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# PRELIMINARY DYNAMIC PRESSURE MEASUREMENT SYSTEM AT UME

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***Abstract*** – Obtaining the fast dynamic pressure signal is necassary for the dynamic checks and calibrations for the dynamic pressure sensors as well as data acquisition part, conditioning units and amplifiers in dynamic measurement phenomena. For this purpose a drop mass system was developed. This paper describes the drop mass system improved and used for the dynamic calibration of pressure transducers in hydraulic media at Tubitak UME of National Metrology Institute of Turkey.

***Keywords***: pressure, drop mass system, dynamic calibration, dynamic pressure, dynamic pressure transducers

## 1. INTRODUCTION

Dynamic pressure sensors have a wide area of usage both in measurement and in controlling process in lots of fields like aerospace, medicine production, food processing [13,14].

Some pressure calibration applications show time invariant static characteristics so certain types of transducers can be used to measure such static time invariant value of pressure. If pressure value is changing by time or in other saying if it is time-dependent, it is defined as dynamic because it varies significantly in a short period of time demanding a dynamic calibration.

The necessities in precise high dynamic pressure measurement have increased in miscellaneous industrial and research applications [4-6]. For example, including development and monitoring of automotive and gas turbine engines, hydraulic systems, and development within the ammunition and firearms, medicine, aviation and spaceflight, defence industries, turbo machinery, aerodynamics, fluid power and control and oil industries [2,7,8,12]. So, it is seen that dynamic pressure is needed to be measured in wide frequency band is appeared [3,9]. The means of a dynamic calibration of a pressure transducer or a measurement system consist of the evaluation of their dynamic treatment with sufficient and suitable accuracy value [10]. In dynamic pressure calibration, a measurement system should be used. This system should generate dynamic pressure which is time varying and reliable and controllable way and whose value is well known. This generated pressure wave is taken as reference pressure value in calibration of transducers [13,15].

## 2. DROP MASS SYSTEM

### *2.1. Working principle*

The dynamic pressure facilities of some set-ups operate according to the "drop mass" principle. A drop mass system is given schematically in Fig. 1. The impact on the piston leads to the compression of a small volume of a hydraulic liquid within a pressure cavity that is connected to the test device(s), thus a shock pressure excitation to the test device is applied [1].

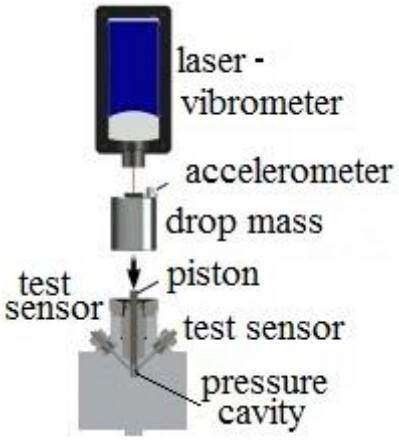


Fig. 1. Drop weigh system [11]

### *2.2. Design of drop mass system*

Drop mass system is consists of three main parts. First part is mechanical unit. Second one is control unit and the third part is called data logging and sensor configuration unit. Three dimensional (3D) picture of the drop mass system is given in Fig. 2.

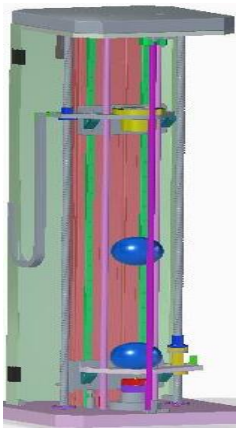

Fig. 2. Three dimensional (3D) figure of the drop mass system

In mechanical part, there is a closed chamber which is filled with transmitting fluid and equipped with piston-cylinder unit, test and reference sensors. Also, electro magnet, sphere as dropping mass and holder which holds the sphere after the first hit on to the piston are the other main parts of the mechanical side. Mechanical part is given in Fig. 3.

Fig. 3. Mechanical part of the drop mass system

Control unit includes PLC (programmable logic controller) unit, two servo engines and display unit for control the PLC. Using the control display it is possible to set the dropping height.

