

ROTATING STALL CELL AND VON KARMAN VORTEX STREET  
A METEOROLOGICAL THEORY

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ABSTRACT

A meteorological theory is established for the rotating stall in axial turbocompressors, namely, that this is guided by the Rossby wave of the blade channels under the action of (1) the baroclinic waves in the annular spaces in front of and behind the rotor, and (2) the circular Karman vortex street around the circumference of the rotor.

The inception of the rotating stall is introduced by the reverse flow (with high temperature and high entropy) from the outlet toward the inlet of the rotor because of its formation with the forward flow (with low temperature and low entropy) to a front, whose property is similar to the polar front of the weather system of the meteorological vortex pairs of "highs and lows" in the mid latitude (related to the Northern Hemisphere in the paper) of our earth. These vortex pairs circulate about the earth's axis in the same manner as the Karman vortex pairs do about the rotor axis in the event of the rotating stall.

Because of the difference in temperature and entropy between the two sides of the front, a baroclinic wave is generated on the front by instability process in the rotating fluid of the rotor similar to that in the weather system. These baroclinic waves in front of and behind the rotor are spun by the induction field of the Karman vortex pair to give the configuration of the stall cell a bubble form enveloping the elementary recirculating loops, each of which circulates around one of the blades in the corresponding stalled region. These elementary recirculating loops are brought into action by the reverse flow mentioned previously.

In a multistage axial compressor the induction fields of the Karman vortex pairs of the rotors between the neighbouring stages are coupled with each other and then keep their stall cells in the axial direction.

This meteorological theory is examined by means of the experimental results available in the literature whereby its confirmation is achieved. Among these experimental results, the fundamental investigations of Day (1976, 1991 a & b) and Breugelmans with his associates (1983, 1985 a & b, 1988) have especially served throughout as guidelines for the development of the present theory.

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