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CONTENTS

<u>Yuliia HEORHII</u>	
DETECTION AND MITIGATION OF AI-DRIVEN ATTACKS	6
<u>Ivan GUZMAN, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
RESEARCH OF THE INERTIAL NAVIGATION SYSTEM	9
<u>Vitalii VIAZOVYK</u>	
FEATURES OF RESEARCH ON OZONE PROCESSES FOR ABSORPTION PURIFICATION OF GASES FROM NITROGEN OXIDES	11
<u>Tymofii PYLYPENKO, Viacheslav TUZ</u>	
UTOMATIC PUMP SPEED CONTROL SYSTEM FOR ACCURATE AND SAFE LIQUID FILLING	14
<u>Yevhenii USENKO, Viacheslav TUZ</u>	
ANALYSIS OF DOMINANT FACTORS AND PHYSICAL MECHANISMS OF INTERLAYER ADHESION IN FDM 3D PRINTING	16
<u>Maksym MANKO, Viacheslav TUZ</u>	
COMPARATIVE ANALYSIS OF CLASSICAL AND QUANTUM ENCRYPTION METHODS FOR SECURE MILITARY COMMUNICATIONS	18
<u>Viktoriia LYTOVCHENKO</u>	
DEVELOPMENT OF A RISK ASSESSMENT SYSTEM AND METHODS FOR MINIMIZING THE IMPACT OF CYBER THREATS IN A REMOTE OFFICE	21
<u>Andrii YAROSLAVSKYI</u>	
DEVELOPMENT OF A COMPUTER PROGRAM FOR MODELING THE ELECTRICAL IMPEDANCE OF A PIEZOELECTRIC CERAMIC TRANSFORMER	24
<u>Oleksandr RYZHAK, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
DEVELOPMENT AND RESEARCH OF ENERGY INSTALLATIONS FOR SENSOR NETWORKS	26
<u>Eduard BED, Viacheslav TUZ, Volodymyr HALCHENKO</u>	
RESEARCH ON FLIGHT ROUTING DEVICES FOR UNMANNED AERIAL VEHICLES	28
<u>Anton PIROGOV, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
STUDY OF THE AUTONOMOUS MECHATRONIC MODULE OF THE CAR CONTROL SYSTEM	30
<u>Vitaly ZAVALNYUK, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
IMPROVING THE QUALITY OF X-RAY DIAGNOSTIC IMAGES IN MATLAB ENVIRONMENT IN AUTOMATIC MODE	32
<u>Artem ANDREOLI, Viacheslav TUZ, Constantine BAZILO</u>	
RESEARCH OF A HYBRID WIND-SOLAR-DIESEL SYSTEM FOR AUTONOMOUS ENERGY SUPPLY	34

