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Design and Development of Dynamic Axial Load Sensor System for Measurement of Impact Load Canister on Arrestor

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ABSTRACT: Design and development of sensor system for the measurement of impact load due to canister collapse at sub sonic speeds in a compressed air operated bird/ice pellet launcher.this experiment is carried out to find impact of canister on canister arrester. Canister is a device which cup shaped structure front side is opened and rear side is close that carry the dummy bird.it will strike at high pressure at canister arrester, the dummy bird flow in air and strike at iron board. This project to find the impact of canister on canister arrester at different pressure.

KEYWORDS: Canister, canister, air gun, strain gauge, transducer.

I. INTRODUCTION

Canister is basically a deep drawn cylindrical vessel, closed at the back end and open at the front end. It is the most critical Dynamic- component in a bird launcher, which accelerates the bird or ice-pellet from rest to the desired launch velocity within a few milliseconds. It keeps the bird/bird specimen centralized and coaxial with the launch barrel and provides necessary damping for withstanding the shock of launch impact with the arrestor lip, prevents the bird specimen from rubbing with the internal surface of the gun barrel. The canister is also expected to fold over at least partially in the circumferential direction and thus serve to seal the high pressure air at the end of the gun barrel and prevent compressed air from gushing out into the target area and introduce secondary damage and minimize obscure visibility of the target components and thus help in obtaining clear high speed photography / videography. The Canister is a thin walled cylinder with either a flat back surface or a dome- shaped semi-hemispherical back end, with the front end being open, for inserting the sabot and the bird specimen. The thickness of the cylindrical body as well as that of the back end could either be uniform or variable. The wall thickness at the front end and the rear end of the canister, wall thickness over on the cylindrical body are controlled during the Deep drawing process. The strength of this canister, to withstand the “impact and shock”, is imparted to the canister during the heat-treatment process. There are major impact test programs in the country which are aimed at studying the penetration mechanisms, Containment Capability of “armour” materials, and bird strike capability of aero engine components.

II. EXPERIMENTAL SETUP

Subsonic is measured to be as fast as any speed that is slower than the speed of sound. If something is traveling at the speed of sound, it is considered transonic. If something is traveling faster than the speed of sound, then it is considered supersonic.The impact could be caused by a weight falling on the design object or possibly from the design object falling and striking a hard surface. In both cases, the loads are not obvious but can be easily derived from our knowledge of mechanics. We know that the weight will deform the design object when it strikes it. The design object will behave like a spring being compressed. The kinetic energy of the falling weight will be transferred to the design object and stored as compression. All if its kinetic energy is derived from the fall. A transducer is a device that converts a signal in one form of energy to another form of energy. Energy types include (but are not limited to) electrical, mechanical, electromagnetic (including light), chemical, acoustic and thermal energy. While the term transducer commonly implies the use of a sensor/detector, any device which converts energy can be considered a transducer. Transducers are widely used in measuring instruments. A sensor is used to detect a parameter in one form and report it in another form of energy, often an electrical signal.For example, a pressure sensor might detect pressure (a mechanical form of energy) and convert it to electrical signal for display at a remote gauge.An actuator accepts energy and produces movement (action). The energy supplied to an actuator might be electrical or mechanical (pneumatic, hydraulic, etc.). An electric motor and a loudspeaker are both actuators, converting electrical energy into motion for different purposes.Combination transducers have both functions; they both detect and create action. For example, a typical ultrasonic transducer switches back and forth many times a second between acting as an actuator to produce ultrasonic waves, and acting as a sensor to detect ultrasonic waves. Rotating a DC electric motor's rotor will produce electricity and voice-coil speakers can also act as microphones.A sensor is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (today mostly electronic) instrument. For example, a mercury-in-glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, most sensors are calibrated against known standards.Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics.A sensor is a device, which responds to an input quantity by generating a functionally related output usually in the form of an electrical or optical signal. A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C (it is basically the slope Dy/Dx assuming a linear characteristic). Sensors that measure very small changes must have very high sensitivities. Sensors also have an impact on what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors need to be designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages. Technological progress allows more and more sensors to be manufactured on a microscopic scale as micro sensors using MEMS technology. In most cases, a micro sensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches.Canister is basically a deep drawn cylindrical vessel, closed at the back end and open at the front end, as shown in Fig. It is the most critical Dynamic- component in a bird launcher, which accelerates the bird or ice-pellet from rest to the desired launch velocity within a few milliseconds. It keeps the bird/bird specimen centralized and coaxial with the launch barrel and provides necessary damping for withstanding the shock of launch impact with the arrestor lip, prevents the bird specimen from rubbing with the internal surface of the gun barrel. 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There are major impact test programs in the country which are aimed at studying the penetration mechanisms, Containment Capability of “armour” materials, and bird strike capability of aero engine components. When a metal conductor is stretched or compressed it resistance change on account of the fact that both length and diameter of conductor change. The value of resistivity of the conductor also changes. When it is strained its properties is called piezo-resistance. Therefore resistance strain gauges are also known as Piezo resistive gauge.

The strain gauge is the measurement transducer for measuring strain and associated stress in experimental stress analysis. Secondly many other detectors, and transducer, notably the load cell, torque meter , diaphragm type pressure gauge, temperature sensors, accelerometer and flow meter, employ a strain gauge as a secondary transducer.

