VERTICAL TAKE-OFF AND LANDING PROPULSIONS

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Keywords: *Vertical Take-Off and Landing (VTOL), propulsions, unmanned aerial vehicles (UAV), urban air mobility (UAM)*

Abstract: *Creating weight and energy efficient propulsors is a key issue in creating UAV-friendly UAVs. Various types of propulsors are considered and are particularly suitable for ducted fans due to low noise and high static thrust.*

ДВИЖИТЕЛИ ЗА ВЕРТИКАЛНО ИЗЛИТАНЕ И КАЦАНЕ

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Ключови думи: *вертикално излитане и кацане (VTOL), движители, безпилотни летателни апарати (UAV), градска авиационна мобилност (UAM)*

Резюме: *Създаването на теглово и енергийно ефективни движители е ключов проблем за създаването на UAV, подходящи за UAM. Разглеждат се различни видове движители и се предлагат като особено подходящи тунелните вентилатори, поради ниския шум и високата статична тяга.*

Introduction

Population of the world is concentrated in large cities. It is expected that 80% of 9 billion population of the world to live in urban areas in 2050 [1]. Many cities have difficulties with social and ecological problems as a result of overcrowding, poverty, pollution, and intensive traffic. Providing of effective mobility in urban areas is a key challenge for their future development.

Number of cars has risen with the increase of the number of roads. A radical solution for urban mobility in the future is the opportunity to be used 3D space instead of 1D space which is used at the moment. It means that flying vehicles could be applied corresponding to Urban Air Mobility [2].

The article discusses the opportunities for application of different type propulsion systems for unmanned VTOL aircraft [3, 4].

Propulsors for unmanned urban air mobility aircraft

By analyzing different unmanned VTOL aircraft projects, It has been found out that a major problem with UAM aircraft is absence of light, efficient and ecological propulsion systems, engines and energy sources with a high level of specific energy. (Fig. 1).

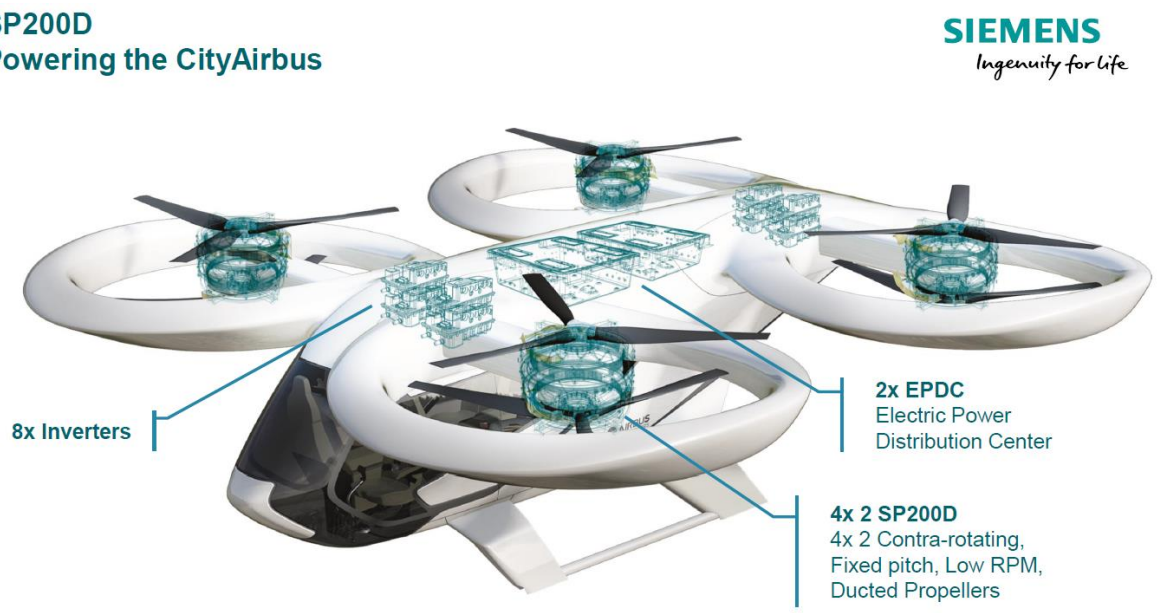

Fig. 1

With VTOL aircraft, propulsion systems with jet and aerodynamic thrust have been used so far. However, jet engines are not appropriate for urban air mobility because of noise regulations and high level of fuel consumption at low speed. Jet systems have been ruled out of this research. Propulsion systems with aerodynamic thrust can be divided into three main groups: propeller systems, systems with ducted fan modules, and systems with cross-flow fans.

Rotary wing aircraft (helicopters and multi-rotors) possess a high level of static thrust but low level of aerodynamic effectiveness so that they are suitable for short distance flights.

Propulsion systems are driven by motors, which are powered by energy sources. Motor revolutions are controlled by an auto-pilot system through a fast acting controller.

Regulations for UAM aircraft require a low level of noise and zero chemical pollution. Only vehicles with electric motors, which are powered by batteries, fuel cells, super-condensers or hybrid systems, fulfill these requirements.

Batteries (Fig. 2), which are produced by TESLA in Nevada, possess the highest level of specific energy – approximately 300 Wh/kg. They provide flight duration less than 60 minutes. After that batteries need re-charging or replacement.

Fig. 2

According to some forecasts, batteries with specific energy close to 1,200 Wh/kg will be produced by 2026. These batteries will provide flight distances up to several hundred kilometers with one charging, which is acceptable for urban mobility.

The other sources of energy do not correspond to some UAM requirements – safety, effectiveness, pollution regulations, noise regulations, and simple maintenance. They are not subject of research in this article.

Electric motors have been highly developed in the past years. They are noiseless, ecological and possess a high level of specific power up to 5.9 kW/kg (Fig.3). These motors are perspective for aircraft with a cruise speed under 0.5 M.

Fig. 3

Propulsion systems with tilt rotor /wing possess a high level of static thrust but they are not effective at horizontal flight. In addition, they have large dimensions so that they are not suitable for UAM.

Cross-flow fan systems do not have a high level of thrust so they cannot be used for aircrafts. Propulsion systems with ducted fan modules possess a higher level of static thrust than propellers at equal diameters. They provide good energy effectiveness and high cruise speeds (Fig.4). High level of static thrust at zero speed and good effectiveness at cruise speeds can be achieved by controlling the intake diameter. This system needs reduction of noise levels and improvement of energy effectiveness.

Fig. 4

Conclusions

It may be concluded that propulsion systems are the main drawback for development and application of unmanned VTOL aircrafts for urban air mobility. In this respect, researches for creating and development of appropriate propulsion systems should be accelerated. This would allow urban mobility to enter into 3D (the third dimension) during the next decade.

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