27th INTERNATIONAL SCIENTIFIC SYMPOSIUM

METROLOGY AND METROLOGY ASSURANCE 2017

PROCEEDINGS

September 8-12, 2017, Sozopol, Bulgaria

RESEARCH ON AIR-ELECTRONIC GAUGES AND METHODS FOR ELIMINATION OF INFLUENCING FACTORS

1) Miroslav Hristov 2) Georgi Dukendjiev
1) Mag. Eng. "Mechanical Engineering and Instrumentation", Ph.D. student in the Department of Precision Engineering and Instrumentation, Mechanical Engineering Faculty, Technical University of Sofia e-mail: miro_hr@ymail.com 2) mechanical engineer (1981). Professor (2015), PhD (1994), Department of Precision Engineering and Instrumentation, Mechanical Engineering Faculty, Technical University of Sofia, Control Engineering and Quality Management. e-mail: duken@tu-sofia.bg

Abstract: Modern air gauges are directly related to the development of electronics and computers. This leads to some advantages associated with their exploitation. Compared to conventional air gauges appliances in air-electronics we have a simple setup of the measuring equipment, but it still remains complex and depends on the operator. The main factors influencing the accuracy and metrological reliability of these devices are the supply pressure, the non-linearity of the transformation function. These factors have been studied, their influence has been assessed and software offsets are proposed.

Key-words: air gauges, accuracy, pressure regulator
Pages from: 86 to: 90
Language of the report: english

Click here for full text

VI.2. EVALUATION OF UNCERTAINTY OF ACTIVE COMPONENT OF ULTRASONIC SHEAR WAVES COMPLEX REFLECTION COEFFICIENT FROM THE LINE OF DEMARCATION SOLID BODY – LIQUID
VI.3. METHODS OF MEASUREMENTS OF PARAMETERS OF THE ACOUSTIC FIELD CREATED BY IONIZING RADIATION
VI.4. EVOLUTION AND EXTENSION OF SPECTRA'S OWN SOLUTION FOR MEASUREMENT, MONITORING AND REAL TIME DISPLAY OF ENVIRONMENTAL PARAMETERS (NOISE, VIBRATION, POWDER, METEO DATA, OTHER) - WEBNOISE.EU.
VI.5. PRESENTATION OF THE RESULTS AND CONCLUSIONS OF THE REGULATORY SECOND ACOUSTIC PROJECT FOR THE NEEDS OF “SOFIA AIRPORT”, PERFORMED BY SPECTRY EOOD - A PART OF THE CONDUCTS PERMANENT MONITORING AND MANAGEMENT OF SOIL IN THE ENVIRONMENT, FROM "SOFIA AIRPORT" EAD
VI.6. METROLOGICAL ASSURANCE, CONFIGURATION AND LAUNCH OF A NEW SPECTRI TECHNICAL FIELD - SPECTROMETER, CALIBRATORS AND NOISE MEASURING LABORATORY SPECTRI-LAB. ESTABLISHING ITS OWN METHODOLOGIES AND APPLYING THE RELEVANT INTERNATIONAL STANDARDS
VI.7. IMPLEMENTATION OF THE REQUIREMENTS FOR THE ACCREDITATION OF EXECUTIVE AGENCY “BULGARIAN ACCREDITATION” SERVICES AND THE REQUIREMENTS OF THE STANDARD ISO / IEC 17020: 2012 TO THE SPECTRUM MEASUREMENT CONTROL AUTHORITY WITH SPEKTRI LTD
VI.8. EQUIPMENT TESTING FOR ENVIRONMENTAL EFFECTS TO ENSURE SAFE TRANSPORT