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Fig : Experimental setup

III. METHODOLOGY

The ice pellet launcher is an aeronautical testing device. . In general pressure is generated on the tank which is supplied by an air compressor Once the desired pressure is obtained we fire and the canister strikes the arrestor at a very high velocity. Strain gauge mounted on the bolts detect the load which is obtained by a transducer and can be seen in a display unit. Ice-Pellet Launcher is a Test Facility that launches ice pellets to simulate ice impact on aircraft and aero-engines. When ice pellets and slabs hit the aircraft, which fly at high speeds, including near-sonic speeds, they cause huge damage on to the body of the aircraft. This will also cause extensive damage to aero-engine parts, endangering the flight safety. The damage profile due to ice and even bird hits needs to be extensively analyzed through simulation effort. More importantly they need to be experimentally studied by launching ice pellets on to aircraft/aero-engine parts at appropriate speeds and directions. Fig gives the schematic details of the Facility being set up under this Project Compressed air is used to launch the ice pellets or any other projectile in this facility.

A metallic canister is used to hold these ice pellets and is surrounded by a layer of gelatin. A high pressure air-tank, with 1500 litre capacity 10 bar operating pressure rating, is filled with compressed air by a 10-kW air-compressor. This stored compressed air is made to suddenly gush out by opening an electronically operated solenoid valve or a sophisticated rupture disc. The expanding compressed air accelerates the ice-pellets housed in the metallic canister. The “fired” canister would accelerate throughout the length of the barrel connected to front of the air receiver, gets arrested at the canister arrester junction at the end of the gun barrel and ejects the ice pellets at the desired speed.

Before the arresting action of the canister the velocity of the projectile inside the gun barrel would be measured using a laser operated velocity measuring system.

IV. EXPERIMENTAL RESULTS

Impact load is measured on the bolts due to the high pressure launching of canister. The following observation are made with variable pressure and different velocities.

Collapsibility of canister at 3 bar:

FIRING PRESSURE OF CANISTER AT 3BAR					
Sl no	**Weight of canister in grams**	**Velocity attained in m/s**	**Von MesisStrees in Mpa**	**Impact Force on the canister in N**	**Impact Force on bolts in N**
1.	165	58	1.43×10^3	336.93×10^3	84.23×10^3
2.	166	66	6.45×10^3	1519.75×10^3	379.937×10^3
3.	162	58	1.18×10^3	278.03×10^3	69.50×10^3
4.	165	58	1.25×10^3	294.53×10^3	73.632×10^3

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COLLAPSIBILITY OF CANISTER AT 4 BAR:

FIRING PRESSURE OF CANISTER AT 4 BAR					
Sl no	**Weight of canister in grams**	**Velocity attained in m/s**	**Von MesisStrees in Mpa**	**Impact Force on the canister in N**	**Impact Force on bolts in N**
1.	165	68	2.051×10^4	4.83×10^6	1.208×10^6
2.	164	68	3.44×10^4	8.105×10^6	2.03×10^6
3.	166	71	6.44×10^4	15.17×10^6	3.79×10^6
4.	165	68	6.45×10^3	1.52×10^6	379.94×10^3

COLLAPSIBILITY OF CANISTER AT 5 BAR:

FIRING PRESSURE OF CANISTER AT 5 BAR					
Sl no	**Weight of canister in grams**	**Velocity attained in m/s**	**Von MesisStrees in Mpa**	**Impact Force on the canister in N**	**Impact Force on bolts in N**
1.	165	83	8.78×10^4	20.68×10^6	5.17×10^6
2.	168	83	8.225×10^4	19.38×10^6	4.84×10^6
3.	165	91	9.2×10^4	21.68×10^6	5.42×10^6
4.	163	83	8.22×10^4	19.37×10^6	4.84×10^6

COLLAPSIBILITY OF CANISTER AT 6 BAR:

FIRING PRESSURE OF CANISTER AT 6 BAR					
Sl no	**Weight of canister in grams**	**Velocity attained in m/s**	**Von MesisStrees in Mpa**	**Impact Force on the canister in N**	**Impact Force on bolts in N**
1.	163	100	1.25×10^4	2.95×10^6	0.7375×10^6
2.	166	91	2.23×10^4	5.25×10^6	1.3125×10^6
3.	166	100	1.387×10^4	3.27×10^6	0.8175×10^6
4.	165	100	2.27×10^4	5.35×10^6	1.34×10^6

V. CONCLUSION

Canisters are manufactured successfully with CNC spinning machine maintaining constant wall thickness i.e., 0.5mm. At lower pressure i.e. 3 bar the collapsibility of canister of the front portion is merger compare to higher pressure rate. Collapsibility/ foldability of canister in front portion is higher. As pressure of firing of the canister is higher the velocity at the arrestor is high. Canisters are tested at different pressure i.e., 3bar, 4bar, 5bar, 6bar. Test conducted for different lip angle of arresters i.e., 00, 100, 150, 200. Foldability of canister at the front end after impact is found similar with slight extra folding in case of higher lip angle. Impact load are uniformly distributed on all the four bolts.

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