Micro-turbine engines usage in power generation systems.

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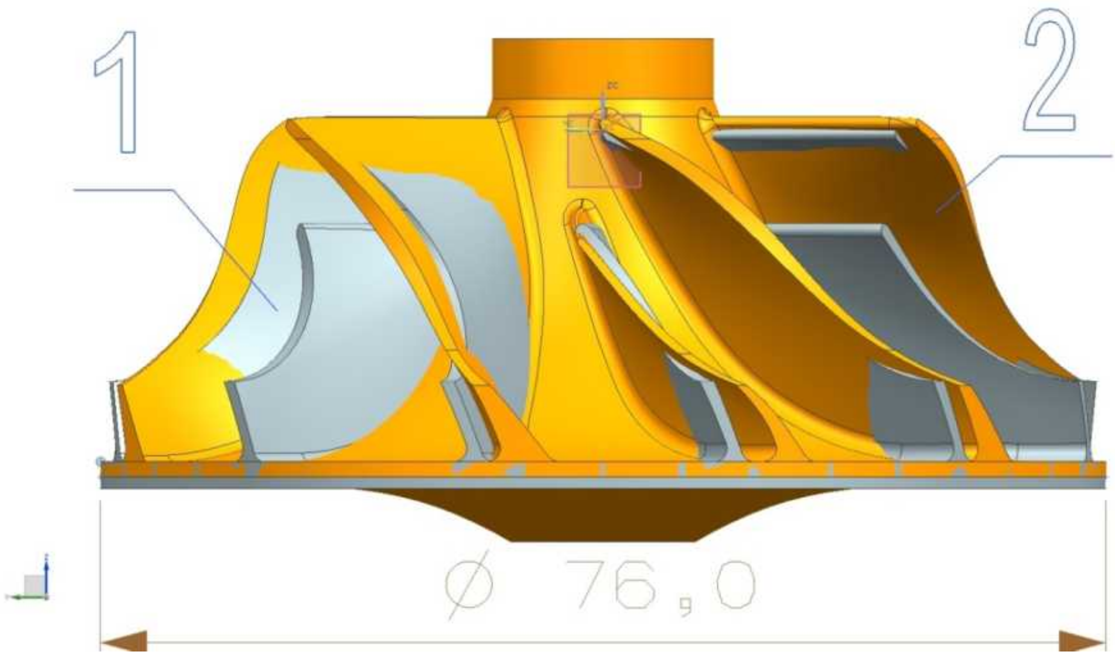
Small size gas-turbine engines (micro-turbine) are becoming more common. These engines could be applied for all-weather unmanned aerial vehicles (UAVs), subsonic air defense targets, and maneuverable small size weapons; also, they find their application in ground-based generator sets. Power unit on the base of micro-turbine engines has several advantages like small size, mobility, high specific capacity. Specified requirements of such plants are quite high: it must have high reliability, economical efficiency, have long time before overhaul (TBO) and be manufacturable. Design of such plants has encountered with difficulties, firstly micro-turbine engines design stage due to massive degeneration of the workflow the dimension reduction causes the disproportionate power reduction. The engineering developments of micro-turbine engines and power units are carrying out on such micro-turbine engines basis at the aircrafts engines department of Moscow Aviation Institute (National Research University).

In spite of high demand into reliable and mobile power plants, there are not many manufacturers of such plants, but in many countries, the engineering developments of micro-turbine engines and power units are carrying out. Such plants oriented, first of all on emergencies services, fire department brigades, military needs, as well as for work in the North, Arctic and Antarctic, reserve ships power supply, for temporary accommodation, gas pipelines etc. In the Russian Federation such plants are not produced commercially, and their foreign counterparts have a high cost.

The main challenges for the research team are to increase efficiency and TBO of such plants. Increasing of efficiency achieved by using new composite materials and new methods of design, directed to increase turbine gas temperature and compressor compression ratio. Small size of a plant allows using composite materials in a hot part of the engine: nozzle block, turbine, and generator shaft. Other important option is a compression ratio in a compressor. Now days most part of small size centrifugal compressors are working in 3-8 compression ratio diapason, which is far away from the efficiency extremum. The research team have performed a verification compression design methodic, as a result of which a methodic for high-pressure wide chord centrifugal compressor design was realized (pic. 1).



Pic. 1 - comparing of the calculated impellers (1) and the prototype (2)

Besides that, assumed to install before centrifugal stage an axial flow compressor stage. The hybrid wide chord compressor usage allows to increase compression ratio to 10-14, which corresponds extremum of the efficiency for non-cooling construction materials. Table 1 shows a comparison of power unit with various degree of modification of its micro-turbine engines part. All calculations were made with air flow 0.7 kg/s and other parameters were gained from test bench (first column). High-pressure compressor was calculated with the help of Ansys software.

