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Achieving Full Dynamic Similarity with Small-Scale Wind Turbine Models[1] MARK MILLER, JANIK KIEFER, Princeton University, CARSTEN WESTERGAARD, Texas Tech University, MARCUS HULTMARK, Princeton University — Power and thrust data as a function of Reynolds number and Tip Speed Ratio are presented at conditions matching those of a full scale turbine. Such data has traditionally been very difficult to acquire due to the large length-scales of wind turbines, and the limited size of conventional wind tunnels. Ongoing work at Princeton University employs a novel, high-pressure wind tunnel (up to 220 atmospheres of static pressure) which uses air as the working fluid. This facility allows adjustment of the Reynolds number (via the fluid density) independent of the Tip Speed Ratio, up to a Reynolds number (based on chord and velocity at the tip) of over 3 million. Achieving dynamic similarity using this approach implies very high power and thrust loading, which results in mechanical loads greater than 200 times those experienced by a similarly sized model in a conventional wind tunnel. In order to accurately report the power coefficients, a series of tests were carried out on a specially designed model turbine drive-train using an external testing bench to replicate tunnel loading. An accurate map of the drive-train performance at various operating conditions was determined. Finally, subsequent corrections to the power coefficient are discussed in detail.

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