Ministry of Scientific Research
National Institute of Standards
(NIS)

Written report covering the period 2019 – 2021

Mass and Related Quantities

National institute of standards (NIS)- Egypt

18th meeting of the CCM

20 and 21 May 2021

Tersa Street, El-Haram, El-Giza – EGYPT
Box: 136 Giza Code No. 12211
Fax: 33867451- Tel: 33879241

TABLE OF CONTENTS

I. Main running/completed research activities in Mass, Force, Torque, Pressure, Density, Viscosity, Hardness and Fluid Flow

1. Using Single Crystal Silicon Sphere for Primary Density Measuring Systems

Ongoing PhD study by Mohamed Hamdy

Using Single Crystal Silicon Sphere (SCSS) as international standard to replace the Platinum Iridium kilogram (Pt-Ir) is under investigation through the Avogadro constant redetermination project. Using this (SCSS) in density measurement will become mandatory which needs a lot of studies and investigations that will be covered in this research.

As an application the using of (SCSS) to determine the density of various types of materials. The most important of these types are liquids and solids which cover the applicable range from 400 kg/m^3 to 9000 kg/m^3. Given the importance of these measurements scientifically and industrially, the National institute of standards (NIS) has some primary standards instruments in these fields, but these primary standards instruments do not cover all ranges, and do not full fill the requirement (Accuracy and Uncertainty). So, this research aims to use of (SCSS) for primary density measuring systems in order to complete the density measurements ranges at the National institute of standards through Avogadro constant traced to (SCSS).

2. Establishment of NIS Watt Balance Prototype

Plan of PhD study by Elsayed Emira

Establishment and characterize of NIS Watt balance.

Study the metrological characteristics of the balance system.

Study the contribution of different parameters on uncertainty measurement.

Study the improvement of magnetic properties for different alloys of the permanent magnet through:

Preparation and development of nanostructured hard permanent magnet using different techniques.

Characterize the magnetic properties by vibrating sample magnetometer (VSM).

Characterize the phase structure and composition by X-ray diffraction (XRD).

Characterize the morphology of nanostructured permanent magnet using a transmission electron microscope (TEM) / (SEM).

Characterize the thermal analysis by differential thermal analysis (DTA).

Determine Planck's constant from known mass standards traceable to the national prototype kilogram (NPK).

Estimate of the uncertainty associated with the Watt balance measurements.

Investigate of the Watt balance measurements.

3. Establishment a versatile system for measuring the density of various kinds of materials"

Plan of PhD study by Mohamed Rabie Hassan

Establishment a new hybrid (vertical-horizontal) system for measuring the density of materials using magnetic levitation method (Mag Lev).

Apply the mathematic model for hybrid (vertical-horizontal) system to measure the materials density.

Simulate the Mag Lev method using a software package.

Study the proposed method for measuring density through the following variables to obtain the optimal operating conditions:

- Using different distances between the two magnets.
- Using different magnet's shape and magnetic flux intensity and then analysis of their influences.
- Using different paramagnetic solutions.

4. Factors influencing primary and standard masses values dissemination and determination

Completed M.Sc theses by El sayed Emira

This research aims to study the effect of environmental and storage conditions of the laboratory on the stability of surface of the standard masses. The influence of these factors on the change of the values of the standard masses and the possible different kinds of contamination which would form on the surface of these masses will be investigated.

The work will includes measuring the thickness of the contamination layer formed on the surface of the mass standard and study some of the ways used for the disposal of various types of contamination, which formed on the surface of the mass standard. Re-establish of the mass scale at mass, density and pressure lab traceable to the National prototype Pt-Ir No. (58), as well as calculation of the associated uncertainty.

5. Investigation of non-rotating piston gauges as primary and secondary standards for the intermediate vacuum-pressure range from 0 to 15 kPa

Ongoing PhD study by Ahmed Hashad (in cooperation with PTB)

Analysis of Force-balanced Piston Gauges (FPG) as primary and secondary absolute and gauge pressure standards in the pressure range from approximately 0 Pa to 15 kPa. Possible approaches for the realisation of FPG traceability to the SI units. Preparation of a concept of dimensional measurements to be performed on the piston and cylinder bore of the FPG, coordination of the dimensional measurements and evaluation of the dimensional results.

Review of gas flow models for FPG piston-cylinder gap. The models should provide a pressure distribution in the piston-cylinder gap as a function of the operational mode (gauge or absolute), gas type and the generated pressure. In particular, the Dadson theory describing the viscous flow has been considered.

