A NEW TEST RIG FOR MEASURING THE SPIN STABILISED ROCKET CHARACTERISTICS

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The article describes the general arrangement and function of a new test rig designed and fabricated by the authors for testing and measuring chamber pressure, forward thrust and spin rate developed by spin stabilised rockets on firing under simulated flight conditions.

Almost all the rockets so far in service are of fin stabilised type. Now there is a tendency to experiment with spin stabilisation for some types of rockets either by itself or in addition to the fin stabilisation. This is particularly so in the case of antisubmarine rockets for achieving high accuracy.

Very often static firings are required to be conducted for measuring some of the design parameters of both the rockets and the propellants. These firings are carried out on test stands or rigs. Ideally these test rigs should be capable of simulating all the conditions to which the rockets will be subjected to in actual flight.

As the design of spin stabilised rockets is still new in India, test rigs for these had not been designed so far. It is also not possible to get realistic measurement of the various parameters of spin stabilised rockets on test stands for non-spinning rockets. This paper describes a test rig designed specifically for measuring the forward thrust, chamber pressure and rate of spin of a spin stabilised rocket on firing.

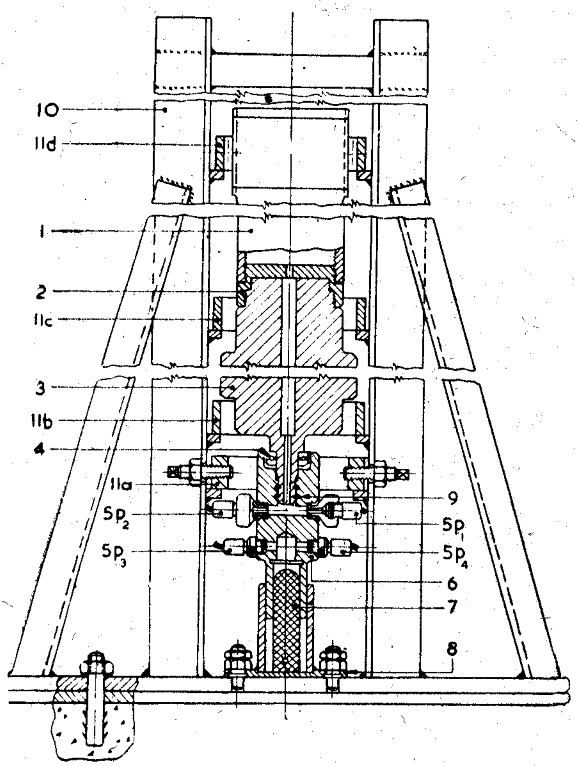

Fig. 1—General arrangement of the test rig assembled with the rocket (1) Rocket motor, (2) Body base adapter of the rocket, (3) Dummy warhead of the rocket, (4) Thrust ball bearing with spherical seating (5 P_1,P_2, P_3, P_4) Piezo-gauges with adapter, (6) Reaction head having pressure and thrust measurement chambers, (7) Piston (8) End plate subassembly, (9) 'O' rings (10), vertical structure subassembly, and (11 a, b, c, d) Guide ring subassemblies.

DESCRIPTION

Fig. 1 shows the general arrangement of the test rig along with the rocket assembly. The body base (2) of the rocket chamber is screwed on the dummy warhead (3) which has the same rotational moment of inertia as the actual warhead. The dummy warhead has a through axial hole which is filled with a continuous fluid column (petroleum jelly). The body base (2) of the rocket also has a through axial hole, connecting the rocket chamber to pressure measurement chamber of the reaction head (6) through the dummy warhead. The bottom end of the dummy warhead is located inside the pressure chamber of the Reaction head (6) which is filled with the same fluid medium (petroleum jelly). A thrust ball bearing with spherical seating ring (4) is fitted at the entrance of the pressure chamber in order to isolate the rotation of the warhead from the reaction head and still transmit the thrust. Two 'O' rings (9) are fitted between the pressure chamber wall and the dummy warhead stem to prevent leakage of petroleum jelly under pressure and thus to avoid occurance of erratic results. One end of Piston (7) rests squarely on the bottom plate of the test rig whereas the other end of the piston slides inside the thrust chamber of the reaction head. The piston and the thrust chamber have been designed to have just sufficient clearance for accommodating a fluid film to prevent any metal to metal friction and yet small enough to prevent any leakage of the fluid contained in the thrust chamber of the reaction head. The pressure chamber and the thrust chamber of the reaction head are connected to the Piezo-gauges ($5P_1$, $5P_2$, $5P_3$, $5P_4$) through cross drilled holes which are threaded to accept the gauge adaptors. These gauges are connected to the recording instruments kept in the remote control room. The continuous fluid column is carefully maintained between the Piezo-gauges and chambers during assembly.

