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TWO SHOCK MACHINE SIMULATIONS PRESTUDY FOR PRIMARY LOW LEVEL SHOCK CALIBRATION SYSTEM

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Abstract − From a view of human safety and product improvement, precise and reliable calibration facilities are the index of industrial development. In NML (National Measurement Laboratory), shock accelerometer is calibrated by comparing to a reference transducer with acceleration range from 1000 m/s^2 to 10000 m/s^2. For the Taiwan's industrial demand of low shock calibration and decrease the inconvenience due to transfer the standard from foreign primary shock calibration Lab. NML prepare to develop a low shock calibration system during 2009. We set up two simulations to confirm the ISO 16063-13[1]. First simulation is to set up a simple pendulum instead of rigid body motion, and second one is to generate shock waveform using a shaker. Two realistic simulation results show the feasibility of the constructing primary shock calibration system and provide a well experiment to our future work.

Keywords: Shock vibration, Primary calibration system, Rigid body motion

1. INTRODUCTION

The electronic and acoustical products, vehicles electron, information products and so on, must be executed impact test during R&D process. At the same time, the vehicles hit-test also has to use the impact accelerometer to monitor acceleration, the shock calibration technology and the industrial development are obviously connected tightly. At present NML only provides the comparison shock calibration service. Due to the shortage of primary calibration system, NML is unable to trace the system standard by self, and must send the standard accelerometer to foreign laboratory calibrated by a primary calibration system (German PTB for example). Transferring the standard from primary calibration system, NML must suspend service for 4 months, it makes the enterprise inconvenient. On the basis of mention, NML plans to establish primary shock vibration calibration system. According to the applicable international standards 16063-13, primary shock calibration system comprises two main parts of shock machine and interferometer. The shock machine of low level shock calibration system was based on rigid body motion of an anvil. To evaluate the demand of NML and refer to the NMIJ(National Metrology Institute in Japan)[2], NML will develop a low level shock calibration system with acceleration range from 200 m/s^2 to 5000 m/s^2 by using rigid body motion method. Before developing the primary shock calibration system, we set up two realistic shock machine simulations for feasibility study. The first one use a simple shock pendulum as shock source, and the measurement results show that the maximum difference of shock peak value is 6.8%. The second one combine arbitrary waveform generator and electrodynamics shaker as shock source, and the measurement results show that the maximum difference of shock peak value is 4.3%.

2. SHOCK MACHINE SIMULATIONS

2.1. Generation of shock using simple shock pendulum

The rigid body motion displacement technology mainly produces the shock pulse by using the hammer block to hit the pulse-forming anvil block. After pulse-forming anvil block is hit, the shock accelerometer withstanding specific shock acceleration and output the voltage signal to a high frequency digital recorder, simultaneously the laser interferometer measure the displacement of shock accelerometer, and then the sensitivity of accelerometer can be calculated.

We use a Doppler laser vibrometer(VibroMet 500V made by MetroLaser Company) as an interferometer. The velocity measurement capability is from 3 nm/s to 800 mm/s. The instrument of laser vibrometer was shown in Fig. 1.

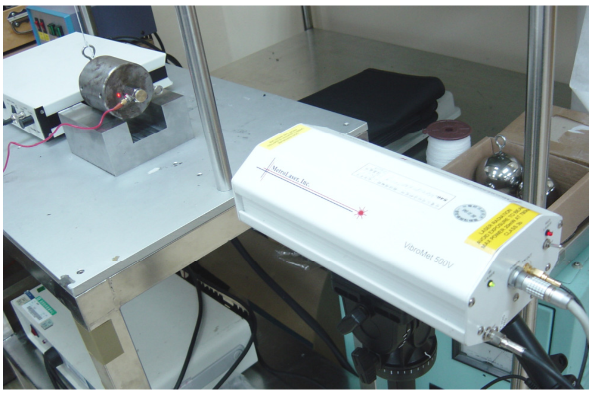

Fig. 1. Laser Doppler vibrometer.

We set up a simple pendulum which is composed of a steel ball as hammer and a steel cylinder as anvil. The diameter of steel ball is 45 mm, and the cylinder is 60 mm (diameter) x 60 mm (height). A pulse forming rubber with 4 mm diameter is attached on anvil, at the same time we bolt an ENDEVCO 2270 accelerometer in the opposite side. To avoid rotation when the anvil was struck by the hammer, we put the anvil on a straight guide block. The instrument of simple shock pendulum was shown in Fig. 2.

