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THE BIRD IMPACT TEST METHODS AND EQUIPMENT OF THE NANCHANG AIRCRAFT MANUFACTURING COMPANY

by

Zhou Jialiang, Xu Guomin, Tang Hongguang

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AUTHOR: Zhou Jialiang Xu Guomin Tang Hongguang

Incidents in which flying airplanes and flying birds collide with each other in mid-air, causing aircraft damage or loss of aircraft and lives, are frequently seen both domestically and outside China.

Due to the fact that bird collisions pose a severe threat to the safety of aircaft flight, and, in conjunction with that, they bring with them quite considerable economic losses, as a result, when designing modern aircraft, it is necessary to adequately consider the problem of mutual collisions between birds and aircraft, and, when test validating designs, one should carry out tests simulating collisions between aircraft and flying birds. Internationally, an anti-bird collision design standard has already been created for aircraft. Generally speaking, when in level flight, different types of aircraft, after their front windshields or wings have collided with a 4 pound (1.8 kg) bird in flight, as well as large model planes, after their tail surfaces have collided with 8 pound (3.6 kg) birds in flight, should not give rise to danger and damage to the aircraft's subsequent flight safety, or destroy it. In order to satisfy the requirements of this standard, various countries of the world, in succession, manufactured equipment for tests simulating collisions between birds and aircraft, as well as creating testing grounds (target ranges). Most of the methods for which they have opted use a "bird bullet" or projectile gun bombarding an aircraft (test stock).

Early on, our country, in the late 1960s, began research on bird collision tests. The Nanchang Aircraft Manufacturing Company, in the early 1970s, set up bird collision test equipment. Going through 20 years of effort, it currently already possesses a bird collision laboratory with relatively perfected equipment. Below, from five aspects, we introduce the bird collision test methods and equipment of the Nanchang Aircraft Manufacturing Company.

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"BIRD BULLET" FIRING

When doing ground simulation testing, generally, one does not consider bird speed (this is because the ratio between the speed of the aircraft and the speed of the bird is approximately 25:1). On the basis of comparative or relative motion theory, using high speed bird collisions with aircraft in order to realize ground simulations is feasible. The test equipment that is used is called an air gun.

The air gun is composed of air tanks, air tubes, and auxilliary equipment. During tests, the air tank is first charged to the predetermined air pressure by the air compressor device. After that, a high speed air current is released. Moreover, the released air current pushes the "bird bullet" along the air tube, causing it to collide with the test stock at high speed and realizing a simulation of collisions between birds and aircraft. The test stock is installed in a frame where its angle can be adjusted. A 4 cubic meter transitional air tank is capable of supplying air to the air gun air tank on a continuous basis in order to facilitate fast continuous "gunfire." Fig.1 is a schematic diagram of the bird collision test apparatus.

"BIRD BULLET" SPEED MEASUREMENTS

"Bird bullet" speeds are measured by laser speed measurement systems which are microprocessor controlled. These systems include laser firing structures, laser signal recieving structures, microprocessors, typewriters, as well as digital display devices among their various components (See Fig.2).

Laser firing devices and laser signal receiving devices are installed in the specially manufactured framework between the air gun and the test stock platform. The framework is very close to the test stock. The distance of the two laser bundles is selected appropriately. In order to make calculations convenient, they are generally chosen as fixed values, for example, 1,2,5, or 8 meters, or other similar values. After the "bird bullets" go through laser bundles 1 and 2, microprocessors then take the automatically collected times and convert them to speeds. In conjunction with this, they are recorded in a typed form. This type of laser speed measuring system has a built-in error which is not greater than 6.4 microseconds.

In order to precisely guarantee speeds under slightly changed conditions, they can all be measured out. During tests, one selects for use two sets of laser equipment and carries out measurements at the same time.

DYNAMIC MEASUREMENTS

Dynamic measurements of bird collision tests include strain measurements, collision impact power measurements, as well as position movement measurements.

When aircraft and flying birds contact each other in collisions between them, the time period is extremely short. The period of time between the contact of the bird and the plane and the disintegration of the bird from the impact is only approximately 3 milliseconds. The period of time of the effect of the load on the aircraft is quite a bit longer. However, it is also an instantaneous dynamic parameter. Because of this, one must opt for the use of a super dynamic strain meter, a new model of position movement sensing device, a new model of force sensing device, as well as an instantaneous recording device. It is also necessary to bring in the use of the concept of stress waves, and other similar ideas.

STRAIN MEASUREMENTS

Strain measurement systems are composed of strain slices or shards, super dynamic strain meters, instantaneous recording devices, and microprocessors.

The important links in super dynamic strain measurements are the selection of the locations for the positioning of the strain slice placement and the selection of the course of measurements to be recorded.

The selection of locations for strain slice positioning is determined by the configuration of the location where the test stock is impacted and the status of the forces exerted or received. For example, in full arc-shaped front windshields, the placement of strain shards is generally in accordance with a fan-shaped arrangement (See Fig.3). The advantage of the fan-shaped placement is that, if, after the "bird bullet" comes out of the barrel, there is a small amount of offset or deviational motion, it will still be possible to get accurate measurement data.

Before formal bird collision testing, one carries out added load testing on typical test stock and precisely determines the scope of the strain, deformation, and collision forces, in order to act as references for selecting the course of measurements by the recording devices during formal bird collision tests.