Section: VII. MEASUREMENTS IN THE ECOLOGY, BIOTECHNOLOGY, MEDICINE, AND SPORT

VII.1. AUTOMATION OF MEASUREMENT OF OBJECTS GEOMETRICAL PARAMETERS
VII.2. COMPUTERIZED SYSTEM FOR INVESTIGATION OF ORGANIC MONOLAYERS AT THE AIR-WATER INTERFACE AND FOR DEPOSITION OF NANO THIN LAYERS FOLOWING THE LANGMUIR AND BLODGETT METHOD
VII.3. PHOTOMETRIC FLICKER IN COMPUTER DISPLAYS BACKLIGHT AND A METHOD FOR REDUCTION OF ITS HUMAN HEALTH EFFECTS
VII.4. DISEASES OF INTERNAL ORGANS SUCH AS THE VALUE DEFINED BY USING MEASUREMENTS SET OF PARAMETERS OF THE HEART RATE
VII.5. MODERN ENGINEERING TECHNOLOGY FOR SWIMMING MEASUREMENTS
VII.6. DEVELOPMENT OF SCIENTIFIC AND TECHNICAL CAPABILITIES OF THE BULGARIAN INSTITUTE OF METROLOGY IN THE FIELD OF CHEMICAL ANALYSIS
VII.7. QUALIMETRY PEDAGOGICAL TECHNOLOGIES IN PHYSICAL CULTURE AND SPORTS
VII.8. TOPICAL TASKS OF METROLOGY FOR DIAGNOSTICS OF INFANT'S BRAIN PATHOLOGIES

Section: VIII. MEASUREMENTS IN HUMANITIES

VIII.1. COMPUTER ANALYSIS OF MUSICAL SOUND AND PROBLEMS OF RESULT NOTATION
VIII.2. DIFFERENCES BETWEEN MEASURING DURATIONS IN THE LABORATORY EXPERIMENTS AND TIME MEASUREMENTS IN THE LIFE-SCIENCES AND HUMANITIES
VIII.3. HUMANITARIAN MEASUREMENTS: PRINCIPAL PECULIARITIES (SYSTEMIC-INFORMATIONAL APPROACH)
VIII.4. 'REGRESSION TO THE MEAN' IN CREATIVE ABILITIES: A TRIAL TO MEASURE THE PEDAGOGIC PROCESS
VIII.5. ANALYSIS OF MULTIDIMENSIONAL PROBABILISTIC PROCESSES IN PSYCHOLOGICAL EXPERIMENTS
VIII.6. THE PERSONALITY OF THE STUDENTS DIFFERENT SPECIALIZATIONS

Section: IX. QUALITY MANAGEMENT AND CONTROL, STANDARDIZATION AND CERTIFICATION

IX.1. THE CONTENTS AND THE DIFFERENCE BETWEEN THE TERMS „DESIGN“ AND „DEVELOPMENT“ IN THE QUALITY MANAGEMENT PROCESS „8.3 DESIGN AND DEVEL-

OPMENT OF PRODUCTS AND SERVICES“ ACCORDING TO THE ISO 9001:2015 REQUIREMENTS
IX.2. CONTROL STABILITY OF INDICATORS PRODUCT QUALITY
IX.3. EFFICIENT SYSTEM FOR CONDUCTING QUALITY INSPECTION ON THE PRODUCTION LINES
IX.4. DETERMINATION OF SAMPLE SIZE IN STATISTICAL PROCESS CONTROL WITH A SET RISK OF INCORRECT DECISION-MAKING
IX.5. AUTOMATED SYSTEM FOR CONTROL AND MANAGEMENT OF A MACHINE FOR AUTOMATIC ASSEMBLY OF CURTAIN BRACKETS AND HOOKS
IX.6. ESTIMATION OF THE MEASUREMENTS’ ACCURACY DURING THE PRODUCTION OF THE NEW LIQUOR "MENTINA"

RESEARCH ON AIR-ELECTRONIC GAUGES AND METHODS FOR ELIMINATION OF INFLUENCING FACTORS

Miroslav Hristov, Dukendjiev Georgi

Abstract: Modern air gauges are directly related to the development of electronics and computers. This leads to some advantages associated with their exploitation. Compared to conventional air gauges appliances in air-electronics we have a simple setup of the measuring equipment, but it still remains complex and depends on the operator.

The main factors influencing the accuracy and metrological reliability of these devices are the supply pressure, the non-linearity of the transformation function. These factors have been studied, their influence has been assessed and software offsets are proposed.

Key words: air gauges, accuracy, pressure regulator.

1. Introduction

Air-electronic gauges (AER) are constantly evolving, with manufacturers' efforts aimed at reducing deficiencies and expanding their capabilities.

