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Title

Performance estimation of supersonic impulse turbine at transient conditions

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Abstract

During startup as well as operational point changes, a supersonic impulse turbine can encounter gas dynamical conditions in which can result in excessive loads or immediate loss of performance. Effects such flutter [01], buzzing [02], under and over expanded flow and full gas blockage [03] can appear and induce high levels of stress, reducing the expected life of the turbine or deteriorating the expected efficiency.

Most performance prediction method for supersonic impulse turbine are restrictive for one single operational conditions and doesn't take into consideration the majority of effects in the system, as partial admission, leakage losses, etc. However, in a throttleable engine, the optimization must cover all operational envelope, as well as the transient conditions in between, as well as the startup, resulting in increase of performance in all expected conditions.

Different considerations need to be taken into account while evaluating the transient effects during performance estimation at such low load points. The most significant constrain is the evaluation of the das-dynamic condition and the boundary-layer effect during the analysis process in the pre-defined operation range.

The main models for design turbine systems applied for LRE are adjusted to engines with medium to high thrust levels (usually above 50-100kN), where various losses, as friction, leakage, non-uniform flow, partial admission and others are considerably smaller than the performance generated per rotor blade. With a decrease of nominal thrust at design conditions, especially during starting conditions or transient points, the turbomachinery size decreases considerably, result in losses outside of the well-known modelled ranges, making the performance estimation of such components imprecise.

The improvement of in house tools for off-design conditions prediction and its validations with experimental test cases allow to better estimate the effects of startup conditions and transient effects as well as its expected performance, increasing reliability on current tests and futures designs, with adequate precision for turbomachinery ranging from small sizes to standard high thrust models.

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