|| Volume 2 ||Issue 11 ||JUNE 2017||ISSN (Online) 2456-0774

INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH

AND ENGINEERING TRENDS

Experimental Analysis and Simulation of Impact in Spheres

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Abstract— **The impact of spheres is the fundamental problem in engineering. The effect of impact is characterised by coefficient of restitution. A classical problem of impact or ball bounce can be converted into equivalent mass-spring-damper model. This paper deals with experimental analysis of impact of spheres with aluminium surface. Different methods are studied to determine COR experimentally. Experiments are carried out to find COR for various configurations of experimental parameters. The effect of material of ball and initial release height on COR in low velocity impacts is investigated through experiments. Total time of bounce is calculated through simulation model.**

Keywords:- *Coefficient of Restitution (COR),simulation, Impact.*

I INTRODUCTION

The phenomenon of collision of two bodies which occurs in a very small interval of time and during which the two bodies exert a very large force on each other, is called an impact. The severity of impact is mainly characterised by coefficient of restitution (COR). The coefficient of restitution is defined as the ratio of relative velocity of bodies after impact to the relative velocity before impact, and denoted by ‘e’.

The COR generally lies in between zero to one. When the COR is zero, the impact is fully plastic and when this is one, then it is fully elastic. In case of elastic collision, both momentum and energy are conserved. Thus, the energy before impact is equal to the energy after impact. But, in actual practice COR is neither zero nor one. This value depends upon factors such as release height, impact velocity and contact duration etc. The coefficient of restitution has large number of significant applications ranging from macroscopic mechanical engineering to microscopic particle technology. Being a basic and fundamental problem in engineering a lot of research and work has been carried out on collisions and coefficient of restitution.

The problem of impact of sphere is equivalent to bouncing ball model. Many researches proposed the concept of mass, stiffness, and damping as the three elemental properties of any mechanical system. This paper develops a simulink model for a system of bouncing ball. It is observed that the mechanical properties of a bouncing ball are related to the coefficient of restitution.

A.Aryaei et al. [1] analyzed COR in low velocity impact. Impact experiments were performed in a drop test apparatus. Steel and aluminium balls are placed at the top of wooden frame and dropped on steel sheet. The rebound height of ball is observed using high speed camera. To verify the results obtained from experimental analysis, finite elemental analysis is carried out using ANSYS. In order to observe the effect of balls’ size, the modelling and analysis of different steel balls dropped on steel plate is carried out. Plates and balls were treated homogeneous and isotropic. Two different shapes were used for ball meshing; viz. brick and tetragonal shapes. For sheet meshing, brick shape elements were used. It is observed that the ball size has more significant effect on COR in impact of a ball and sheet made from different materials than in those occurred between a ball and sheet made up of same materials.

Mark Nagurka et al.[2] proposed a simple mass-spring-damper model for a bouncing ball. The ball is represented by its mass *m*, viscous damping *c*, and linear stiffness *k*. A ping-pong ball was released from height of 30.5 cm on a table. The acoustic signals coming from impact between table and ball were recorded using a microphone. The microphone is attached to the acquisition system of computer. The coefficient of restitution can be calculated by given known initial height, total time required for ball to come to rest and number of bounces. It is observed that, as the contact time increases, the stiffness decreases and damping increases. Also, as the coefficient of restitution increases, the total time of bounce also increases.

Mark Nagurka [3] carried out an experiment in which the signals from an acoustic emission are recorded. In the experiment, a ping-pong ball is allowed to fall freely on a table. The audio signals of impact between ball and table are recorded. The time interval between two successive bounces is used to determine the height from which ball is dropped and COR of sphere. The path of a ball is predicted. It shows that, a height from which ball is dropped is a function of time. The ball is modelled as a particle. Only vertical motion considered in the analysis of a ball. Due to inelastic nature of impact between ball and table, the height of bounce for a ball decreases continuously with each impact. It is observed that, the total time required for a ball to come to rest always depends upon COR.

Mark Nagurka (4) experimentally studied effect of aerodynamic drag on the ball bounce model. A ball is allowed to fall freely on a table top from initial height h_0. The ball is modelled as a particle. Only vertical motion is considered. In this work, two aerodynamic models are considered. One model assumes a constant drag coefficient, whereas the alternative model assumes a velocity dependant coefficient based on an empirically determined relation. It is observed that, by considering a model which neglects aerodynamic resistance the time intervals between the consecutive bounces can be used to find the height from which ball is dropped and coefficient of restitution of a ball.

