Original Article

Positive pressure breathing and G-tolerance in the SU-30 aircraft

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SU-30 is one of the newest aircraft in the Indian Air Force inventory. The aircraft is a twin-seater, multi-role fighter aircraft. Due to its large endurance and multiple role capability, the aircraft has a different G-profile, as compared to other fighter aircraft of the Indian Air Force. Acceleration profiles reveals that the peak average +Gz was 5.53. The maximum +Gz varied between 1.9 and 8.0 while the minimum +Gz varied between 0.1 and 2.4. The average onset rate was 1.44 +Gz, ranging from a maximum of 4.5 G/sec to a minimum of 0.2 G/sec. Typically there would be large periods of inactivity followed by intense combat. The average duration of sorties was 1.54 hours varying from a maximum of 2.08 to a minimum of 1.45 hours. The total time spent in air combat manoeuvre varied from a maximum of 22.04 minutes to a minimum of 4.01 minutes, with an average of 14.04 minutes. In percentage figures, in long duration sorties, the pilot spent 12.5% of the time on ACM as compared to the total duration of the sortie. The twin seater fighter aircraft also has clear cut roles and tasks for the two pilots in the front and rear cockpit. This would mean that the pilot controlling the aircraft would have to warn his other crewmember of imminent aircraft manoeuvres. This is achieved by providing PBG, which cuts in at 3-G level. Though the G-suit provides protection at 2-G and beyond, the PBG also serves as a warning to the other crewmember to start AGSM. This method also provides a warning to the other crewmember, to limit G-related injuries and GLOC. This paper aims to bring out the G-profile of the aircraft and the peculiarities of the PBG. It also highlights the fact that the pilots are extremely reluctant to use this facility due to difficulty in speech during PBG and the unacceptable heat load on wearing the BKK - 15 suit. Therefore it is mandatory to train all pilots of this aircraft on PBG, for optimum utilization of this excellent facility.

Keywords: Twin crew fighter cockpit, G-profile, PBG, warning system.

The induction of SU-30 aircraft in the Indian Air Force inventory has brought about a sea change in the firepower and technology of military aviation. The SU-30 is a two-seater multirole fighter aircraft. It is designed to intercept enemy targets at close, medium and long ranges, in air and on the ground. The aircraft is powered by two bypass - turbofan engines, capable of generating 12.5 tons of thrust each, giving the aircraft awesome power and agility in combat. It is capable of maintaining

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station for upto 10 h or 8400 km range with two in-flight refuelling. The maximum permissible G limits are +8 and –2Gz[1]. A two pilot fighter aircraft with an airborne capability of upto 10 h poses a challenge to the aviation medicine specialist in terms of aircrew comfort, fatigue and ability to withstand high acceleration forces. Not only does the pilot have to contend with the high G forces but also has to ensure adequate warning to his co-pilot, to prevent accidental injuries and mishaps. The extreme agility of the aircraft, ability to sustain high-sustained G coupled with long duration of flight has forced the designers to incorporate innovative design features in the aircraft.

The aim of this paper is to discuss the G profile of the aircraft, the major differences as compared to other Air Superiority Fighters (ASF) like the Mirage 2000 and MiG 29 and analyses the utility of providing positive pressure breathing for protection against G forces.

Materials and methods

The data relevant to this study was collected from the flight data recorder of the SU-30 aircraft (Tester - y3 series 3). The FDR is designed to collect, convert and record the information characterizing the technical condition of the aircraft, its attitude in space and the pilot's action[2]. The system has the capability to record upto 250 events, including continuous parameters, like +Gz, speed, altitude etc and one time recording of events like warning signals, operation of after burners etc. It is capable of recording the last 3 hours of the aircraft flight. The system is automatically switched on once electrical power is fed in to the aircraft or manually by a switch, located in the nose landing gear. The information is stored on removable magnetic tape, which is downloaded to a computer, operating on Windows NT Workstation. The display is available in three modes viz., tabular display, graphic output and pictorial display of aircraft attitude. The information so available not only helps technical rectification but also pilots to relive their sorties for debriefing.

A retrospective analysis of some combat and training sorties was undertaken. These sorties were of two different classes, those pertaining to routine training and combat sorties and sorties of duration greater than 1.45 hours. The data was obtained from the graphs and digital printouts of the FDR. The parameters obtained were duration of the sortie, maximum +Gz, minimum +Gz onset rate in G/sec and duration of aerial combat in sorties exceeding 1:45 h. The total duration of the air combat manoeuvre was calculated as the percentage of total duration of the sortie. There were a total of 108 sorties for which the data was calculated for +Gz data and 16 long duration sorties exceeding 1:45 hours. This did not include ferries, air tests and aerobatic sorties.

Results

Table 1 presents the analysis of the G profile of SU-30 aircraft. Analysis of acceleration profiles reveals that the peak average +Gz was 5.53. The maximum +Gz varied between 1.9 and 8.0 while the minimum +Gz varied between 0.1 and 2.4. The average onset rate was 1.44 +Gz, ranging from a maximum of 4.5 G/sec to a minimum of 0.2 G/sec.

