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C2Po1A-07: Pre-design and efficiency analysis of electric generator brake cryogenic helium turbine expender

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A high-speed cryogenic helium centrifugal turbine expander with an electric generator brake for experimental helium refrigerator is presented in this paper. This design differs from traditional compressor-braked cryogenic helium turbine expanders. The turbine expander is braked by a permanent magnet generator (PMG), and its shaft is coupled to the PMG to enhance operational stability. The designed power output of the turbine expander is 28.3 kW, and the pressure ratio is 2.85 under the design conditions. In comparison to compressor braking, generator braking can increase the braking power, which facilitates improvements in the power of individual turbines. The braking power and speed of the turbine can be rapidly adjusted through control of the brake generator, thereby enhancing the operational capability of the turbine under variable operating conditions. However, due to the limitation of generator, the rotational speed of the turbine is restricted to 10,000 rpm, which adversely affects its efficiency. To achieve high-speed operation of the generator, the shafting structure is supported by hydrostatic gas bearings. Additionally, part of the working substance is extracted from the impeller to dissipate heat from the generator rotor. The design rotational speed is established at 96,000 rpm. This paper introduces an overall design approach for the turbine expander and provides predictions regarding its efficiency.

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