<u>Serhii OSADCHYI, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
AUTOMATED SYSTEM FOR CORRECTING MEASUREMENT ERRORS IN LIQUID FLOW METERS	37
<u>Kyrylo YURKIN, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
AUTOMATION OF ELECTRIC SPARK TESTING OF CABLE PRODUCTS	40
<u>Roman BATEKHA, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
RESEARCH ON AN AUTOMATED ACCESS CONTROL SYSTEM BASED ON FINGERPRINT BIOMETRICS	43
<u>Denys PERKIN, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
RESEARCH ON AN AUTOMATIC CONTROL SYSTEM FOR A MANIPULATOR FOR MOVING OBJECTS	45
<u>Vladyslav PRYDATKO, Viacheslav TUZ, Volodymyr HALCHENKO</u>	
AUTOMATED CONTROL SYSTEM FOR VALVE-INDUCTOR DRIVES	47
<u>Liudmyla KOMPANIETS, Viacheslav TUZ, Constantine BAZILO</u>	
AUTOMATION OF NON-INVASIVE HEALTH MONITORING	49
<u>Mykhailo KRASNOKUTSKYI, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
RESEARCH ON A WIRELESS MONITORING SYSTEM FOR SERVO DRIVE PARAMETERS	51
<u>Mykola ONISHCHENKO, Viacheslav TUZ, Volodymyr HALCHENKO</u>	
DEVELOPMENT AND RESEARCH OF AN AUTOMATED GAS CONSUMPTION CONTROL SYSTEM	54
<u>Vitaly ROTAYENKO, Viacheslav TUZ, Ruslana TREMBOVETSKA</u>	
AUTOMATED MEASURING STAND FOR SPACECRAFT CONTROL	56
<u>Olha BASARAB, Maksym BONDARENKO</u>	
RECONSTRUCTION OF SURFACES WITH SCALE-INVARIANT MORPHOLOGY USING ATOMIC FORCE MICROSCOPY	59
<u>Serhii BOHDAN, Constantine BAZILO</u>	
DEVELOPMENT AND RESEARCH OF AN OPTICAL TELEVISION SYSTEM FOR MONITORING AIRSPACE	61
<u>Vitalii CHEREDNICHENKO, Volodymyr HALCHENKO</u>	
DEVELOPMENT AND RESEARCH OF A COMBINED 3D SCANNER WITH PRECISE DETERMINATION OF THE GEOMETRY OF DARK AND TRANSPARENT OBJECTS	63
<u>Ruslan CHUMAK, Maksym BONDARENKO</u>	
COMPARATIVE ANALYSIS OF SCANNING PROBE MICROSCOPY METHODS	66
<u>Andrii STEPANENKO, Constantine BAZILO</u>	
IMPROVEMENT OF PIEZOELECTRIC DRIVE FOR MICRO-ROBOT CONTROL	70

<u>Oleksandr STEPANENKO, Constantine BAZILO</u>	
RESEARCH ON THE INFLUENCE OF TECHNOLOGICAL MODES OF FORMING ANTI-REFLECTION COATINGS ON THEIR OPERATIONAL CHARACTERISTICS	73
<u>Liuba KAMIANSKA</u>	
COMPARATIVE ANALYSIS OF CLASSICAL AND MODERN APPROACHES TO INFORMATION STEGANOGRAPHY	76
<u>Olha ZATORA</u>	
COMPARATIVE ANALYSIS OF STATE SECRET PROTECTION IN UKRAINE AND CANADA	78
<u>Vladyslav FAI, Volodymyr HALCHENKO</u>	
WEAR CONTROL OF HIGH-PRECISION SLIDING ELECTRICAL CONTACTS IN LOW-SPEED APPLICATIONS	80
<u>Maksym SOROKA, Constantine BAZILO</u>	
ULTRASONIC AUTOMATED SYSTEM FOR CONTROLLING THE ORIENTATION OF DETAIL EDGES DURING LASER WELDING	82
<u>Maksym TKACHENKO, Volodymyr HALCHENKO</u>	
CONTROLLED TWO-SIDED CONVECTIVE-BEAM GRAIN DRYING SYSTEM	85
<u>Constantine BAZILO, Maksym BONDARENKO, Liudmyla USYK, Emil FAURE</u>	
AN INTELLIGENT PLATFORM FOR ULTRASONIC ASSISTED EXTRACTION OF PLANT RAW MATERIALS FOR PERSONALISED NUTRIENT SUPPORT	87
<u>Yevgeny KORSHUN, Volodymyr TYCHKOV, Ruslana TREMBOVETSKA, Volodymyr HALCHENKO</u>	
IMPROVING THE EFFECTIVENESS OF ENVIRONMENTAL MONITORING AND PROTECTION OF WATER RESOURCES	89
<u>Dmytro TYCHKOV, Maksym BONDARENKO</u>	
ANALYSIS OF THE INFLUENCE OF EXTERNAL FACTORS ON THE ACCURACY AND RELIABILITY OF MEASUREMENTS OF LOW-INTENSITY ELECTRIC FIELDS USING AN INFORMATION-MEASUREMENT SYSTEM	91
<u>Natalia TYCHKOVA, Volodymyr HALCHENKO, Ruslana TREMBOVETSKA</u>	
DETERMINING EFFECTIVENESS BASED ON THE ACCURACY CRITERION OF THE OPTIMIZATION METHOD FOR RECONSTRUCTING PROFILES IN THE PCA SPACE	93
<u>Oleksandr RUDENKO</u>	
ADAPTIVE OPTIMIZATION OF INDUSTRIAL VENTILATION SYSTEM ENERGY CONSUMPTION BASED ON MODEL PREDICTIVE CONTROL (MPC)	95
<u>Nikon BUGAYCHUK, Volodymyr TYCHKOV, Volodymyr HALCHENKO, Ruslana TREMBOVETSKA</u>	
ROBUST PARAMETRIC DESIGN OF EDDY CURRENT PROBES FOR ACCURATE MEASUREMENT OF MAGNETIC PERMEABILITY IN MOVING FERROMAGNETIC STRIPS USING TAGUCHI OPTIMIZATION	98

