which is current speed so in order to promote the speed through inclination. It has been controlled through rotation and mass too. Additionally at the time 30s the propulsion speed attains 220m/s、400m/s、580m/s & 800m/s as the blade rotation is 220r/m、280r/m、340r/m & 420r/m in Figure 5 respectively at angle θ=11° and 11 tons gravity. At the same time, at the time 30s the propulsion speed attains 120m/s、200m/s、300m/s & 400m/s as the blade rotation is 220r/m、290r/m、360r/m & 420r/m respectively in Figure 6 at the same angle θ and 38 tons gravity. It means that the heavier gravity with high inclination θ has lower propulsion speed due to its bigger load with angle ϕ= 40º in this paper.

IV. Conclusions

The propulsion will incline when the inclination increases. It increases with blade radius inclines secondly. It will incline too with the increasing angle $\phi$and rotation thirdly. The turn is $n > \phi > r$ ie. Rotation is first and then angle ϕ, final radius in terms of this paper. The speed of helicopter will incline when the rotation and the inclination increase respectively. Meantime the speed will decline when the mass of helicopter increases from 11tons to 38tons. That's saying the speed per time incline steeply in the former which is caused by light weight. In order to promote the speed through inclination. It has been controlled through rotation and mass too.

The biggest propulsion force has attained 120 tons with 320 r/m of blade rotation. The propulsion speed attains the 400m/s with 38 tons gravity and 420r/m rotation of blade in helicopter. On the other hand, it will

arrive 800m/s with 11 tons helicopter gravity and the same rotation in helicopter with maximum inclination 11°. As the blade inclination increases the propulsion speed and force has increased.

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