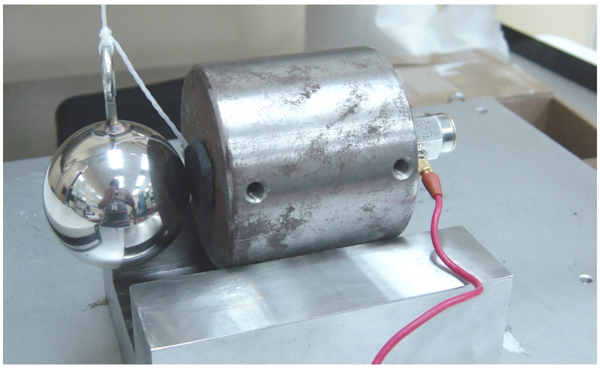

Fig. 2. Simple shock pendulum.

2.2. Generation of shock using shaker

In about the mid-1950s, according to the development of electrodynamics shakers for realization of vibration test, the need for a realization of shocks on this facility was quickly felt. This simulation is shown in fig. 3. We define a Gaussian waveform with arbitrary waveform generator, and output the signal to shaker. The Gaussian waveform is set up in a period of 200 Hz, and the duration time about 1 millisecond.

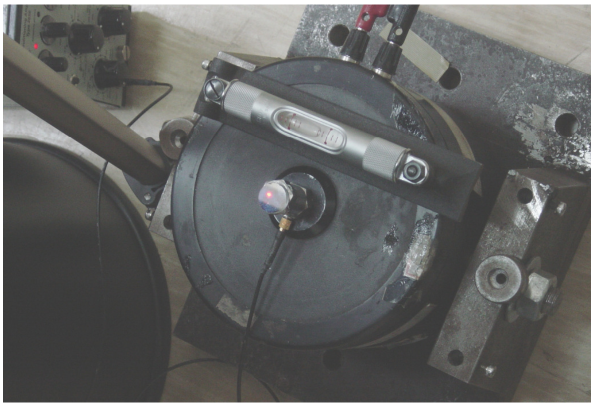

Fig. 3. The shaker generates shock pulse.

We also use a Doppler laser vibrometer as interferometer which were mentioned in ***2.1***.

3. SIMULATION RESULTS

3.1. Generation of shock using simple shock pendulum

The measurement result of the output signal from accelerometer is shown in fig. 4 and from laser Doppler is shown in fig. 5. Thought out the calculation, the peak shock acceleration value of accelerometer is 513 m/s^2 and the peak shock acceleration value of laser Doppler vibrometer is 500 m/s^2.

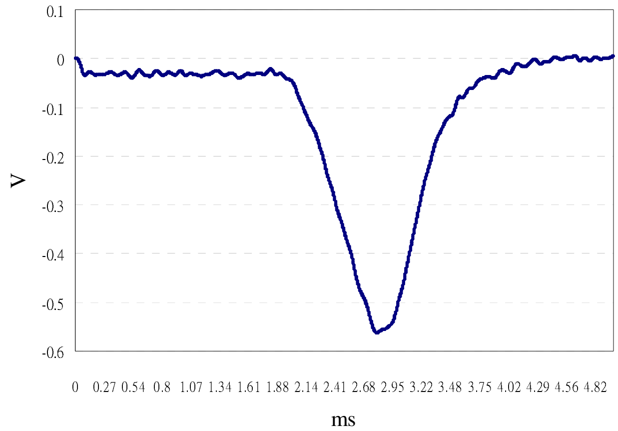

Fig. 4. The output signal from accelerometer.

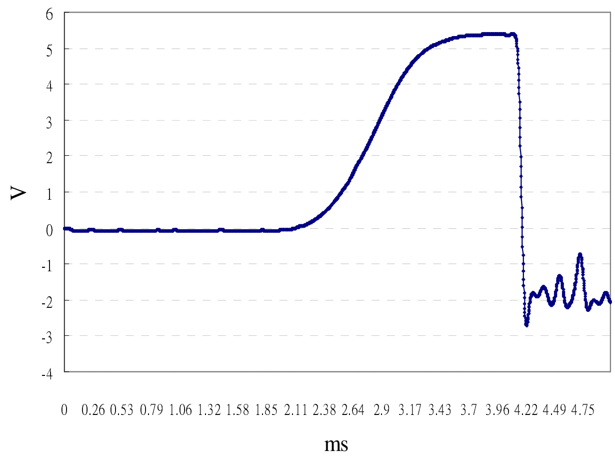

Fig. 5. The output signal from laser Doppler vibrometer.

Six serial experiments had been done and the peak shock value derived from accelerometer and laser Doppler vibrometer were listed in table 1. It shows the difference between the peak shock value from laser Doppler vibrometer and accelerometer is variation from 2.4% to 6.8%.

Table 1. The peak shock acceleration value in six serial experiments.