Application of the viscous flow model to a real FPG taking into account its dimensional properties and axial non-symmetry of the piston-cylinder assembly (PCA). Calculation of the effective area of the PCA based on the dimensional data and the flow model.

Determination of the effective area changes when the measured pressure is reduced down to zero.

Experimental study of the FPG aimed at the validation of the theoretical results and, also, determination of the measurement capabilities of the FPG as a secondary pressure standard.

Comparison of the FPG against the primary mercury manometer from the maximum operating pressure of 15 kPa down to 100 Pa in gauge and absolute pressure mode.

Comparison of the FPG against the static expansion vacuum system from the operating pressure of 300 Pa down to 3 Pa in absolute pressure mode.

6. Establishment and characterization of reference system for calibration of dynamic pressure sensors

(Completed PhD theses by Shaker Gelany)

Measurement standards for dynamic pressure and its traceability to the International System of Units (SI) is a novel field in metrology. Therefore, such standards are not commonly found in National Metrology Institutes (NMIs) that could enable calibration of modern dynamic pressure transducers. For several industrial fields using dynamic pressure technologies, this in turn, limits quality assurance. Due to, the lack of traceability in the dynamic pressure measurements, the dynamic pressure sensors and transducers are calibrated using static or quasi-static methods. This may lead to significant errors in measurements as the behavior of the sensor in the dynamic mode differs from the static mode. In response to this problem, this study has been dedicated to establish and investigate a primary standard system for dynamic pressure measurements up to 100 MPa with relative uncertainty as low as 1.5 %. This new reference dynamic pressure standard is of crucial importance to develop calibration methods for dynamic pressure transducers. Furthermore, it provides the metrological basis for the dynamic pressure technologies such as automotive industries, military, aerodynamics, medicine, and material testing.

7. Two-phase flow in changing area conduit and its application in flow metrology

(Completed PhD theses by Ali Zahran)

The present study will concentrated on two-phase flow patterns in nozzle and diffuser at different phases flow rates and uses the end experimental and numerical data to correct the flow meter performance.

The research's cases will be investigated by using commercial CFD and CFX modules in Fluent software and using the Two-fluid model with the available empirical corrections.

With regard to the vision of volume and fluid flow laboratory at NIS-Egypt, it is planning to establish a test rig for two-phase flow rate measurements through this PhD research to apply the experimental work on this system.

8. Design and Implementation of a Novel All-Terrains Wearable Vehicle

(Completed PhD theses by Bikhet Sayed)

Transferring humans while carrying loads on all types of terrains efficiently using compact means is still representing a challenge. This may be due to the unstructured areas they need to move through unstructured roads, which are problems facing the laboratories and geologist. Also there are upper extremity exoskeletons is using the calibration of heavy Standard weights. It will be useful and extremely needed to make the process of carrying, stacking, moving and storage of the standard weights much easier.

To solve the above-mentioned problem, we propose in this research a new transportation system consisting of a lower extremity exoskeleton carries two motorized wheels and has free wheels installed below its feet. On flat free ground, this novel system utilizes its motorized wheels and free wheel to travel fast. In this fast mode of transportation, the human stays in sitting configuration on a foldable seat attached to the exoskeleton body. The system can be integrated to carry the mass

standards and mass handler. This approach will make the calibration process easier and accurate than traditional method.

9. New Design for Build-up Force system up to 10 MN

Ongoing PhD study by Mohamed AbdelHakeem

The multi-capacity force transducer is an innovative design of an ordinary force transducer. The new transducer will be able to operate at different capacities perhaps 10 times its original one. The multi-capacity force transducer represents a qualitative shift among the force measuring devices currently available in the global market, as all available designs have some restrictions that limit their usage. Among these restrictions are; each load cell has a unique capacity that cannot be exceeded, and if this occurred it might lead to a complete collapse or at least a significant change in its performance. The manufacturers of load cells are advised not to use their devices to measure forces at capacities below its lower limit that might reach 10 % of its capacity. The multi-capacity force transducer provides a fundamental solution to these restrictions. By adding a new part to the load cell parts, a certain load cell could reach higher levels. The main function of this new part is to increase the whole stiffness of the system to be able to withstand higher forces.

This idea was tested experimentally by designing and implementing a prototype. The prototype's original capacity is 10 kN, this capacity was doubled to 20 kN. The metrological characteristics of the device after duplication its capacity were better than expected as the device achieved class 0.5 according to ISO 376: 2011.

10. Determining and studying the parameters of force transducers under applying static and dynamic forces for Dynamic force calibrations. Plan of PhD study by Mohamed Ammar

The dynamic force measurements are used on a large scale in many industrial fields as in different machining processes, crashing tests, and fatigue tests. Consequently, the demands on measuring the accuracy error have been increased by the manufacturers.