Table 1. *Comparison power unit parameters on a base of the engine with various degree of modification.*

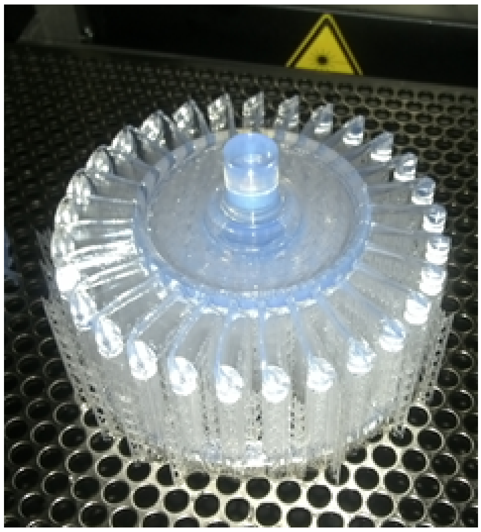
Parameter	Power unit on a base of engine without modifications	Power unit on a base of engine with composite materials usage	Power unit on a base of engine with a wide chord hybrid compressor	Power unit on a base of engine with composite materials usage and a wide chord hybrid compressor
π	3.8	3.8	11	11
T, K	1050	1600	1050	1600
N, kW	225	325	235	380
C, g/kW	165.6	151.56	105.48	92.52
Tt, K	785	1200	620	935
η, %	21	25	32	40

Used designations: π-total pressure increasing degree, T-turbine gas temperature, N-power plant electricity output, C-specific consumption, Tt-heat exchanger gas, η-electrical efficiency.

Weak point of micro-turbines are bearings. Primary option is using contactless gasdynamic bearings: it allows to avoid necessary of lubrication and cooling, and to reduce deterioration of the bearings during engine work, which extremely increase engines TBO.

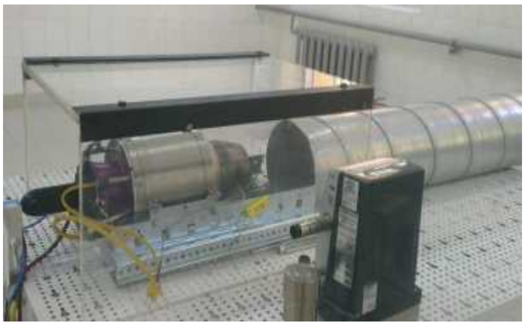
As well as the engineering design is held, the work of the production of micro-turbine engines parts for the prototypes at the existing production facilities: machines for CNC machining, stereolithography machines, vacuum casting in silicone molds, precision laser welding, as well as mobile scanning system for the control of manufactured parts. Fundamentals of manufacturing technology of compressor, turbine, shaft, combustion chamber, engine body, nozzle (pic. 2, pic. 3).

Pic. 2 - processing compressor wheel

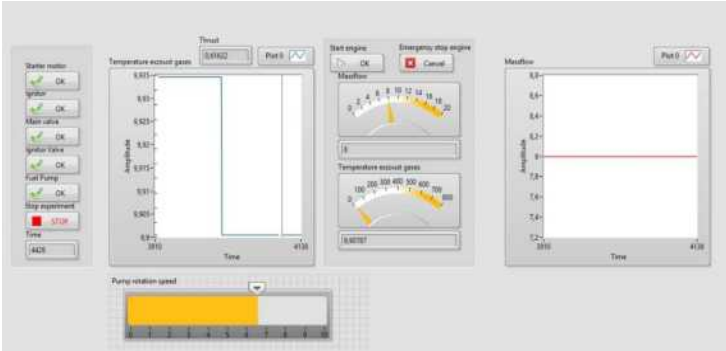


Pic. 3 - burns SLA-model of the turbine wheel

The research team works out design and program solutions for micro-turbine engines test bench. There were several engine prototype starts held, which gave data for compressor and turbine design methods verification (pic. 4, pic. 5). By means of software MathCAD thermo-gasdynamic calculation of prototype was made. There was centrifugal compressors design verification made, which increase its efficiency.



Pic. 4 - the appearance of the stand



Pic. 5 - interface management program

Perspective development direction is to increase gas temperature up to 1800 K and compression ratio to 20 for increasing efficiency.

The new methods usage of design and composite materials in a hot part allows extremely increase power output and shift the ratio heat/electricity.