II EXPERIMENTAL ANALYSIS

It is always necessary to properly plan and execute the experiments in desired sequence for success of any research. After conduction of the experiments, it is also important to analyze and interpret the data. On the basis of different methods of analysis studied, total 3 numbers of parameters are finalized for conducting experiments. It is necessary to identify the effect of these parameters on COR

Table 1 Configuration of Experimental Parameters

No.	Parameters	Levels			Unit
		1	2	3	
1	Ball material	Steel	Copper	Lead	-
2	Ball diameter	2			mm
3	Initial release height	300	200	100	mm

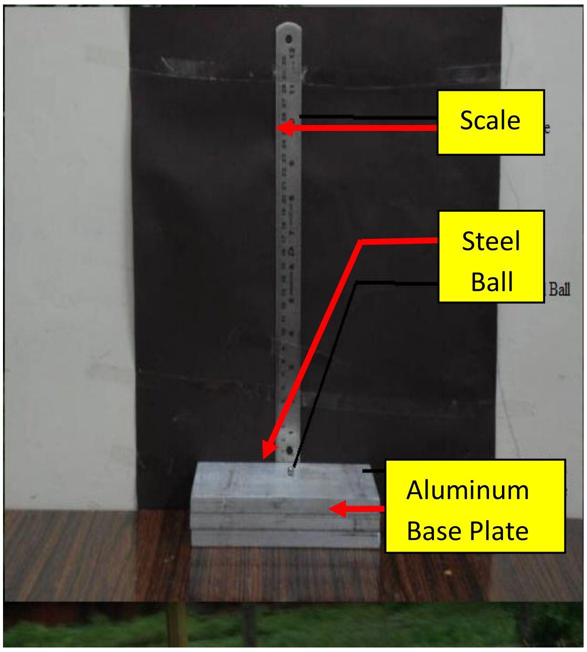

Figure 1 Experimental Setup

Experimental setup is done as shown in figure 1. Aluminum base plate is used as a surface. The balls of different materials are dropped on aluminum base plate with various initial release heights. The motion of the ball is recorded using a DVD recorder. Using slow motion mode of the film, rebound height of a ball is noted. From initial release height and rebound height, COR can be found out.

III SIMULATION

To convert the system into equivalent mass-spring-damper system, the values of number of bounces n and ΔT are to be found out. To find these values, a simulink model is prepared, which simulates the ball bounce. The standard prepared model is as follows

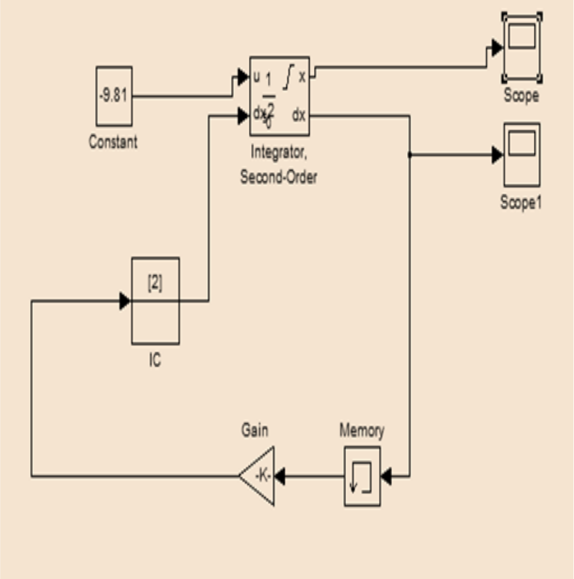

Figure 2 Simulink model for ball bounce

For the model, a second order integrator block is used. The values of COR are given to the gain block. Simulation is done and graphs are plotted for all the three materials for displacement with respect to time.