<u>Yeqor ANTAS, Oleksandr VASYLKIVSKYI, Oleksandra SEREDA, Ievgen KHYZHNIAK</u>	
REVIEW OF METHODS AND PROSPECTS FOR POST-PROCESSING OF METAL 3D-PRINTED PARTS	100
<u>Heorhii KANASHEVYCH, Yevhenii MALETSKYI, Ihor KOSTIUK, Roman KUSHNIROV</u>	
ETHICO-LEGAL ASPECTS OF DEVELOPING AN ALGORITHM FOR THE OPERATION OF INDIVIDUAL INTELLECTUAL MEDICAL DEVICES – "LAST RESORT" DEVICES IN TACTICAL MEDICINE	102
<u>Oleksandr HREBENIUK, Anton ZHYZHKA, Viktor VASYLCHENKO, Andriy LEGA</u>	
TECHNOLOGIES FOR APPLYING LUBRICANTS AND COOLANTS AND THEIR POTENTIAL IMPACT ON THE WEAR RESISTANCE OF THE WORKING SURFACE OF THE TOOL	105
<u>Volodymyr KOVTUN, Yevhenii ZHYRNYI, Viktor VASYLCHENKO, Oleksandr KOVALENKO</u>	
INVESTIGATION OF THE INFLUENCE OF FUEL OZONATION ON FUEL ACTIVATION	107
<u>Valentin GORDIENKO, Viktor VASYLCHENKO, Vladyslav VYHOVSKYY, Maksym HOLUB</u>	
RESEARCH OF THERMAL COMPENSATION IN OPTOELECTRONIC MODULE	109
<u>Serhii MATSEPA, Yurii KOVALENKO, Maryna YURCHENKO, Andrii MATIUKHA</u>	
MODELS AND METHODS FOR ANALYSIS OF MONITORING DATA OF ELECTRON BEAM PROCESSING OF OPTICAL COMPONENTS	111
<u>Oles STANKEVYCH</u>	
INTELLIGENT SYSTEM FOR THE SMART SORTING OF METALS: A GENERATIVE ADVERSARIAL APPROACH TO SOLVING THE INVERSE PROBLEM	114

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AUTOMATED SYSTEM FOR CORRECTING MEASUREMENT ERRORS IN LIQUID FLOW METERS

Abstract. The aim of this work is to develop an automated system for correcting measurement errors of liquid flow meters, particularly those using orifice plate type restriction devices. The relevance of the work stems from the need to improve the accuracy of commercial and technological accounting of liquid flow, especially in the context of energy saving, and to account for operational factors affecting the metrological characteristics of flow meters. The research focuses on analyzing the impact of inlet edge dulling of the orifice plate on flow measurement results. Using hydrodynamic modeling in the SolidWorks Flow Simulation environment, a quantitative relationship between the edge rounding radius and the measurement error was established. Based on these studies, the structure of an information-measuring system (IMS) is proposed, capable of automatically correcting the flow meter readings considering the identified dependency and measured flow parameters (temperature, pressure).

