INSTITUT 27/17/19 FÜR METEOROLOGIE U. KLIMATOLOGIE DER TECHNISCHEN UNIVERSITAT 3 HANNOVER · HERRENHAUSER STR. 2

# Fluid dynamic measurements in the industrial and medical environments NK 557.571

Proceedings of the Disa Conference held at the University of Leicester April 1972

Volume I Conference papers

Edited by David J. Cockrell Senior Lecturer in Engineering University of Leicester

Leicester University Press 1972

# Contents

Preface

	David J. Cockrell	5
I	Review lecture <b>Fluid dynamic measurements in the industrial environment</b> Gino Sovran Supervisor of Fluid Mechanics, General Motors Research Laboratories, Michigan, U.S.A.	11
11	Measurements of velocity in the industrial environment	33
11.1	Mean velocity measurements by thermistor and hot-wire techniques	35
11.1-1	Hot-wire anemometer measurements in turbulent flow close to a wall U. K. Singh and R. Shaw University of Liverpool	35
11.1-2	<b>Measurement of the radial profile of axial velocity in an axisymmetric stream of small dimension</b> A. Arrowsmith and P. J. Foster University of Sheffield	39
11.1-3	Wall effects on the heat loss from short hot-wire probes F. J. Mak The Gas Council, London	45
II.1-4	Subminiature hot-wire probes for measurement of vortical flows M. J. De Santis and E. L. Rakowsky The Singer Company, New Jersey, U.S.A.	53
II.1-5	<b>Hot-wire gauge of drip-expenditure of fluids</b> Z. Smolski Institute of Applied Mechanics, Warsaw's Technical University, Poland	60

# Fluid dynamic measurements

11.1-6	<b>The oscillatory anemometer</b> J. Kielbasa, J. Rysz, A. Z. Smolarski, B. Stasicki Applied Physics Laboratory, Polish Academy of Sciences	65
11.1-7	Determination of the size and the sign of the velocity vector in a non-stationary unidimensional flow F. Chometon and J. P. Damion Conservatoire National des Arts et Métiers, Paris, France	69
11.2	Mean and fluctuating velocity measurements by optical techniques	73
11.2-1	Laser doppler meter of turbulent flow parameters V. S. Sobolev, V. P. Koronkevitch, Yu. N. Dubnitshev, A. A. Stolpovski, E. N. Utkin, N. F. Shmoilov Institute of Automation and Electrometry, Novosibirsk, U.S.S.R.	73
11.2-2	Optical anemometer measurements in recirculating flows and flames F. Durst, A. Melling and J. H. Whitelaw Imperial College, London	81
11.2-3	Limitations on the measurement of unsteady flow velocities with a laser doppler velocimeter W. K. George Ordnance Research Laboratory, The Pennsylvania State University U.S.A.	88
11.2-4	Constant temperature anemometer measurements in hostile liquids S. Zakanycz, H. E. Wright and W. C. Elrod Air Force Institute of Technology, Wright-Patterson AFB, Ohio, U.S.A.	100
11.2-5	<b>Experimental use of LIDAR in turbulent pipe flow studies</b> C. E. Hackett Massachusetts Institute of Technology, U.S.A.	105
11.2-6	<b>The laser doppler velocimeter applied to turbomachines</b> R. K. Turton University of Technology, Loughbourough	114
11.3	Special problems of sensor calibration	118
11.3-1	A method for calibrating a hot-wire anemometer in unsteady flow F. Fairbanks and F. S. Bhinder The Hatfield Polytechnic, Hatfield	118
11.3-2	<b>Effects of dirt accumulation on hot-wire and hot-film sensors</b> T. B. Morrow University of Technology, Loughborough	122

#### Contents

11.3-3	Calibration of hot-film anemometers L. J. Saunders and P. Lawrence The Gas Council, London	125
11.3-4	Calibration of constant temperature hot-wire anemometers for low velocity air flow measurements R. W. Johnson Whirlpool Corporation, Benton Harbor, Michigan, U.S.A. and A. M. Dhanak Michigan State University, U.S.A.	131
11.4	Mean and fluctuating velocity measurements by hot-wire and hot-film techniques	136
11.4-1	<b>The statistical analysis of hot-wire anemometer signals in</b> <b>complex flow fields</b> K. Dvorak and N. Syred University of Sheffield	136
I.4-2	The application of digital techniques to hot-wire anemometry in highly turbulent flows R. Cheesewright Queen Mary College, London	145
11.4-3	A simplified method of improving the accuracy of hot-wire anemometry T. W. Davies and M. A. Patrick University of Exeter	152
11.4-4	<b>An analysis of hot-wire sensitivity in non-isothermal flow</b> J. W. Elsner Technical University of Czestochowa, Poland	156
11.4-5	<b>Evaluation of hot-wire signals in highly turbulent flows</b> F. Durst and W. Rodi Imperial College, London	160
11.4-6	Measurements of turbulent quantities by single hot-wires and X hot-wires using digital evaluation techniques H. H. Bruun and P. O. A. L. Davies Institute of Sound and Vibration Research, Southampton University	163
11.4-7	Low-frequency characteristics of two methods for turbulence measurements in water J. Noskievic University of Ostrava, Czechoslovakia	167
11.4-8	Aerodynamic studies in models of high-intensity gas burners J. R. Thomas, D. R. Brown and A. D. Birch The Gas Council, Solihull	170