Fig. 4. Control unit of the drop mass system

Sensor configuration part is responsible for configuration the quartz dynamic pressure sensors. Calibration ranges, sensitivity values should be entered and amplifier should be operated. Data logging facility collects the analogue data at desired rates which were amplified by amplifier. It may be at about 200 KHz sampling speed. Data logging and sensor configuration parts are given in Fig. 5.

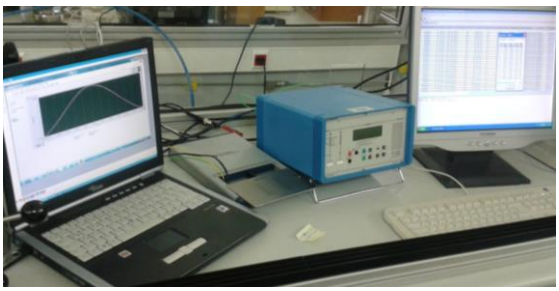

Fig. 5. Data logging and sensor configuration parts of the drop mass system

## 3. EXPERIMENTAL SETUP AND MEASUREMENT RESULTS

### *3.1. Experimental setup*

Drop mass system experimental setup is includes mechanical part, control unit and sensor configuration and data logging parts. Reference and test sensors and piston-cylinder unit are inserted into a closed chamber which was filled with transmitting oil. Piston-cylinder unit positioned under the vertical axis of the free fallen sphere. Closed chamber equipped with piston-cylinder unit, reference and test sensors is given in Fig. 6.

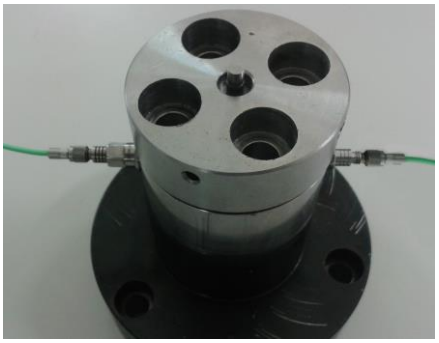

Fig. 6. Oil filled closed chamber equipped with piston-cylinder unit, reference and test sensors

### *3.2. Measurement results*

Dynamic pressure calibration measurements have been carried out at pressure values 100 MPa, 200 MPa, 300 MPa, 400 MPa and 500 MPa. At each nominal pressure value, analogue output values in volt from reference and test sensors were collected as well as displayed pressure values were also registered. Pressure values were taken from display of amplifier. Measurement results were given in Table 1.

Table 1. Dynamic pressure calibration measurement results at five pressure values for five cycles

| Cycle | Channel | | drop height h=19 mm | | drop height h=60 mm | | drop height h=115 mm | | drop height h=180 mm | | drop height h=260 mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 100 | | 200 | | 300 | | 400 | | 500 | |
| | | | MPa | | MPa | | MPa | | MPa | | MPa | |
| | Volt | Pressure | P (bar) | V (Volt) | P (bar) | V (Volt) | P (bar) | V (Volt) | P (bar) | V (Volt) | P (bar) | V (Volt) |
| 1 | 0 | 1 | 1023 | 2,040 | 2015 | 4,000 | 3030 | 6,050 | 4020 | 8,126 | 4830 | 9,805 |
| | 1 | 2 | 993 | 1,975 | 1973 | 3,950 | 2975 | 5,900 | 3965 | 8,046 | 4870 | 9,688 |
| 2 | 0 | 1 | 1020 | 2,040 | 2020 | 4,000 | 3030 | 6,050 | 3975 | 7,949 | 4875 | 9,806 |
| | 1 | 2 | 993 | 1,997 | 1960 | 3,900 | 2965 | 5,900 | 3925 | 7,861 | 4830 | 9,759 |
| 3 | 0 | 1 | 1025 | 2,050 | 2020 | 4,048 | 3030 | 6,000 | 3965 | 7,900 | 4930 | 9,877 |
| | 1 | 2 | 990 | 1,960 | 1958 | 3,948 | 2970 | 5,900 | 3910 | 7,800 | 4895 | 9,806 |
| 4 | 0 | 1 | 1018 | 2,050 | 2025 | 4,051 | 3030 | 6,050 | 3960 | 8,008 | 4775 | 9,651 |
| | 1 | 2 | 990 | 1,960 | 1960 | 3,986 | 2965 | 5,900 | 3910 | 7,943 | 4725 | 9,610 |
| 5 | 0 | 1 | 1018 | 2,030 | 2025 | 4,000 | 3020 | 6,050 | 4010 | 8,032 | 4800 | 9,587 |
| | 1 | 2 | 990 | 1,983 | 1958 | 3,900 | 2955 | 5,900 | 3910 | 7,994 | 4750 | 9,513 |

