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Design and verification of a controlled induced mass flow system

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ABSTRACT

The Medium Speed Wind Tunnel (MSWT) of the Aeronautic Systems Competency (ASC) within the Council for Scientific and Industrial Research (CSIR) performs majority static stability wind tunnel testing. The facility does not have an active inlet simulation capability, or a pressure system to support such a capability. Airframes with air breathing engines are tested with inlets either covered with fairings or left open to operate in a passive mode. To expand the wind tunnel offerings to include an inlet test capability, an active inlet flow induction and metering system was required. An ejector driven duct was designed to provide simulated engine air flow at rates and conditions appropriate for the MSWT size and operating envelope. Integral to the design was a mass flow metering system featuring a translating conical plug. To reduce the risk and size footprint the ejector unit comprised 14 ejectors clustered around a hollow central core housing the mass flow plug support and drive system. The ESDU 92042 software was utilised as the design tool to develop the ejector geometry and Computational Fluid Dynamics (CFD) was employed as a verification and off-design performance prediction tool. The entrained mass flow rate predicted by the CFD model for the 14-ejector unit exceeded the predicted entrained mass flow rate determined by the ESDU 92042 software. Experimental tests were performed to determine the actual entrained mass flow rate of a single ejector in order to verify the design predictions of the CFD model. The maximum entrained mass flow rate determined from the experiment is greater than the maximum entrained mass flow rate predicted by the CFD model. The CFD model over-predicts the entrained mass flow rates of the ejector in the sub-critical mode and will envisage it to under-predict the entrained mass flow rates in the critical mode. The experimental results for the single ejector suggest that the designed operating envelope predicted for the parallel arrangement of 14 ejectors should be reached.