Simulation of Climbing Process of Aircraft on Plateau Airport

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Abstract. In order to solve the problem of the minimum climbing gradient of plateau airport and the problem of limiting slope at ends of clearance obstacles, we establish a model for calculating the performance of aircraft climbing and analyse the performance of climbing during the flight of the aircraft in the course of taking off. Through the simulation calculation, the variation law of the flight route height at different air pressure heights is analysed for the aircraft’s full and one engine failure, and the relationship between the flight path gradient and the air pressure height when the aircraft is in full engine and one engine failure condition is established.

1. Introduction

China is a mountainous country. The plateau area with an elevation of more than 1500m accounts for 30% of the total national area, and the average elevation of Qinghai Tibet plateau is more than 4000m, making it the region with the worst air transport environment in the world [1]. Factors such as harsh climate and environment, poor air clearance conditions, and aircraft performance degradation pose great challenges to the safe operation of plateau airport [2].

In the modeling and simulation of flight tracks, scholars usually make appropriate simplification based on the kinematics equation of the center of mass. Miller et al. did not consider the impact of aircraft Angle of attack and engine installation Angle on engine thrust to analyze aircraft's turning performance [3]. Wittenberg and Cavcar et al. calculated the sine value of climbing Angle approximately equivalent to climbing Angle [4,5]. Laurle S studied the estimation problem of TOD in continuous descent operation, adopted polynomial approximation algorithm to quickly calculate the position information of TOD, and compared the estimation results of B737-700 and A320 aircraft with the calculation results of FMS, the error was no more than 5 nautical miles [6,7].

In the area of clearance analysis. Literature [8] makes clear the specifications of obstacle limiting surface of clearance area. Wu P [9] et al. train BP neural network to predict the spatial position of aircraft and analyze the influence of obstacle height on aircraft flight.

This paper focuses on the analysis of the influence of the air pressure altitude on the horizontal distance of the route, and the change in the case of single failure. Based on the simulation results, the limit surface requirements of the end clearance obstacle at the plateau airport are given. Other paragraphs are indented (BodytextIndented style).
2. Another section of your paper Aircraft Climbing Simulation Model.
The main indexes to describe the performance of climbing are: the rate of climb, the maximum rate of climb at a given altitude, the angle of climb track, the gradient of climb, the time of climbing, and the horizontal distance through which the climb passes. The main factors affecting the aircraft climbing performance are the residual thrust and climbing mode of the aircraft [10]. Aircraft forces in the air can be simplified. In this paper, the numerical integration method is used to calculate the climbing performance of the aircraft. It can be considered that the aircraft moves in the vertical plane without side slip during the take-off and climb stages or in the phase of preparing to land, so the climbing model can be written as [11].
The variation history of velocity, height and distance with time is obtained by numerical integration method. The initial values of each set angle of attack and track angle are calculated iteratively and the final angle of attack and track angle are obtained. According to the calculated angle of attack, the lift coefficient and the resistance coefficient are obtained by checking the lift curve and the pole curve of the corresponding time period. The thrust is determined by the method of [12].

3. Another section of your paper Aircraft Climbing Simulation Model.

3.1. Simulation Model
After determining the mathematical model of the climbing and sliding of the aircraft and determining the values of each calculation parameter in the model under the condition of the airfield runway at that time, the numerical integration method can be used to solve the problem. Finally, the computer program of aircraft climbing and descending is written by Visual C++ language.

3.2. Influence of Pressure Height on Climbing Performance
The effect of air pressure height on climbing performance is as follows: with the decrease of air pressure altitude, the thrust of aircraft decreases and the velocity of landing increases.

1. Simulation conditions of normal mass climbing of aircraft: normal take-off mass 24.14t, initial relative height of climb 0 m, relative altitude of 600 m at end of climb, engine in full throttle working state, temperature 15 °C, no wind. The relationship between the horizontal distance and the climbing height of different air pressure heights. The relationship between the climbing-level distance of different barometric altitudes and the aircraft relative to the airport height is shown in Figure 1.