Permanent targets for improvement include metrological features and calibration methods for AER, measurement uncertainty reduction and increased reliability.

Despite the existence of various influencing factors on the accuracy of measurement with air gauges, one of the main components of the error is due to the change in supply pressure.

This error depends on the pressure regulators, which are one of the most important elements of AER.

2. Exploration of the characteristics of the IBR ae-1

To determine the influencing factors, it is necessary to study the static characteristics of the measuring system. In this case, a function of transformation of the input magnitude is represented in graphical form - displacement and the value reported by the device (Fig.1). It shows the change of the instrument reading in relative units vs. the linear displacement in µm. For this purpose a characterization was performed with 3 of the most common measuring nozzles - 1.5; 2 and 2.5 mm. The graphical representation is for a 2 mm nozzle.

In the middle part of the graph a relatively large linear region is observed. This section approximates to linear as the error of non-linearity is below 2%. The non-linearity is 7.14% across the surveyed range.

Of particular importance is the hysteresis of the regulator (Fig. 2). It varies between 0.15 and 0.85 relative reading units on the digital display of IBR ae-1. Depending on the operation of the appliance, this may lead to a result error within ± 0,45 µm.

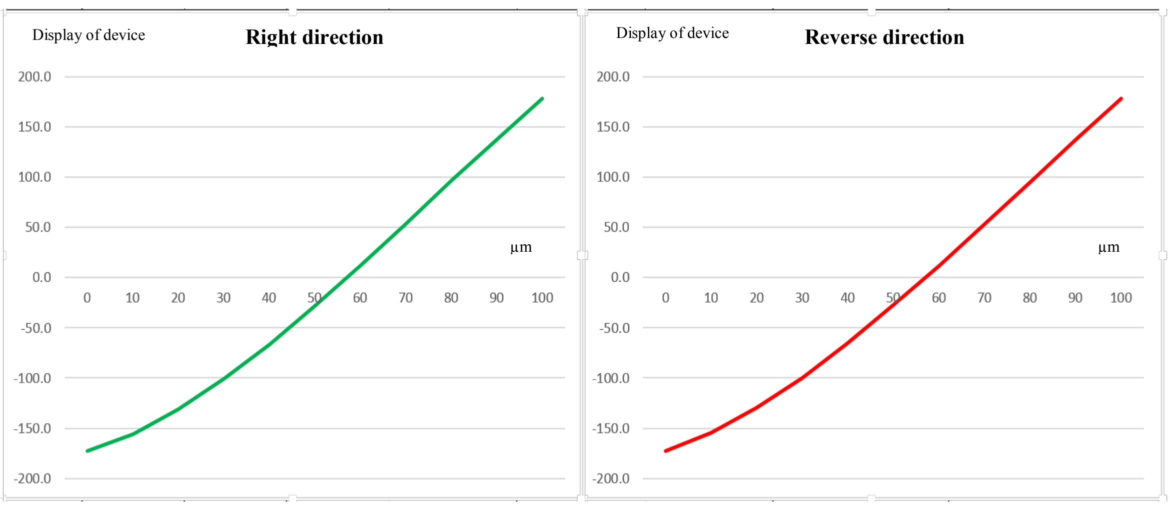

Fig.1 – Conversion function - relative unit to linear displacement in µm

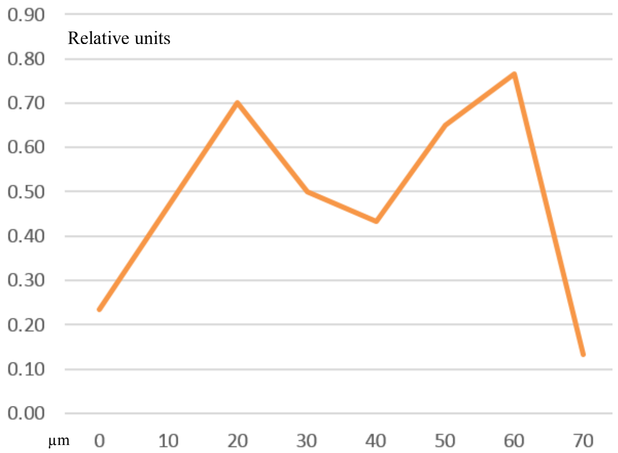

Fig.2 – Change hysteresis of IBR ae-1 in the range 0-70 µm.