# Fluid dynamic measurements

11.5	Other techniques for mean and fluctuating velocity measurement	175
11.5-1	<b>Magnetohydrodynamic measurement of velocity fluctuation</b> J. Janalik University of Ostrava, Czechoslovakia	175
ш	Measurement of voidage	181
111.1	<b>Void fraction measurements in bubbly mixtures of gas and liquid</b> T. F. Roylance University of Nottingham and D. McWilliam Dounreay Experimental Reactor Establishment	183
111.2	<b>Local measurements in two-phase flow</b> J. M. Delhaye Centre d'Etudes Nucléaires de Grenoble, France	191
111.3	<b>Determination of gaseous void fractions by measurement of the velocity of sound in hot flowing sodium</b> J. A. McKnight United Kingdom Atomic Energy Authority	201
IV	Stress determination	209
IV-1	Vibrational noise in pressure fluctuation measurements E. B. Kudashev, M. F. Skladnev, L. Ya. Dubovik The B.E. Vedeneev All-Union Research Institute of Hydraulic Engineering, Leningrad, U.S.S.R.	211
IV-2	Measurements of wall shear stress, wall pressure and fluctuations in the stagnation region produced by oblique jet impingement A. Kamoi Composite R & D Center of Toyo Seikan and Toyo Kohan Companies, Yokohama, Japan and H. Tanaka Institute of Space and Aeronautical Science, University of Tokyo, Japan	217
IV-3	<b>Transient pressure measurement in a centrifugal seal for</b> <b>rotating shafts</b> F. B. Howard and M. T. Thew University of Southampton	228
IV-4	Measurement of oil pressure in motor vehicle power steering under road conditions I. Fazekas Research Institute of the Automotive Industry AUTOKUT, Budapest, Hungary	232

#### Contents

IV-5	<b>Thermal measurement of wall shear stress</b> P. O. A. L. Davies and G. R. Kimber Institute of Sound and Vibration Research, Southampton University	236
۷	Measurement of temperature	241
V-1	Temperature fluctuations near a surface washed by turbulent flow A. F. Polyakov Institute for High Temperatures, Moscow, U.S.S.R.	243
V-2	<b>A combined thermistor thermometer and anemometer</b> H. P. McNair The Gas Council, London	250
VI	Review lecture Fluid dynamic measurements in the medical environment D. L. Schultz Lecturer in Engineering Sciences, University of Oxford	259
VII	Medical measurements by thermistor and hot-film probe techniques	287
VII-1	<b>Blood flow measurement with a low power thermal flowmeter</b> W. M. Morris and J. Murray University of Edinburgh and J. H. Filshie Poultry Research Centre, Edinburgh	289
VII-2	The application of hot-film anemometry to the measurement of blood flow velocity in man W. A. Seed Imperial College, London and I. R. Thomas Kings College Hospital, London	298
VII-3	An experimental study of velocity profile development in the aorta G. P. Francis, K. M. Kiser, H. L. Falsetti State University of New York at Buffalo, U.S.A.	305
VII-4	<b>A probe for temperature and velocity measurement in biological tissues</b> A. M. Dittmar Faculté de Médecine de Lyon, France	314
VIII	Medical measurements by pressure transducer and doppler techniques	319

### Fluid dynamic measurements

VIII-1	Diagnosis of aortic incompetence using directional doppler blood velocity measurements — problems of quantitation D. S. Tunstall Pedoe Radcliffe Infirmary, Oxford	321
VIII-2	<b>Ultrasonic doppler techniques in blood velocity measurement</b> L. H. Light Clinical Research Centre, Harrow	332
VIII-3	Measurement of energy and flow distribution within heart chambers in vivo D. E. M. Taylor and J. S. Whamond University of Edinburgh	340

Index of names

345