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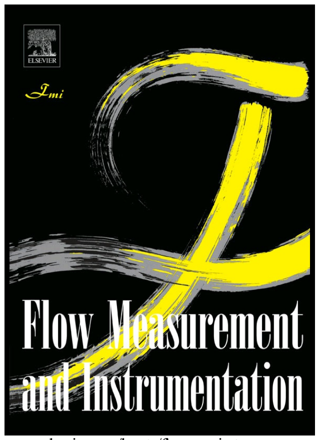

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Research on the dynamic characteristics of a turbine flow meter

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Abstract:

In the hardware-in-loop simulation of aero-engine control system where the real fuel regulator is engaged, it's crucial to measure the real-time flow rate. In view of this, a flow meter with high precision and fast response is important. In this paper, modeling and experiments are conducted to verify the dynamic characteristics of a turbine flow meter(TFM). For the modeling part, driving torque and resistance torques are analyzed to derive the kinetic equation of TFM. Simulation with the kinetic equation shows good dynamic performance of TFM. In experiments, a workbench is designed to generate step-type flow and sine-type flow for identification in time domain and frequency domain. Results show that the settling time for TFM is no more than 100ms and its band-with is over 4.61Hz. Compared with the settling time of a main fuel valve and the band-width of a main fuel control loop, that is, 1.2s and 2Hz respectively, TFM is considered to be adaptive to measure the fuel of aero-engine.

Keywords: dynamic characteristics, kinetic equation, time domain, frequency domain, experiments, simulation

1. Introduction

In experiments of the aero-engine, it is crucial to measure the real-time fuel flow rate from the fuel regulator. However, fuel won't always remain stable. It may change in different ways. So a flow meter which is capable of indicating dynamic flow rate with high precision and fast response is of significance [1]. Hence, turbine flow meter is introduced here.

TFM is widely used in industry for its small size, stability, high precision, and wide measurement range. When measuring the dynamic flow rate, it is necessary to know about its characteristics. Early in 1956, Jerry Grey [2] established a relatively accurate model of TFM. [3] and [4] did further research on its model considering with effects of the frictions considered.

G.I. Ovodov in [5] proposed another view that the theoretical investigations of the dynamic characteristics of the flowmeters should take into account not only the dynamic properties of the measuring devices, but also the dynamic properties of the measured object, i.e., the fluid stream. As it is also stated, the difference between the input test flow from the ideal flow should naturally contribute to the error

in the experimental determination of the transient characteristics. So how to attain the ideal flow is crucial.

[6] used a cavitating venturi to provide constant mass flow rate of liquid which was independent of downstream pressure changes. In this paper, different sets of experiments were conducted to investigate the performance of the venturis. The agreement between the theoretically calculated and experimentally obtained mass flow rates makes the cavitating venturi a suitable instrument for flow measurement.

The research group at Brunel University developed a pulsator that comprises a piston driven by a Scotch Yoke mechanism which is powered by a variable speed, servo-controlled, stepper motor. This mechanism produces pure harmonic motion and was used to investigate the dynamic response of Coriolis flowmeters to relatively low-frequency liquid flow pulsations up to 32 Hz [7].

Reference [8] discusses the dynamic characteristics of a liquid flow pulsator that consists of an electro-dynamic shaker that drives a diaphragm to create sinusoidal flow pulsations in the measurement system with the help of mathematical modeling of the entire test system.