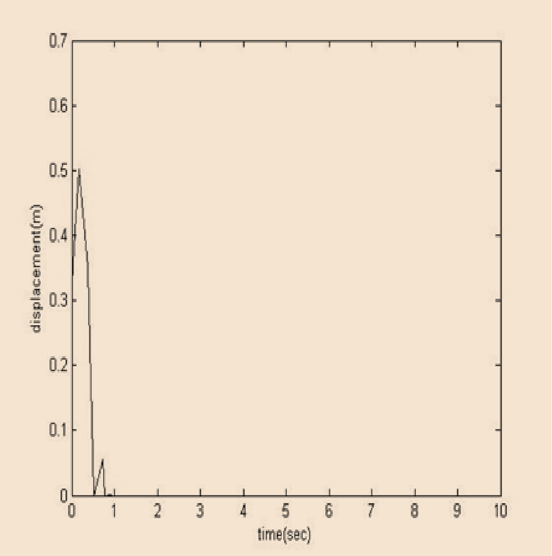

Figure 3 Graph for displacement for steel ball

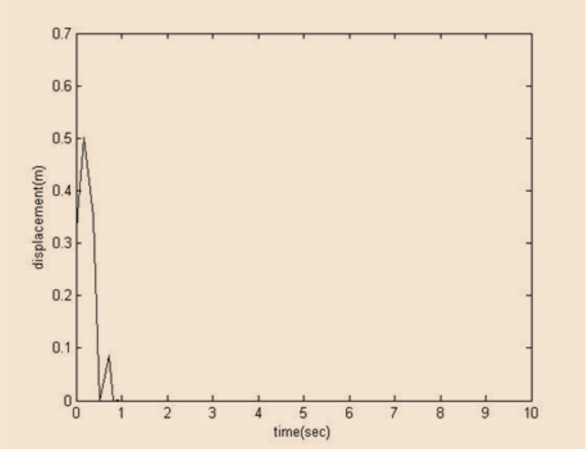

Figure 4 Graph for displacement for copper ball

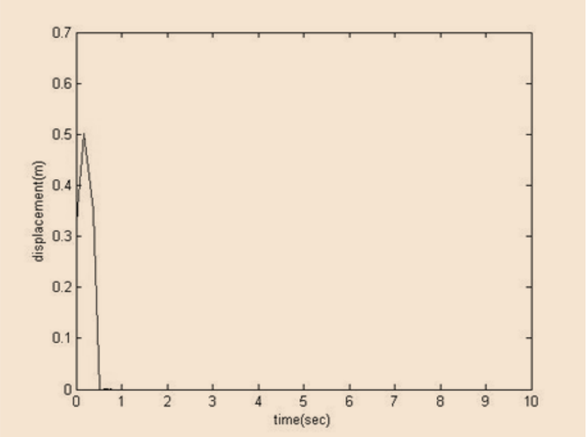

Figure 5 Graph for displacement for lead ball

The simulink model proposed for the equation of total time is as follows

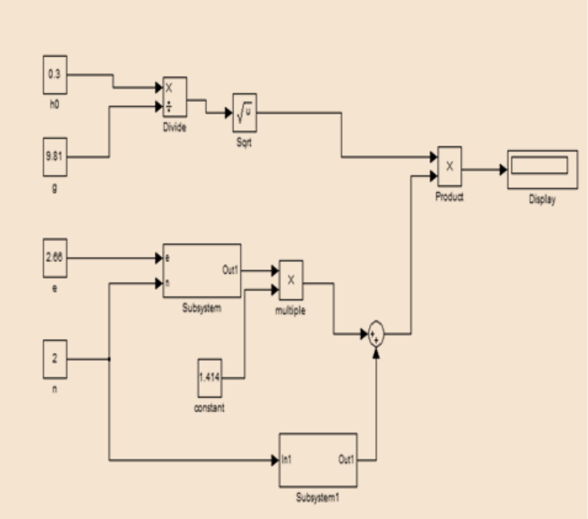

Figure 6 Simulink model for total time calculation

From this proposed model, we get theoretical values for the total time of bounces.

Table 2 Experimental And Simulation Results

Sr No	**Description**		**Initial release height (h_i) (mm)**	**Final rebound height (h_f) (mm)**	**Coefficient of restitution e**	**Total bounce Time (Sec)**	**Total time from simulation results (sec)**
	Material of ball	**Diameter (mm)**					
1	Steel	2	300	30	0.3162	0.8	0.6206
			200	40.67	0.4509	0.7	0.5721
			100	19	0.4359	0.7	0.4919
2	Copper	2	300	53.33	0.4216	0.9	0.7583
			200	39.67	0.4454	0.8	0.6655
			100	22.67	0.4761	0.8	0.5264
3	Lead	2	300	21.33	0.266	0.6	0.4832
			200	18.33	0.3027	0.7	0.5121
			100	8.5	0.2915	0.6	0.3839

IV CONCLUSION

The effect of material of ball and initial release height on COR in low velocity impacts is investigated through experiments. Based on the present experimental results, simulation results and graphs thus plotted, total time of bounce can be found out. It is observed that the results of total time noted in experimentation and found through simulation are in good agreements with each other.

REFERENCES

[1]A. Aryaei a, K. Hashemnia b, K. Jafarpur b,*, Experimental and numerical study of ball size effect on restitution coefficient in low velocity impacts, International Journal of Impact Engineering 37 (2010) 1037-1044

[2]Mark Nagurka,Shuguang Huang, A Mass spring Model of a Bouncing ball, Proceeding of the 2004 American Control conference Boston, Massachusetts june 30-july 02,2004

[3]Nagurka, M.L., 2003, "Aerodynamic Effects in a Dropped Ping-Pong Ball Experiment," International Journal of Engineering Education, 19(4), pp. 623-630. spheres, accounting for plastic deformation: force-driven formulation. ASME J Appl Mech 2000;67:363-71.

[4] Nagurka, M.L., 2002, "A Simple Dynamics Experiment Based on Acoustic Emission," Mechatronics, 12(2), pp. 229-239.