Table 1: G profile of SU-30 aircraft

Aircraft	Maximum G	Minimum G	Onset Rate (G/sec)
Maximum	8.0	2.4	4.5
Minimum	1.9	0.1	0.2
Mean	5.53	0.4	1.44
SD	1.17	0.31	0.66

Table 2: Long duration sorties vs ACM duration

Aircraft	Duration of sortie (hours:min)	Duration of ACM (min seconds) (Expressed as%)	Duration of ACM / Duration of sortie
Maximum	2:08	22:04	
Minimum	1:45	4:01	
Mean	1:54	14:04	12·5
SD	:004	3:07	3·3

Table 2 presents the analysis of the total time spent on ACM in sortie duration of more than 1:45 hours. The average duration of sorties was 1:54 hours varying from a maximum of 2:08 to a minimum of 1:45 hours. The total time spent in air combat manoeuvre varied from a maximum of 22:04 minutes to a minimum of 4:01 minutes, with an average of 14:04 minutes. In percentage figures, in long duration sorties, the pilot spent 12.5% of the time on ACM as compared to the total duration of the sortie.

Discussion

The analysis of acceleration profiles of SU-30 aircraft reveals that the acceleration profile is similar to that of other ASF, currently operating in the Indian Air Force [3]. The average G limits appear to be lower than the corresponding figures for Mirage 2000 and MiG 29 aircraft. This is because primarily the SU-30 is in the process of being inducted and a major part of the flying is training sorties rather than operational flying. The onset rates however, show a higher figure for average rate of onset of +Gz, a reflection of the enormous power and agility of the aircraft.

Analysis of the long duration sorties, a role in which this aircraft would ultimately be employed, show a very interesting finding. Even though the database is small, it reflects that in long duration sorties the pilot spends roughly one eighths of the total duration in combat only. This is partly because of the long endurance of the aircraft and the short but intense periods of engagement. For other aircraft with a smaller endurance and the same engagement pattern, the percentage figure would be higher, though the total duration of ACM may be the same.

The SU-30 is a two-seater fighter aircraft, manned by two pilots. They have their workload strictly demarcated, including areas of overlap. To take an example, the front pilot would be responsible for flying the aircraft and close combat whereas the rear pilot is responsible for early warning radar operations, ESM or long distance strikes. In the initial part of all sorties, the front and rear pilots are aware of the air situation, as time passes by and the work load increases or eases out, attention over the air situation reduces. A combat situation may suddenly develop, when the pilot actively controlling the aircraft may manoeuvre suddenly for combat. The rear pilot may be involved in his own task and there may not be enough time to warn him of the manoeuvre.

Table 1 demonstrates it clearly that the G levels are enough to cause severe neck injuries or even G-LOC, in susceptible individuals. Therefore, there has to be a system of warning the other crewmember of aircraft manoeuvres. Inflation of the G suit at +2 Gz may not provide enough warning, the designers of the aircraft have therefore, provided positive pressure breathing as an effective warning system. Positive pressure breathing is provided to the pilot by a switch on the port side panel. On selecting positive pressure breathing, whenever acceleration force exceeds + 3Gz the unit operates automatically, increasing oxygen inlet pressure and applying the same pressure on the compensated expiratory valve of the mask. Partial counter pressure is applied to the anterior chest wall by simultaneously inflating bladders of the BKK-15 suit. In case, it was meant to be a method of enhancing G tolerance, it would be advisable for positive pressure breathing to cut in at a level when the G-suit protection was exhausted[4]. Positive Pressure Breathing forces the pilot to automatically carry out the AGSM, thereby providing warning and protection simultaneously.

In a survey carried out to determine the use of positive pressure breathing as a warning system, it was apparent that the operators did not view this system favourably. The small database of available pilots made it imperative to carry out an informal survey and the reasons are as under:

a) The BKK-15 suit is made of capron - cotton cloth, it is extremely cumbersome to wear and imposes an unacceptable heat load on the individual. The air-ventilated suit integral to the BKK-15 functions only at 85% RPM and is ineffective on ground.

b) The pilots have very little experience or training on the positive pressure breathing system and therefore, find it extremely uncomfortable. They prefer to keep the system switched off, rather than be surprised at positive pressure breathing suddenly cutting in during aircraft manoeuvres.

The aviation medicine specialist has his role cut out; the importance of this excellent design feature must be highlighted to all aircrew. The aspect of indoctrination and training on positive pressure breathing needs to be incorporated in to the High G Course at IAM, especially for aircrew operating twin crew fighter aircraft. As the number of such aircraft increase, aircrew in large numbers will have to be trained and indoctrinated. It is imperative that the system on the human centrifuge should mimic the aircraft system, to ensure acceptance of training. SOPs for SU-30 may also have to be changed so that the selector switch for positive pressure breathing is kept on at all times and only a positive pilot input will select it off. This important safety feature must be exploited to its full potential, for optimum utilization of aircraft capability.

Conclusion

The study reveals that G profile is similar to other ASF operating in the Indian Air Force. The high rates of onset are an indicator of the enormous power that the aircraft has. The total time spent on ACM in long duration sorties amounts to just 12.5% of the total duration. The aircraft has positive pressure breathing incorporated to cut in at 3G, to warn the other crewmember of aircraft manoeuvres, to prevent injury and G-LOC. However the operators are extremely wary of using this system due to the unacceptable heat loads imposed by the counter-pressure garment, BKK-15 suit, as also a lack of training on positive pressure breathing. It is essential to incorporate training on positive pressure breathing during the high G course at IAM, to exploit this design feature and the aircraft potential to its maximum capability.

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