Technical Note

Recent Developments in Anti-G Systems

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The induction of highly manoeuvrable and agile fighter aircraft like Mirage-2000 and Mig-29 in the Indian Air Force (IAF) has brought the potential hazard of G-Induced loss of consciousness (G-LOC) to the forefront. A continuing effort is on in research and training laboratories to enhance the G-protection of our aircrew. The recent work done towards the development of an anti-G suit, setting up of a static bench test facility for anti-G suits and valves has been described.

Keywords: Anti-G suit, anti-G valve, G-induced loss of consciousness.

The potential hazard of G-induced loss of consciousness (G-LOC) weighs heavily on the minds of the aeromedical community as well as operations managers of the modern fighter aircraft. With the induction of the highly manoeuvrable and agile aircraft like Mirage 2000 and Mig-29 in the Indian Air Force (IAF), the problem has assumed greater importance for us. Of the various methods to be adopted for preventing the occurrence of G-LOC among our aircrew, development of the hardware has been emphasized[1].

Based on the various reports available on the beneficial effects of positive pressure breathing (PPB)[2,3], an oxygen regulator was modified earlier to deliver PPB under +Gz. This paper describes the work done towards the development of an anti-G suit and a static bench test facility for testing anti-G suit and valves. The work was carried out in Defence Bio-medical and electronics Laboratory (DEBEL), Bangalore under the Light Combat Aircraft (LCA) programme.

Light Weight Anti-G Suit

DEBEL has already developed MK II anti-G suit which is in service use. This anit-G suit uses 5 bladders made of natural rubber carried in an outer heavy duty nylon fabric. The broad qualitative requirements of the anti-G suit for the LCA are that it should have all the features of protection and crew comfort. It should have Flame Retardant property and yet it should weigh less than 1.8 Kg.

In the laboratory model for the LCA anti-G suit, the outer nylon fabric of the Mk II anti-G suit was replaced by heavy duty multifilament continuous nylon yarn mixed with single cotton. The number and sizes of pockets were increased, keeping in view operational requirements of present generation aircraft. Two thigh pockets were made with the openings looking down for human engineering considerations, since they afford better access in a seated posture. Three additional zip fasteners were provided, one on the abdominal portion and one each on the thighs. These fasteners can be used to loosen the snugly fitting suit for relaxation on ground. The connecting hose was made of spring reinforced rubber which can take any connector with screw type end. With all these changes incorporated, the weight of the anti-G suit turned out to be 2.5 kg. Subsequently the bladder material was changed to neoprine coated fabric. By bringing about only this change, the weight was brought down to approximately 1.8 Kg. This suit has been tested in the laboratory and can withstand pressure upto 140 kPa when mounted on an anthropomorphic dummy. This suit was subjected to trials in the human centrifuge at the Institute of Aerospace Medicine (IAM) and was found to give adequate protection. It then underwent flight trials with the Indian Navy and has been since accepted for introduction into service.

Further studies are required to explore the alternate materials for bladders and carrier garment (fire retardant fabric), and use of heavy duty nylon zip fasteners to replace metallic ones which are very heavy.

The Test Facility

The broad qualitative requirements for the LCA are that the valve should inflate a standard

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anti-G suit to 10 kPa/G after 1.5 to 2G upto a maximum of 70 kPa. The delay between G and peak pressure achieved in the suit should not be more than 1-2 sec. It is felt that the present generation anti-G valves available in the country will not cater for the requirement of the LCA.

Before the development of an anti-G valve can be undertaken, it is necessary to obtain more information on performance characteristics of the existing anti-G system. To this effect, a bench test facility has been established in the laboratory to study the pressure time history of anti-G suit inflation on instantaneous loading of the anti-G valve to various 'G' valves.

The facility essentially consists of an anti-G valve mounted rigidly on a stand and an anthropomorphic dummy on which an anit-G suit is fastened. The vertical axis of the valve is aligned within ± 2° of the true vertical. Over the anti-G valve, a platform is mounted on which weights can be placed for instantaneous loading. The anti-G valve is supplied with compressed air at 12 -50 PSI through a pressure reducer. The outlet of the valve is connected to the anti-G suit mounted on the anthropomorphic dummy. Weights are kept on the platform for loading the valve to equivalents of +1Gz to 8 Gz as per the requirement. On loading the valve, outlet port opens to fill the anti-G suit.

A transducer senses the pressure at the outlet port of the anti-G valve and sends the signal to a digital pressure indicator which displays the pressure in kPa. The analog signal from the digital indicator is given to a strip chart recorder which is calibrated for recording pressure time history. A make and break switch provided at the platform gives a signal to the recorder at the instant of loading with the weight.

The test facility can be used to study outlet pressures of an anti G valve at various G levels. It can be used to study inflation characteristics of anti G suits especially when different bladder material and/or outer carrier garments are used. The facility can also be used to study the changes in pressure-time history of the anti G suit worn by the aircrew as a result of modifications carried out in the anti-G system.

Preliminary work has been carried out on the Russian Anti-G valve to study its performance. It takes 1.9 to 2.2 sec to inflate the anti-G suit to the peak pressure. Experimental modification was carried out on the anti-G valve to give ready pressure in the anti-G suit. With the ready pressure of only 1kPa, the time to reach the peak pressure is reduced to 1.2 sec, a reduction of 40%.

Further work is required to establish whether the time lag observed between instantaneous loading of the valve and filling of the suit to required pressure actually exists in the dynamic flight situation. Studies are also required to assess the optimum values of ready pressure and filling rates in the suits which are commensurate with the crew comfort.

Conclusion

In view of the potential hazard of G-LOC, work has been carried out for development of an anti-G suit and a static facility for testing the anti-G suit and valves. Preliminary results show that 40% reduction in time to reach peak pressure can be achieved by modifying the existing type of anti-G valve to pre-inflate the suit to 1 kPa.

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