![Figure 1. Curve of relationship between climbing horizontal distance and climbing relative height at different pressure heights](image_url)

It can be seen from Fig.1 that the normal mass take-off of the aircraft decreases with the increase of the air pressure altitude, the climbing angle becomes smaller and the climbing gradient decreases. At
the air pressure altitude of 0 m ~ 1000m ~ 2000m ~ 3000m, the climbing gradient of the normal mass take-off of the aircraft is respectively 0.112 ~ 0.097 ~ 0.079 ~ 0.064 for normal mass take-off.

2. Simulation conditions of aircraft maximum mass climbing: the maximum take-off mass of type I aircraft is 28 t, the initial height of climb is relatively 0 m, the end of climb is relatively high at 600 m, the engine is in the state of full after power, the temperature is 15 ℃, and there is no wind, the relationship between the horizontal distance and the climbing height of different air pressure heights. The relationship between the climbing-level distance of different barometric altitudes and the aircraft relative to the airport height is shown in Figure 2.

![Figure 2. Curve of relationship between climbing horizontal distance and climbing relative height at different pressure heights (maximum mass)](image)

As can be seen from Fig. 2, the maximum mass take-off of the aircraft decreases with the increase of the air pressure altitude, the climbing angle becomes smaller, the climbing gradient decreases, and at the air pressure altitude of 0 m, 1000m, 2000m, 2000m. The maximum mass take-off gradient of the aircraft is 0.171, 0.143, 0.126, 0.104. The maximum mass take-off and climb performance of the aircraft under full after loading is better than that of the normal mass take-off under the full throttle condition, and the unfavorable condition of the clearance space of the type I aircraft is the normal mass take-off under the full throttle condition.

### 3.3. Performance of Climb and Fall in Case of One Engine Failure

Simulation conditions: maximum take-off mass 28 t, initial relative altitude of climb 0 m, relative altitude of end of climb 600 m, engine in full after power working state, temperature 15 ℃, no wind, The relationship between the climbing horizontal distance and the climbing height at different pressure heights. The relationship between the horizontal distance of a failure climb and the height of the aircraft relative to the airport at different barometric altitudes is shown in Figure 3.
At the air pressure altitude of 0m ~ 1000m ~ 2000m ~ 3000m ~ 4000m, the maximum mass take-off gradient of an aircraft is 0.077, 0.064, 0.052, 0.041, 0.030. With the increase of the air pressure altitude, the aircraft's climbing performance decreases, the angle of climb becomes smaller, and the climbing gradient decreases. At the same air pressure level, the aircraft's failure climbing gradient is the lowest value of the aircraft's obstacle crossing performance.

3.4. Analysis of The Influence of Barometric Altitude on The Climbing Gradient of The End Clearance.

The climbing gradient of type I aircraft at different pressure heights was calculated, and these data were fitted with curves. The fitting results are shown in Figure 4.

The effect of barometric altitude on the climbing gradient of type I aircraft is linear. With the increase of air pressure altitude, the linearity of climb gradient is less. Among them, the relationship between the climbing gradient and the pressure height of type I aircraft is as follows:

\[ y = 0.0757 - 1.18 \times 10^{-5} x (0 \leq x \leq 10000) \]  

In the formula: x means the height of the air pressure, y means the gradient of climb. the below is same.

The relationship between the climbing gradient and the barometric altitude of the type I aircraft with the maximum mass at one failure is as follows:
\[ y = 0.1115 - 1.56 \times 10^{-5} x (0 \leq x \leq 10000) \]  

(2)

4. Conclusion

Based on the analysis of the initial climbing process of the aircraft, the climbing performance calculation model under control is established, and the climbing performance calculation program is written by Visual C++ language. Through the simulation calculation of the initial climbing process of the aircraft, the relationship between the climbing gradient and the air pressure height is obtained. The validity of the model is verified by the track test. Based on the analysis of aircraft landing and descent process, the minimum value of glide gradient is determined by means of favourable velocity descent, a glide model based on favourable velocity is established, and the influence of pressure height change on landing and glide path is analysed.

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