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Very Small Gas Turbine Jet Engines - Current Limits and Potential for Improvement

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Gas turbine technology offers propulsion devices with excellent thrust-to-weight ratio for a broad range of flight Mach numbers and altitudes. The small size and weight of gas turbine engines makes them attractive for new or emerging markets like model aircrafts, UAVs, remotely piloted vehicles and autonomous flight systems. However, the low efficiency and the high cost of current small gas turbine engines substantially restrict their use.

In recent years a variety of new gas turbine jet engines in the 1.000 N-thrust-class and below (very small gas turbine jet engines) have been developed and designed. Most of these engines are developed by converting turbo-superchargers in combination with an adapted combustor, which should provide reliable and efficient work in the whole operating range. Based on thermodynamic cycle simulation the paper will show the influence of important design parameters (e.g. pressure ratio, temperatures and losses) and propose possibilities to use further potential to increase the efficiency.

For small turbojets the aerodynamic design of turbo components is guided by turbochargers and the classic scaling from larger gas turbines. On the other hand, scaling techniques for the combustor design are less defined and often do not lead to the desired result. The reasons for this are rooted primarily in an increasing time necessary for evaporation and reaction, because of the lower temperature and pressure at the combustor inlet as well as the lower fuel flow rate, which requires a minimum number of injectors. Additionally, the dome height reduction increases the effects of wall quenching and the higher ratio of surface area to volume results in an increase in friction losses. Hence, for developing efficient small gas turbines particular attention must be paid to the design and optimization of the combustor. Over the last past years a lot of new combustor and fuel injection concepts have been published, but almost all current very small gas turbine jet engines are still using vaporizing sticks in different shapes and number. For configurations with vaporizing sticks there are still only few computational studies and far fewer detailed experimental data for validation.

At the Institute for Flight Propulsion of the Technische Universitaet Muenchen a gas turbine test stand was designed for investigating small gas turbine technologies. In particular a transparent casing permits optical access to obtain information from inside the combustion chamber. The proposed paper will present experimental results, e.g. temperature distribution in the liner material (*Figure 1*), flow direction at the combustor inlet and the influences of different combustor designs like variation of number of vaporizing sticks. The influence of overall engine performance like pressure drop, combustion efficiency, pattern factor and specific fuel consumption will also be discussed and new design proposals will be introduced.

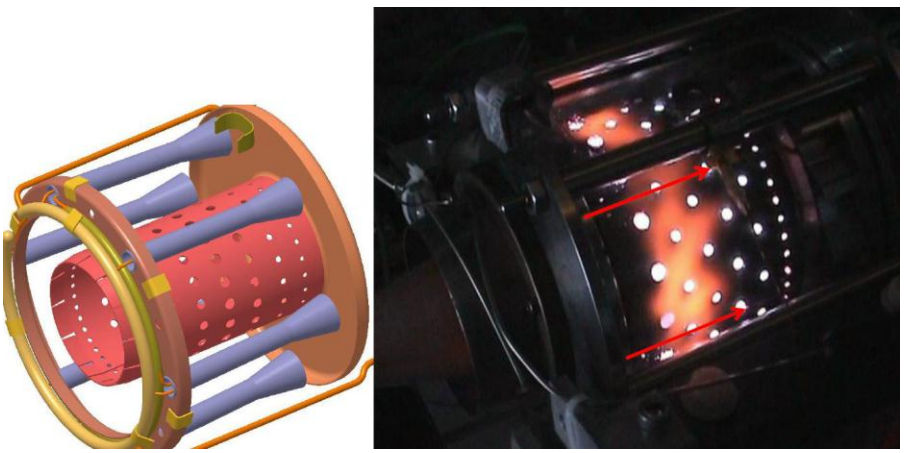

Figure 1: Cut view of a very small gas turbine combustor (left) and radiant heat color (right) of the outer liner (experimental data @100% rpm).