3. Pressure regulators.

The correct choice of a pressure regulator is important in a metrological aspect when developing an air gauge. The solution requires familiarization with the operating conditions and principles of the regulator's operation. [1]

3.1. Types of pressure regulators:

In Fig. 3 a diagram of the non-amplifying pressure regulator is shown. The magnitude and stability of the working pressure is a function of several variables. The output of the analytical expression for H is based on the equation equilibrium force acting on the moving parts.

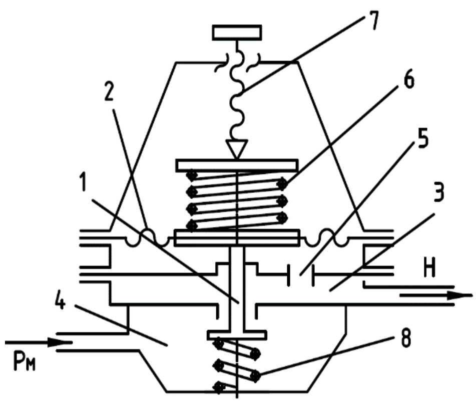

Fig.3 – Principal circuit of non-amplifier regulator: 1. valve; 2.membrane; 3.camera; 4. Inlet chamber; 5. throttle 6. spring; 7.vint; 8. spring

Therefore, the ability of regulators without amplification in terms of accuracy is too limited in terms of principle and construction. In this respect, regulators with an amplification are significantly superior. [1]

Fig. 4 shows a schematic diagram of such a regulator. There are four chambers: 1 and 6 with high pressure, 4 and 7 with working pressure. Even a slight change in working pressure ensures a strong increase (decrease) in air flow and hence great sensitivity of the regulator. The errors of this type of regulator caused by network pressure fluctuations and air consumption are significantly lower than those of the other type without an amplification, and a shift of the working pressure is practically not obtained. [1]

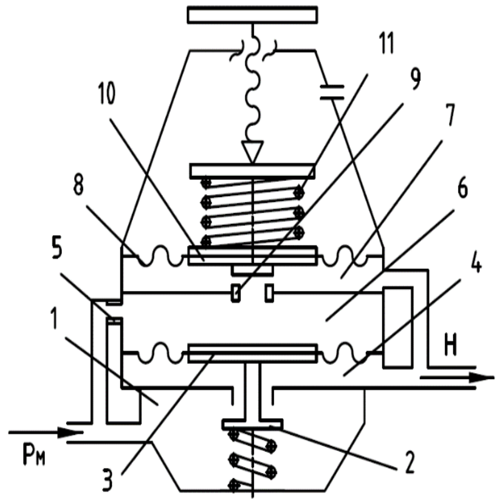

Fig.4 – Principal circuit of a regulator with amplification: 1. Input chamber; 2. valve; 3. membrane; 4. chamber with working pressure; 5. throttle; 6. a high pressure chamber; 7. chamber with working pressure; 8. Membrane; 9. Nozzle; 10. interception; 11. spring

3.2. Pressure regulators offered by leading manufacturers:

One of the leading manufacturers of pressure regulators is SMC (Japan). For the purpose of the study we used two of their regulators:

- Simple (no amplification) - SMC AR20 F02H
- Precision (with amplification) - SMC IR 1000

The manufacturer presents the characteristics as graphs representing the relationship between inlet and outlet pressure, consumption and hysteresis.

For the SMC AR20 F02H pressure regulators, according to the manufacturer's technical parameters, a change in the outlet pressure is observed when the flow rate changes in a relatively small range [2,3]

Standard AERs work with inlet pressure ranging from 2-4 atm. Here, a group of curves with the closest characteristics is observed. A major problem in the application of AER in industrial conditions

