Evaluation of propeller thrust dependence on pressure change for high altitude SUAV operation

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1. Back and purpose
A propeller is used as a way for an airplane to gain propulsion. The Reynolds number *Re* band of the rotor blades is called the low Reynolds number range, and there is still an unexplained part. The method of observation of the stratosphere in the Earth’ s atmosphere is limited.
In this study, we examined the establishment of the observation method by rotating unmanned blade aircraft in the thin atmosphere. Current drone operational altitude is around 5000 m, and basic numerical analysis in high altitude areas and measure using a vacuum chamber. Quantitatively confirm how much propeller thrust can be obtained under conditions of low air density. It obtains specific information as to whether drone can operate at high altitude. Furthermore, it is aimed to evaluate by thrust test whether the thrust which can be operated in the Martian atmosphere cannot be obtained by the propeller.
2. Outline of experiment
We conducted some experiments as describes below. Under the chamber experiments, pressure conditions were simulated to be the altitude of 0-18 km of the Earth’ s atmosphere using laboratory vacuum equipment.The experiment was conducted by changing various parameters, and the propeller characteristics of APC were evaluated. The experiment started at an air temperature of 25 degrees.as an experimental environment and started after sufficient time had passed after evacuation. There were two pressure gauges (Cold Cut Sword ·Pirani vacuum gauge (cc), pressure transducer type digital pressure indicator (pt)) in the vacuum chamber, and both pressure gauges were used in this experiment.
3. Thrust measurement experiment
Fig. 1 shows that the relationship between the thrust coefficient and the altitude when the rotation speed is 5000 rpm with an 11 inches propeller. In the pressure gauge cc, the waveform changes like a trough but decreases monotonically with the pressuregauge pt. Fig. 1 indicates that, in the pressure gauge cc, the change in the thrust coefficient changes like a valley, and the thrust coefficient increases at an altitude of 10 km or more. The pressure gauge cc is not regularly changing. The pressure gauge pt monotonically decreases due to the rise in altitude and has regularity.
4. Consideration
From these circumstances and the data of the cold cathode Pirani vacuum gauge, we concluded that the pressure gauge pt is more accurate in the low vacuum region. It is found that the Reynolds number reduction due to the altitude rise causes a decrease in the thrust coefficient and that it is enough to raise the spiral speed of the propeller to maintain the thrust coefficient. For that purpose, it is possible to solve this problem to some extent by increasing the elevation angle of the propeller or increasing the rotation speed.
5. Conclusion
In summary, we evaluated propeller thrust for SUAV driving in the high altitude of
Earth’ s and Mars atmosphere. It can perform thrust and rotation speed measurement with a commercially available propeller. It is found that the cold cathode-Pirani vacuum gauge (cc) is not suitable for measurements of tens of range. Therefore, in addition to the transducer type pressure gauge (pt), it is required to introduce a good pressure gauge to the system from atmospheric pressure to tens of.
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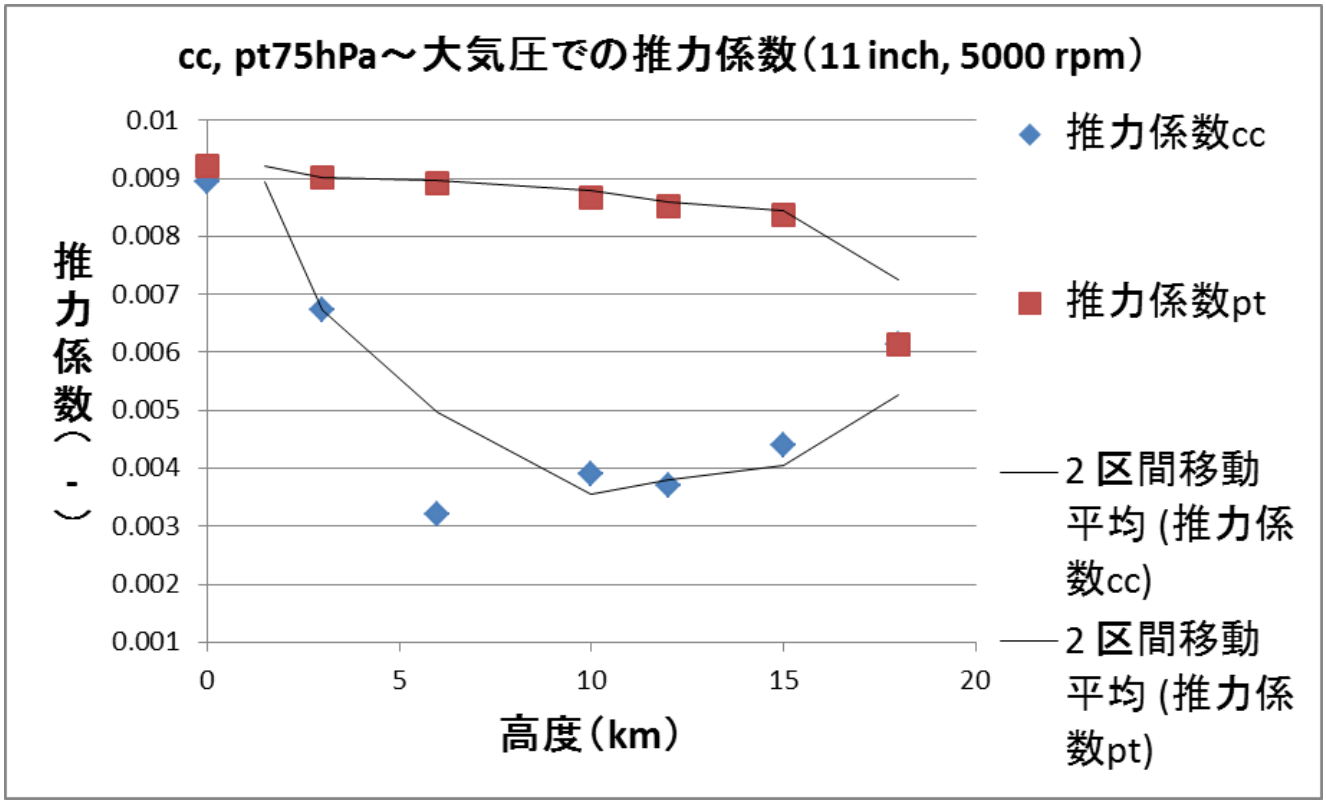

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