The dynamic force type applied on the force transducers depends on the nature of the time. As in case of the fatigue tests, the applied dynamic force is periodic. While the applied dynamic force is shock in case of the crushing tests. On the other hand, the applied dynamic force type in case of the machining processes is step dynamic force.

The aim of this study is:

Establishing a section for the dynamic force calibration in the National Institute of Standards –Egypt (NIS) and developing it through determining the factors that affect this type of measurement.

Specifying the most accurate method that is used in determining the parameters of the dynamic force transducers corresponding to the different applications.

To enhance the traceability of dynamic force measurements at NIS.

11. Metrological Investigation of Flow Rate and Characteristics of Flowing Heavy Oil Mixed with Immiscible Fluids

Plan of PhD study by M. H. Alashker

The main objective is divided into two sections. In the first section, the focus is on overcoming challenges which obstruct formation of certain phase flow patterns, which assures transporting heavy oil through horizontal pipelines effectively. This calls firstly for innovation design of mixing unit to ensure the pattern at the start of operation and a careful adjustment of the water volume fraction to attain the desirable flow distribution. Secondly for Retention of water film at inner wall of pipe to prevent fouling of the pipe wall by oil as much as possible. In the second section, aim to solution of difficult problems that effects on flow stability to get accurate and reliable phase flow measurements in pipelines. Thus, will be develop a new predictive mathematical model to provide more accurate and reliable measurement for two phase flow(oil-water) and pressure drop, which can be used under a wide range of operating condition. This study will be including both experimental and theoretical study.

12. A metrological Study of Air Flow Inside Buildings and its Applications

Plan of PhD study by Fatma Kassem

Design and construction of a wind tunnel in the "Volumes and Fluid Flow Laboratory-National Institute of Standards" to provide metrology service to the industrial side. The use of the wind tunnel in this research to simulate certain conditions that cannot be easily achieved in real life situations. It can obtain different air speeds to help visualize the aerodynamic effects around solid objects.

Study the improvement of the wall boundary layer inside the test section of the wind tunnel for better performance.

Design and construction of an isolation room for one patient that is made of wood (with negative pressure) with dimensions of $2 \times 2 \times 2$ m^3.

The negative pressure inside the room is obtained by connecting the wind tunnel to the ventilation opening of the room.

The negative pressure value inside the isolation room is controlled by controlling the intake fan using a speed regulator.

As previous researches showed that the virus lives in the place for three days, the air drawn from the isolation room, carrying the infection spray resulting from the breathing process, is technically treated in the test section of the wind tunnel to get rid of the viruses to prevent spreading in the surrounding atmosphere.

Study the velocity distribution inside the isolation room as well as the value of the negative-pressure difference.

Investigating the optimum position of the ventilation opening for the patient to prevent harmful vorticity that may affect the breathing process.

Computational study for illustration of the flow details that cannot be easily measured.

II.Participation in relevant comparisons

CCM.P-K1b, K1c and K2

Key comparison in Mass, Pressure
In progress

AFRIMETS.M.P- K2

Key comparison in Mass, Pressure
Absolute pressure: 10 kPa to 120 kPa
In progress
Pressure measurements (absolute mode) - 2012 – 2013

AFRIMETS.M.M-K7

Key comparison in Mass, Mass Standards
Mass: 500 mg, 5 g, 10 g, 100 g and 5 kg.
2017 –
In progress

AFRIMETS. D-K4

Comparison of calibrations of hydrometers for liquid density determination
Supplementary comparison in Mass, Density
2017 -
In progress

III.List of relevant publications since 2019

#	Titles	Journal	Authors
1	An Investigation on using Lagrange, Newton and Least Square Methods for Generating Nonlinear Interpolation Function for the Measuring Instruments	ASM Sc. J., 14, 2021	Gouda M. Mahmoud, Shaker A. Gelany,
2	The resolution of analogue measuring devices and its associated uncertainty: An investigation with practical recommendations	Precision Engineering ,Volume 71, September 2021, Pages 57-62	Hawam, A.A. El_Kassas, A.M Gouda M. Mahmoud Hasan, E.H. Ahmadein, M.
3	Proposed approach for force transducers classification	International Journal of Metrology and Quality Engineering ,Volume 12, 2021,	Gouda M. Mahmoud Osman, S.M., Hegazy, R.S
4	Modelling of the influence of tensile test speed on the fracture load	ASM Science Journal, Volume 12, 22 July 2019, Pages 1-11	Khaled, K.M., Gouda M. Mahmoud