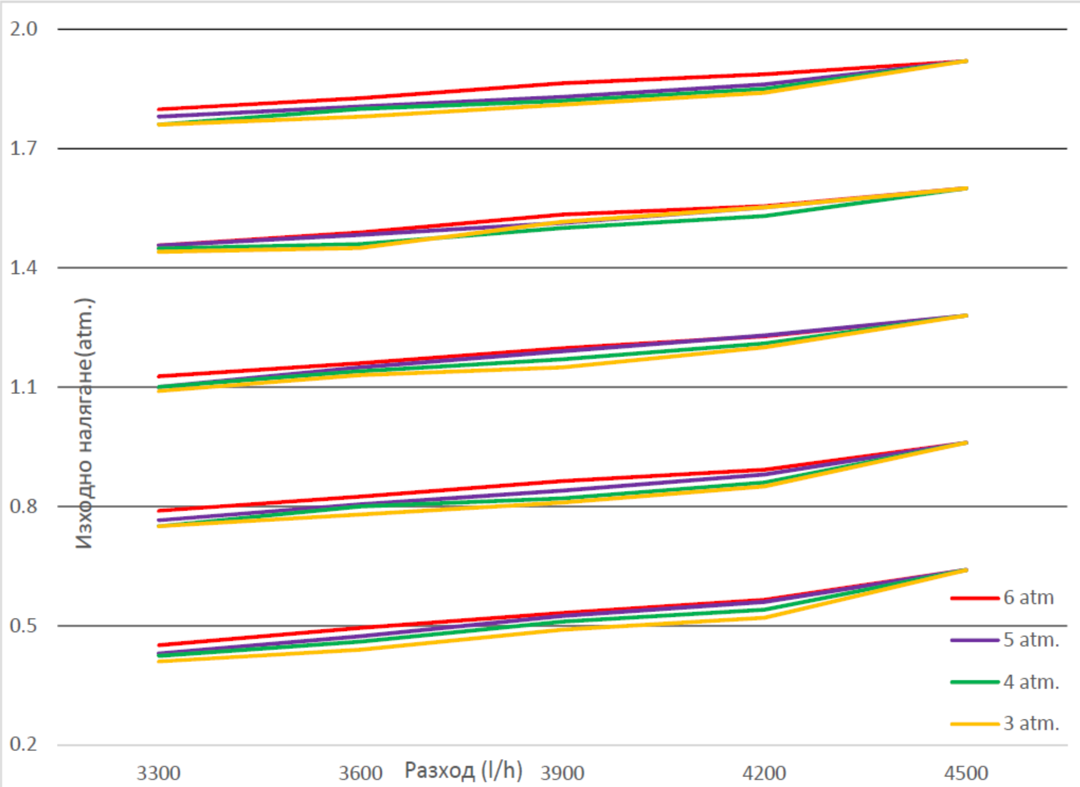

Fig.5 – Graph of change in output pressure as a function of airflow at regulator SMC AR20

where there are too many air consumers and there is a large change in the pressure to the pressure regulator. This leads to an additional stabilization error caused by the change in the rise and pressure reduction - hysteresis of the regulator. This error is around 0.1 atm.

Precision (with amplification) regulators have significantly improved performance. Again, the main influential factors here are related to the variable inlet pressure and the variable flow in industrial conditions. Here the errors that are observed are one order smaller than the non-amplified regulators.

4. Influence of SMC AR20 F02H and SMC IR 1000 on the accuracy of pneumatic-electron measuring instrument IBR-ae1.

From the research done, the influence of the pressure regulator on the pneumatic system IBR ae-1 is observed. The main parameters of the study are related to changes in the supply pressure and the influence it exerts on the outlet pressure of the regulators.

From graphically obtained results, for the SMC AR20 regulator, it can be concluded that when the supply pressure changes by 1 atm.in a normal range for industrial conditions of 3 to 6 atm, a change of the outlet pressure was observed by 0.02 atm. This change caused a ~ 1μm error in the investigated IBR ae-1 (Fig.5).