The rocket, dummy warhead and reaction head are all axially aligned by use of four guide rings (11a, 11b, 11c, 11d). Each of these rings is fitted with four radial screws with balls attached to their front ends. These balls contact the surface of the dummy warhead by screwing the screws in or out as required. These balls lend lateral support to the assembly but ensure free rotation of the rocket during the firing. They also do not prevent slight axial movement if any. To prevent the rotation of the reaction head, a guide ring (11a) fitted with flat-end screws is used. These screws locate themselves in vertical grooves in the reaction head.

FUNCTION

On firing the rocket, the gas pressure developed in the rocket chamber is transmitted to the fluid in the 'pressure chamber' of the reaction head through the fluid column in the dummy warhead. The pressure is recorded by the Piezo-gauges ($5P_1$ & $5P_2$) fitted to the pressure chamber. A continuous permanent record of the chamber pressure versus time is obtained from the recording instrument.

The flow of gases from the rocket chamber through the canted nozzles at the rear end causes the rocket to spin about its geometrical axis and also to thrust forward. The forward thrust is transmitted through the spherical seated ball thrust bearing to the wall of the reaction head which in turn transmits this thrust through the fluid column in the thrust chamber of the reaction head to the piston. The pressure of fluid in the thrust chamber is therefore proportional to the thrust and is measured by the Piezo-gauges ($5P_3$ & $5P_4$) fitted to the thrust chamber. A permanent continuous record of the forward thrust versus time is obtained from the recording instrument.

The Actual Thrust=(Pressure measured by Piezo-gauges P_3 or P_4)$\times$(area of piston)

A small permanent magnet is fitted to the outside surface of the dummy warhead while a reactance coil is fitted to the stationary test rig at the same level as the magnet. The minimum air gap between the coil face and the magnet face is maintained at about 10 mm. A pulse voltage is developed in the reactance coil every time the magnet passes the coil during the rotation of the dummy warhead. These pulses are recorded against a time base and thus spin of the rocket versus time is recorded. From this, it is possible to measure both the maximum r.p.m. and the angular acceleration of the rocket.

Thus three types of continuous permanent records showing the development of chamber pressure, forward thrust and rate of spin of the rocket against a time base can be obtained from the recording instrument connected through Piezo-gauges to the pressure and thrust chamber of the reaction head of the rig. Thus peak values of these parameters as well as time of burning of the propellant can be measured.

Fig. 2 shows the photograph of the actual test rig designed and fabricated by the authors along with the rocket assembly ready for firing.

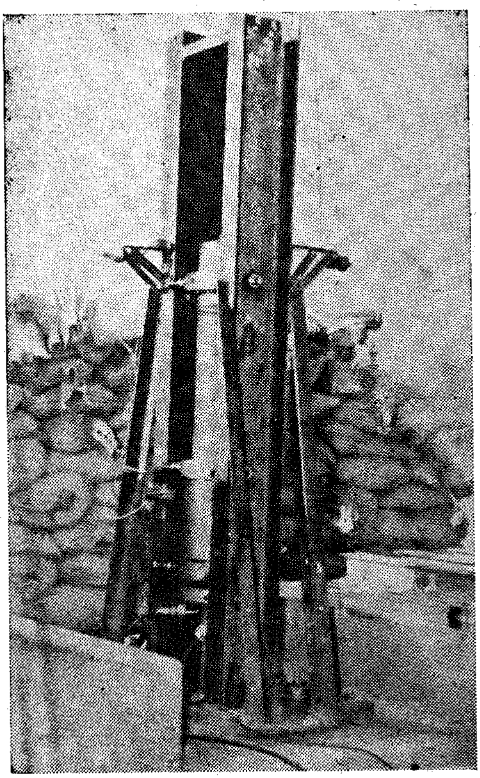

Fig. 2—A view of the actual test rig with rocket assembly, ready for test firing.

CONCLUSION

The test rig has been tested for successful test firing of spin stabilised rockets developing a maximum forward thrust of 2000 kgf while spinning at a maximum r.p.m. of 4000. It is mechanically robust and dynamically well balanced and capable of precisely recording chamber pressure, forward thrust and rate of spin developed by the spinning rocket under flight condition.

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