MEASUREMENTS OF COLLISION FORCES

When aircraft and flying birds collide with each other, they will produce huge collision forces. If one takes the front windshield and views it as a soft or flexible body as well as taking the bird and viewing it as a fluid, then, the collision forces are a study in the mechanisms of collisions between flexible bodies and fluids and the analysis of the several important parameters related to soft material characteristics during the collision. Due to the fact that the contact time is short, the collision forces are large, and the deformations are large, if one uses ordinary force sensors and recording devices, there is no way to carry out measurements. In order to resolve this problem, one opts for the use of our country's newly test produced and successful piezo-electric force sensing devices. This type of sensing device responds quickly, transmits a strong signal, and gives good measurement results. However, it is only capable of being used 1-2 times. Fig.4 is the line and block diagram for the measurement of collision forces.

DISPLACEMENT MEASUREMENTS

Displacement measurements and collision force measurements are the same. The key is the selection of the sensors. Generally, electric sensing type and strain type displacement sensing devices are only capable of measuring low frequency signals. Th-y are not capable of measuring the instantaneous signals of short dι ion bird collisions. The Nanchang Aircraft Manufacturing Cɔmpany opts for the use of the magnetic response sensing devices which our country has test manufactured, and has successfully resolved the problem of displacement measurements in bird collision tests. The measurement line and block diagram is seen in Fig.5.

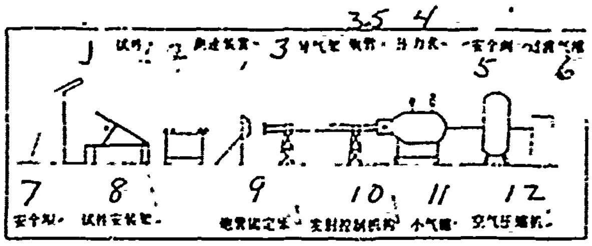

Fig.1 Bird Collision Test System (1) Test Stock (2) Speed Measurement System (3) Gas Guide Framework (3.5) Gun Tube (4) Pressure Gauge (5) Safety Valve (6) Transition Pressure Tank (7) Safety Embankment (8) Test Stock Installation Frame (9) Gun Tube Holding Frame (10) Fire Control Structure (11) Small Air Tank (12) Air Compressor

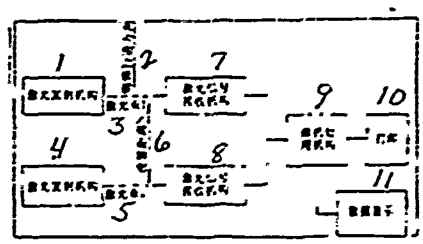

Fig.2 Laser Speed Measurement System (1) Laser Firing Structure (2) Direction of Gun Projectile (Bullet) Travel (3) Laser Beam 1 (4) Laser Firing Structure or Mechanism (5) Laser Beam 2 (6) System Distance S (7) Laser Signal Receiving Mechanism (8) Laser Signal Receiving Mechanism (9) Microprocessor Structure (10) Printer (11) Digital Display (illegible)

HIGH SPEED PHOTOGRAPHY

During testing, one makes use of the assistance of high speed photography to record the process of collisions between birds and airplanes. As far as the high speed photographic recording of the collision damage and collision shattering of relevent test stock by impacts is concerned, it is extremely useful for the study of materials characteristics and the analysis of aircraft structure designs. Also, it has great value for the verification of a number of measurement parameters.

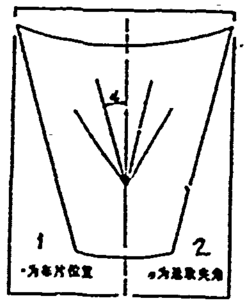

Fig.3 Placement of Strain Slices or Shards in Front of Windshield (1) Is Slice or Shard Arrangement Location (2) Is Selected Included Angle

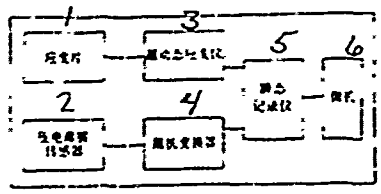

Fig.4 Line and Block Diagram for Collsion Force Measurements (1) Strain Slice or Shard (2) Piezo-electric Membrane Sensor (illegible) (3) Super Dynamic Strain Instrume: : (4) Impedance Transformer (5) Instantaneous Recording Device (6) Microprocesser

The laboratory has opted for the use of two 3000 frame/second high speed cameras, exposed at 90° and 45° angles. The photographing location is also capable of being selected on the basis of needs as appropriate.

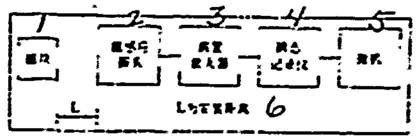

Fig.5 Line and Block Diagram for Displacement Measurements (1) Magnet (illegible) (2) Magnetic Response Probe (3) Pre-amplifier (4) Instantaneous Recording Device (5) Microprocesser (6) L Is the Installation Distance

METHODS OF ANALYSIS

The results from bird collision tests on different types of test stock call for the use of different types of methods in order to carry out analyses. For example, breaking of aircraft forward windshields can be divided into three types: safe breaks, unsafe breaks, and critical breaks.

Safe Breaks or Damage. Windshield frames are not deformed. Glass is not cracked. If there are cracks, they still do not lead to the breaking of the air seal of the cabin and large amounts of air leakage. Small amounts of windshield glass fallen off or shattered off. No damage to pilots nose section or visibility.

Unsafe Breaks or Damage. Windshield frame deformed. Cabin air seal showing large amounts of air leakage. Glass showing cracking, falling off, or broken through.

Critical or Marginal Breaks or Damage. Windshield frame slightly deformed. Glass shows cracking. There is small amounts of falling off and gas leakage. However, the windshield as a whole is still relatively intact. In this type of situation, one should, according to the flight speeds of different aircraft, calculate whether or not the aircraft is capable of completing the original flight.

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