For the precision pressure regulator SMC IR 1000, the error of the input pressure fluctuation of 0.3 MPa causes an error in the IPR to be tested ~ 0.9 ÷ 1,3 μm (Fig.6)

Under real conditions, the oscillating pressure in the feed system rarely exceeds 1 atm, which may result in an error of ~ 0.3 μm

The main source of error in the pressure regulators is the hysteresis error at the supply pressure fluctuations (Fig. 7). With simple regulators, this error results in ~0.02 atm., and with the precision regulators of 0.004 to 0.008 atm. The reported result in a change in IBR ae-1 score of 1 μm in simple regulators (SMC AR20) and up to 0.5 μm in precision (SMC IR 1000)

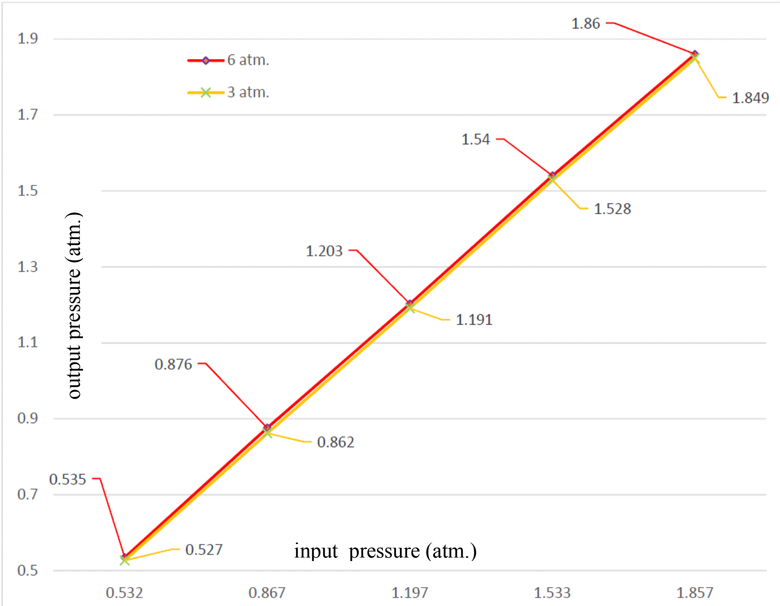

Fig.6 - Graph of change of output pressure as a function of input at regulator SMC IR1000

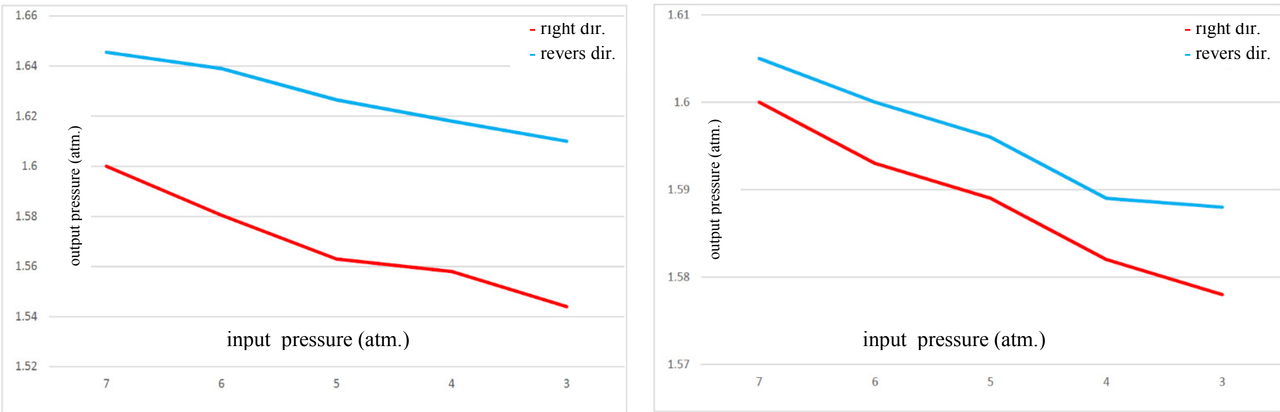

Fig.7 – Hysteresis when changing the supply pressure of pressure regulators SMC AR20 and SMC IR1000

5. Opportunities to improve metrological and operational performance of AERs

In order to determine the dependence of the influence factors on the AER transformation function, a regression analysis is required. The conversion function is nonlinear, but there is a linear dependence between the change in the supply pressure and the change in the output parameter.

When changing the inlet pressure of the system, a family of curves and a relatively large linear region can be observed in the middle of the measuring range (Fig. 8). Based on these curves, a regression model can be calculated.