Key words: automated system, error correction, liquid flow meter, orifice plate, restriction device, edge dulling, measurement error, SolidWorks Flow Simulation, information-measuring system (IMS).

Introduction. Accurate measurement of liquid flow is a critical task for effective process control and rational use of energy resources. Variable pressure drop flow meters with standard orifice plates are widely used due to their simplicity and reliability. However, their accuracy depends on the stability of geometric parameters, particularly the sharpness of the orifice plate's inlet edge. During operation, this edge inevitably dulls due to fluid friction, leading to a change in the discharge coefficient and, consequently, an additional systematic measurement error. Existing calibration methods and standards do not always fully account for this dynamic wear process. Therefore, the development of automated systems capable of correcting measurement errors caused by operational changes in flow meter parameters is a relevant task. The aim of this work is to develop such a system based on investigating the impact of orifice plate edge dulling.

Methods and Materials. An analysis of existing methods for measuring and calibrating liquid flow meters, as well as methods for improving measurement accuracy, including automatic error correction techniques, was conducted. The design parameters of standard orifice plates according to DSTU standards were examined in detail, and the influence of inlet edge dulling on flow hydrodynamics and the discharge coefficient was investigated.

To quantitatively assess the impact of edge dulling on flow measurement, computer modeling was used. A 3D model of the flow meter's flow path with an orifice plate was created in the SolidWorks environment. Using the Flow Simulation module, a series of hydrodynamic calculations of water flow were performed at a fixed pressure drop for various values of the inlet edge rounding radius (r_k). A computational mesh was generated using the finite volume method with refinement near the orifice plate (Fig. 1).

The dependence of the volumetric flow rate on the radius r_k and the corresponding relative measurement error were calculated. It was found that the error significantly increases with an increasing rounding radius.

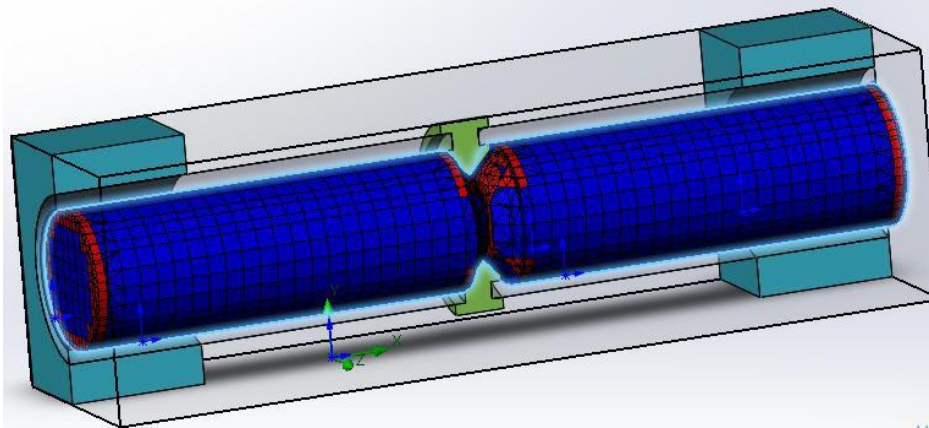


Fig. 1. Adaptive mesh of the model under study

Based on the analysis and modeling results, the structure of an automated error correction system integrated into an information-measuring system (IMS) for flow was proposed (Fig. 2).