The graphical representation of two channels of reference and test sensors' outputs were seen in Fig. 7 for 500 MPa. While the white colour half sine curve indicates the reference sensor output, as the red signal is for test sensor output.

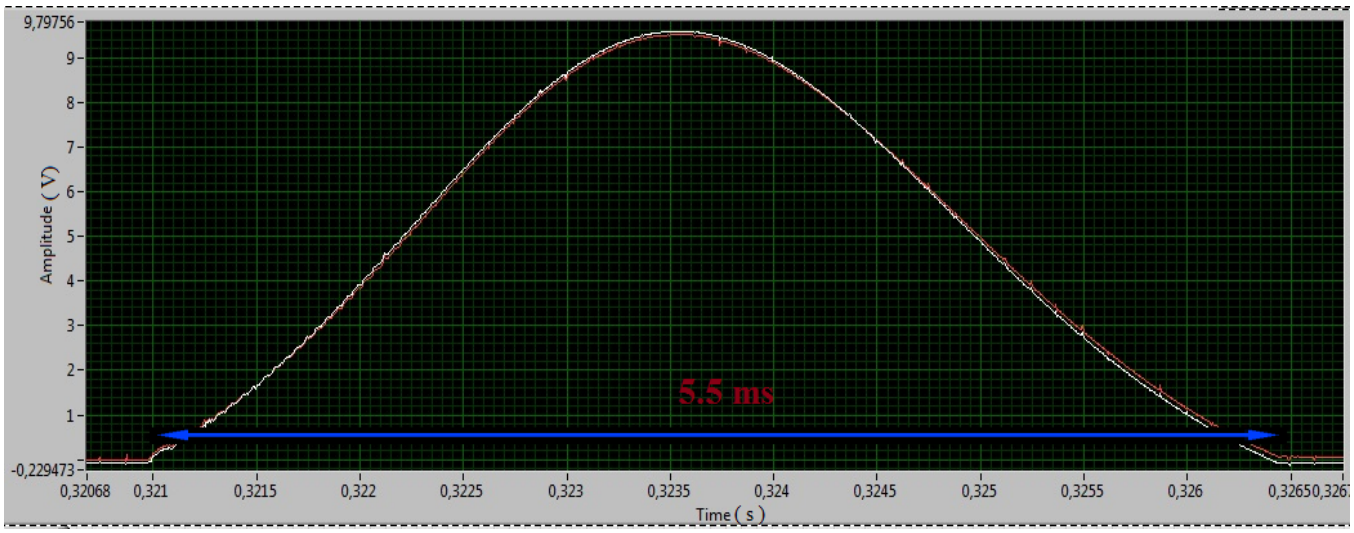


Fig. 7. Reference and test sensors' output values; voltage ( V) vs. time (s)

## 4. CONCLUSIONS

In this paper, new developed drop mass system at UME was presented. Basic working principle, design components were detailed. Some series of dynamic pressure measurements have been done on this drop mass system using reference and test dynamic pressure transducers at hydraulic media up to 500 MPa as repeated cycles. Drop mass system was producing half sine signals with approximately 5 ms period. Similar signals were observed at the output of both sensors which were under measurement. Amplitude of output signals were linearly proportional to applied pressure. Drop mass system has a possibility of setting drop height and number of desired measurement cycles through control display. This options provide doing repeatable measurements on dynamic pressure sensors using this drop mass system.

For the future to do accurate measurements, this drop mass system will be improved as primary dynamic pressure standard. Uncertainty budget will be clarified. Some inter comparison measurements will be done with similar systems.

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