	1st	2nd	3rd	4th	5th	6th
Peak shock value (m/s^2) from Laser Doppler	500	530	478	483	540	511
Peak shock value (m/s^2) from Accelerometer	512	563	502	498	577	538
Difference Error	2.4%	6.2%	5.0%	3.1%	6.8%	5.3%

3.2. Generation of shock using shaker

Due to the electronic limitations of the shaker and the output voltage of the amplifier, we generate two peak shock value 10 m/s^2 and 50 m/s^2. In the case of 50 m/s^2, the output peak value of accelerometer is 48.68 m/s^2(black line in Fig. 6) and the output peak value of laser Doppler vibrometer is 50.79 m/s^2 (red line in Fig. 6). The difference between two signal peak values is 4.3%.

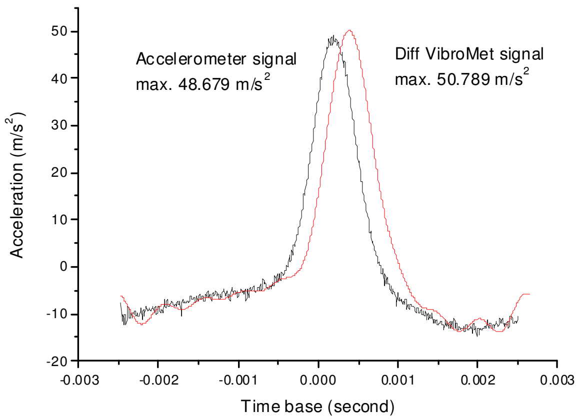

Fig. 6. Compare the output peak shock value derived from laser Doppler vibrometer and accelerometer(50 m/s^2).

In the case of 10 m/s^2, the peak value of accelerometer is 10.10 m/s^2(black line in Fig. 7) and the peak value of laser Doppler is 9.89 m/s^2 (red line in Fig. 7). The difference between two signal peak value is 2.1%.

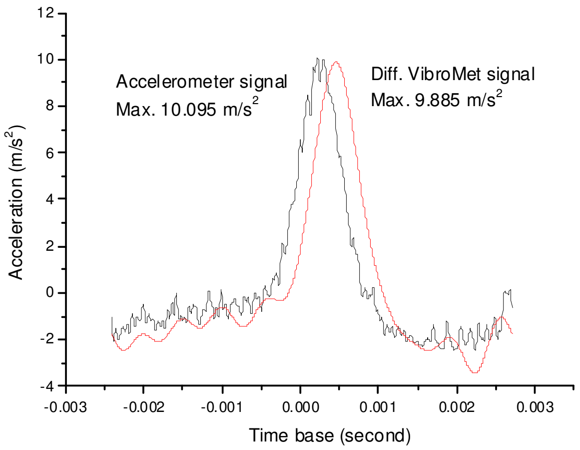

Fig. 7. Compare the peak shock value derived from laser Doppler vibrometer and accelerometer(10 m/s^2).

4. CONCLUSIONS

NML will develop low shock primary calibration system in 2009. We set up two shock machine simulations to confirm the ISO 16063-13. First, we use a simple pendulum to simulate rigid body motion. The maximum difference between two peak shock values from accelerometer and laser Doppler vibrometer is 6.8%. The variation is ranging from 2.4% to 6.8%. It shows that the error mainly contributed from non-coaxial when the hammer striking the anvil and will be improved quickly when we set up a precise rigid body motion. Second, we generate a Gaussian waveform into shaker, and it will generate a signal similar to versed-sine shock waveform. The output signal shown in fig. 6 and 7 is divided into three stages (preshock, shock and postshock), and agree with the principle described in [3]. Compare the peak shock value from laser Doppler and accelerometer, both two different signals have a time shift and the maximum difference between them is 4.3%. The time shift phenomenon reminder us do not take the wrong peak shock value in the future work. Two simulations realize the shock waveform in different ways, and enlighten NML to developing low shock level calibration system.

5. FUTURE WORK

The interferometer will be set up according to ISO 16063-13. The components setting as shown in fig. 8 is just for simulate, so that draw out some components and not tuned very well. We perform the data processing producer mentioned in ISO 16053-13 and refine output signal of the interferometer.

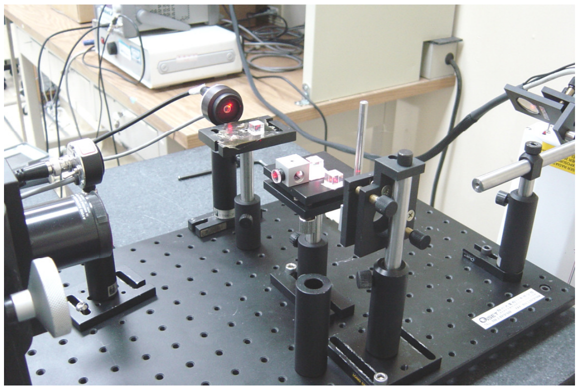

Fig. 8. The interferometer components.

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