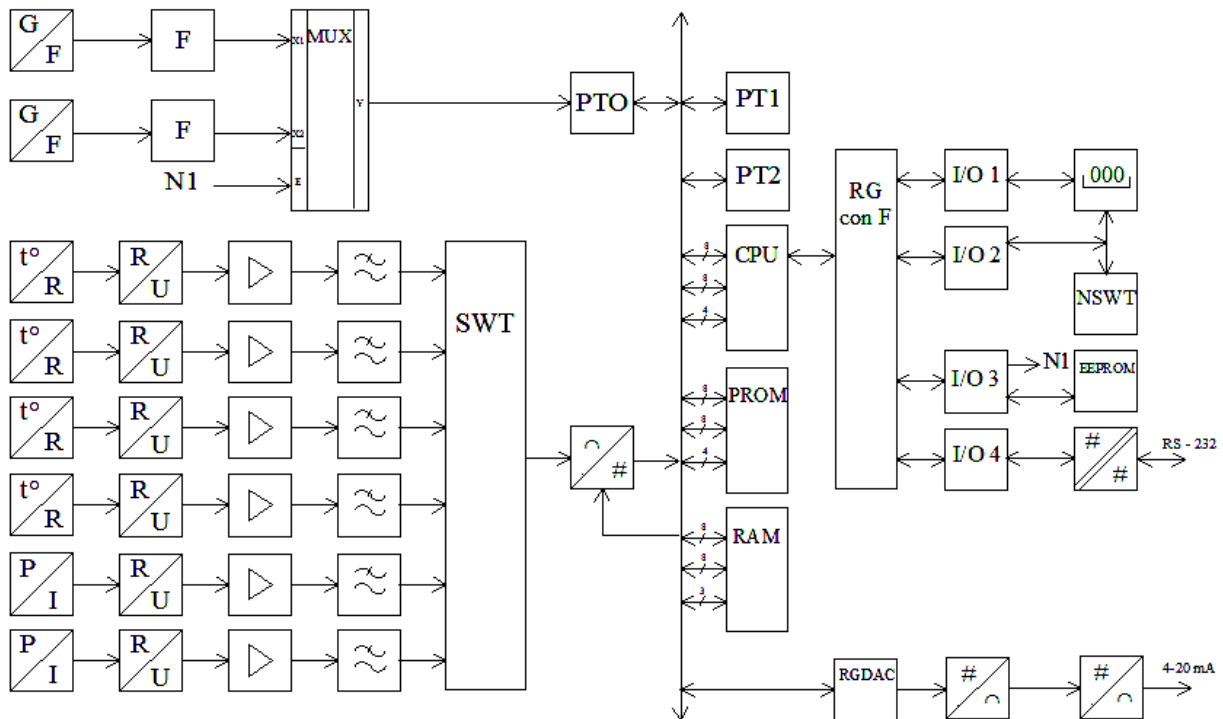


Fig. 2. Functional diagram of the IMS with correction capability

The IMS includes primary transducers for flow (e.g., electromagnetic), temperature (resistance thermometer), and pressure (pressure sensor). The system's microprocessor unit collects data from the sensors, performs ADC conversion, and calculates the flow rate, taking into account the temperature dependence of the fluid density. To correct the error associated with edge dulling (in the case of using an orifice plate flow meter), the introduction of a correction factor into the calculation algorithm is envisaged. This factor can be determined based on the error- r_k relationship obtained from modeling and data on the orifice plate's operating time (using empirical wear models) or from periodic measurements of the actual rounding radius.

Conclusions. The problem of the influence of operational wear (inlet edge dulling) of standard orifice plates on the accuracy of liquid flow measurement was investigated. Using hydrodynamic modeling in SolidWorks Flow Simulation, a quantitative relationship between the edge rounding

radius and measurement error was obtained, confirming the significance of this factor. The structure of an information-measuring system was developed, which measures the main flow parameters (flow rate, temperature, pressure) and allows for automatic correction of errors in variable pressure drop flow meters based on a model of the edge dulling effect. The proposed approach allows for increased accuracy in accounting for liquid flow over the long-term operation of flow meters.

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