STUDIES ON THE EFFECT OF UPSTREAM FLOW CONDITIONS ON THE PERFORMANCE CHARACTERISTICS OF TURBINE FLOWMETER

by

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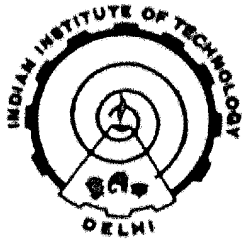

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CERTIFICATE

This is to certify that the thesis entitled,"Studies on the effect of upstream flow conditions on the performance characteristics of Turbine Flowmeter", being submitted by Mohd. Islam is a report of bonafide research work carried out by him under our supervision. This thesis has been prepared in conformity with the rules and regulations of the Indian Institute of Technology, Delhi. We further certify that the thesis has attained a standard required for a Ph.D. degree of the Institute. The research report and results presented in the thesis have not been submitted, in part or full, to any University for any degree or Diploma.

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ABSTRACT

Turbine flowmeter (TFM) is a mechanical flowmetering device and is being used extensively in various industries to measure the flowrate of wide variety of fluids. TFM is known for its excellent repeatability, higher accuracy, wide operating range, high shock capability, low pressure loss, wide temperature and pressure limits and ease of installation. The performance characteristics of a TFM in general is a strong function of the upstream flow conditions, fluid properties and geometrical parameters of the rotor. A critical review of the available literature has shown that although several studies have been conducted to establish the effect of geometrical and dynamical parameters on the performance characteristics of a TFM but full range of parametric investigation has not been carried out. Hence a systematic study has been attempted to establish the effect of two dynamical parameters namely, skewed velocity profile and swirling flow with and without the presence of flow straighteners. These upstream flow disturbances have been created either by a gate valve or by swirlers. Another part of the study has been to establish performance characteristics of different type of flow straighteners. For this study, tube type straightener (TTS), 6 bladed flat plate straightener (6 BFPS) and 10 bladed flat plate straightener (10 BFPS) have been used. Further, a

comparative study on two TFM has also been carried out under standard flow conditions for two fluids namely, water and air to establish the feasibility of calibration with standard fluids for use with other fluids. In the present investigation an indigenously manufactured turbine flowmeter having pipe size of 50 mm NB has been used so that it can be of use to the domestic industry. Though the present work is pre-dominantly experimental, effort has also been made to develop an analytical model to predict the TFM performance, based on the available models in literature. The modified model developed has been used to predict the characteristics of TFM for normal flow conditions and various upstream swirl conditions. The predictions have been compared with experimental results. After having validated the analytical model, a systematic parametric study has been carried out to establish the effect of no. of rotor blades, rotor blade angle, hub diameter, tip clearance and fluid viscosity on the TFM performance.

The performance characteristics of the TFM has been quantified in terms of average meter factor, lower limit of the linear range, usable range, stopping flow and pressure drop across meter. Experimental results have shown that upstream swirl has dramatic effect on the TFM performance. In the absence of flow straighteners, average meter factor increases with co-swirl and decreases for contra swirl flow and simultaneously there is change in the usable range. In

presence of straighteners, it is seen that upto $\pm$ 30^{o} vane angle swirler, the straighteners are effective in damping out the effect of swirl. Study with the distorted velocity profiles has shown that even slight skewness in upstream velocity profile, decreases the usable range in absence of flow straighteners. In presence of straighteners, the performance of TFM is not affected upto 60% closure of the gate valve. Studies with two fluids have shown that it is feasible to calibrate the meter with one fluid and use for other fluid if matching of Reynolds number is achieved.

Predictions by the modified model compare well with experimental results and it is feasible to design a rotor for specific applications with the help of modified analytical model. It is also seen from the parametric study that geometrical parameters have significant effect on the characteristics of TFM. The parametric study carried out to establish the effect of fluid viscosity has shown it to be quite significant on the TFM performance.

CONTENTS

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CONTENTS (contd.)