5.1. Reducing the non-linearity of the AER conversion function

The use of a regression model to calculate the conversion function introduces an error relative to the real transformation characteristic, but significantly reduces the error of the change in the input pressure. For the determination of the regression model we use an average value obtained after experimental dropping of the characteristic for different input value (linear displacement) in different tooling (output nozzle) and different supply pressure values.

In the regression model a coefficient of coverage between the real characteristic and the calcu-

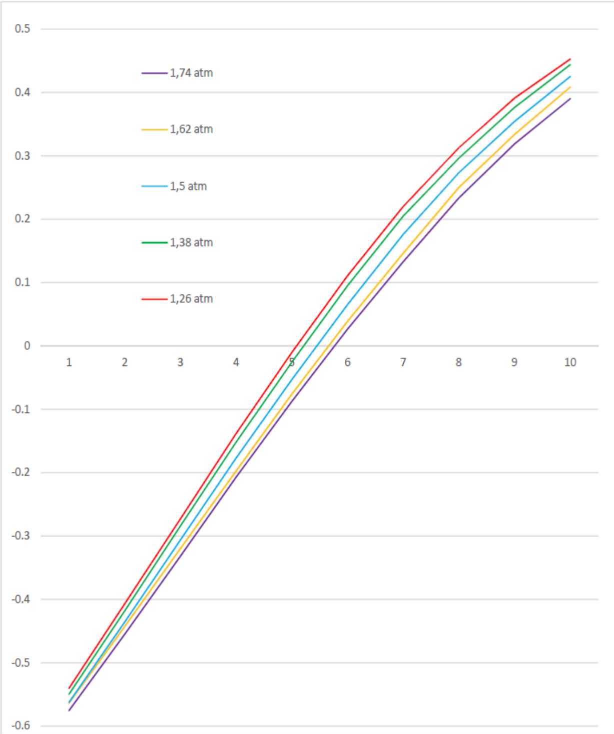

Fig.8. Family curves as a function of the relative value of IBR ae-1 to linear displacement at change of inlet pressure

lated Sm ~ 4% for the different curves is obtained. After correction of each value, a maximum error shall not exceed 0,5%

Because of the nonlinear nature of the conversion function, we have a fault of nonlinearity that can be compensated by importing a "fault map" in which correction values for different cases to construct approximation rights to be entered.

These actions help to directly increase the measuring range as the system can operate close to both ends of the transformation characteristic.

5.2. Compensation of supply pressure oscillation by introdction of „Error map“

The AER characteristics of the pressure regulator used are pre-recorded. With the data thus obtained a database is created - "error map". For correction, it is necessary to monitor the inlet pressure change in operating mode. The resulting current value "subtracts" from the result correction database. Thus, the error of the AER indication is reduced by up to 5% depending on the working pressure and the used tooling.

6. Conclusions

The influence of input pressure on the accuracy of AER was studied. It is proposed to introduce into the measuring system a converter for input pressure reading and direct correction on the result by means of software compensation.

This improves the metrological characteristics of AER and simplifies the setup methodology.

The study is funded by NIS at the TU-Sofia under contract № 162ПД0034-06.

7. References

[1] **Semerdzhiev A.,** Avtomatizatsiya na kontrola v mashinostroeneto, S.Tehnika 1990

[2] **Dukendjiev G., R.Yordanov,** Kontrol i upravlenie na kachestvoto, Sofiya., Softtreyd, 2002

[3] **Modular Type Regulators Series AR.,** *SMC Corporation*, PDF Version 2009

[4] **Precision Regulators Series IR1000/2000/3000,** *SMC Corporation,* PDF Version 2009

Information for authors:

Miroslav Hristov, Mag. Eng. "Mechanical Engineering and Instrumentation", Ph.D. student in the Department of Precision Engineering and Instrumentation, Mechanical Engineering Faculty, Technical University of Sofia

e-mail: miro_hr@ymail.com

Georgi Dukendjiev, mechanical engineer (1981). Professor (2015), PhD (1994), Department of Precision Engineering and Instrumentation, Mechanical Engineering Faculty, Technical University of Sofia, Control Engineering and Quality Management.

e-mail: duken@tu-sofia.bg