5	An investigation on using the falling mass technique for dynamic force calibrations	Metrol. Meas. Syst., Vol. 28 (2021), No. 3	Shaker A. Gelany, Gouda M. Mahmoud
6	Proposal for torque multiplier calibration standard	Measurement: Journal of the International Measurement Confederation, 2020 , 151, 107239	Khaled,K.M., Abdulhakim, M.
7	Proposal for improving force testing machines calibration standards	Measurement: Journal of the International Measurement Confederation, 2019 , 146, pp. 643–652	Osman, S.M., Khaled, K.M.
8	Proficiency Investigation of Torque Tools Calibration as a National Demand	Mapan - Journal of Metrology Society of India, 2019, 34(2), pp. 207–215	Khaled, K.M., Osman, S.M.
9	Novel design of a multi-capacity force measurement instrument	Measurement: Journal of the International Measurement Confederation, 2021, 1 73, 108562	Abdulhakim, M., Hegazy, R., Abuelezz, A.E., .Gaffer, A.M., Zakaria, H.M.

10	Practical investigation for the concept of a serial-type build-up force measurement system	Acta IMEKO, 2020, 9(5), pp. 143–149	Abdulhakim, M., Hassan, S.R., Tegtmeier, F.
11	Experimental and numerical study of air-water flow characteristics in a horizontal duct	Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, Volume: 235 issue: 5, page(s): 843-858, March 1, 2021	Mohamed H Mansour, Ali A Zahran, Lotfy H Rabie, Ibrahim M Shabaka
12	Performance of an Orifice Meter Handling Two-Phase (Gas-Liquid) Flow	MANSOURA ENGINEERING JOURNAL, (MEJ) VOL. 45, ISSUE 3, Sept. 2020.	Ali A Zahran, Lotfy H Rabie, Ibrahim M Shabaka, Mohamed H Mansour
13	The Influence of Fluid Temperature on the Entrance Length of Developing Flow in the Upstream Pipe of Measuring Devices	International Journal of Science and Engineering Applications Volume 8–Issue 04,124-130, 2019, ISSN:-2319–7560	M. H. Alashker, M. E. Elrefaie, I. M. Shabaka, G. Mohamed
14	Verification the Results of the NIS Hydrometers Calibration system	Journal of International Society for Science and Engineering (JISSE),	Mohamed Hamdy, M. A. Bayoumi, Alaaeldin A. Eltawil, A. E. Abuelezz

		Volume 3, Issue 1, Page 9-10, 2021.	
15	Developing the NIS Solid Density Hydrostatic Weighing System up to 20 kg	International Journal of Metrology and Quality Engineering (IJMQE), Vol. 8, pp. 4–11, 2020.	Mohamed Hamdy, Mohamed A. Bayoumi, Alaaeldin A. Eltawil, Ali E. Abuelezz
16	2D Flow model for calculating effective area of piston-cylinder units	Acta IMEKO, vol. 9, no. 5, pp. 319–324, 2020.	W. Sabuga, A. S. Hashad, and S. Ehlers,
17	Validation of a PTB force-balanced piston gauge - primary pressure standard	Acta IMEKO, vol. 10, no. 1, pp. 271–276, 2021.	A. S. Hashad, W. Sabuga, S. Ehlers, and T. Bock
18	Design and Control of a Novel All-Terrains Wearable Vehicle	journal paper is published in Industrial Robot Journal since 21 October 2019, IF 1.205	B.M. Sayed, Mohamed Fanni, Abdelfatah M. Mohamed
19	Case Study on the Non-Linear Behavior of the NIS-50 MPa Pressure Balance	Measurement, 172, 108865	Gelany, S. A., & Sayed, B. M.
20	Determining the Magnetic Properties of	International Journal of Science and	H. H. Hassan, Alaaeldin. A. Eltawil,

	Weights by Susceptometer Method.	Engineering Applications Volume 8–Issue 02,84-89, 2019, ISSN:-2319–7560	M. R. Hassan, Ahmed D. S. Ahmed and A. S. AbdelRahman
21	Results of a project to calibrate mercury sphygmomanometer blood pressure-measuring devices in Egypt	J Hum Hypertens (2020). https://doi.org/10.1038/s41371-020-00424-0	Soliman Ghareeb, Ghada Youssef, Haytham Soliman Ghareeb, Hazem Abd El-Mageed, Muhammad H. Mesalm, Remon Talaat, Alaaeldin Eltawil, Doaa M. Hasan, M. Mohsen Ibrahim