Positive pressure breathing for G - tolerance subjective acceptance among the pilots

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ABSTRACT

SU-30 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, which can cause serious injury or G-LOC during aircraft maneuvers. 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 crew member of imminent aircraft maneuvers, to avoid injury or G-LOC. This is achieved by providing PBG, which cuts in at 3-G level. This method also provides a warning to the other crewmember, to limit G-related injuries. A questionnaire survey was carried out among all aircrew flying the SU-30 aircraft to ascertain subjective acceptance of the PBG. The survey revealed that there was little acceptance for this facility among the aircrew. Apart from the fact that the aircrew had no training on the PBG, the aircrew considered it to be a hindrance to flying & preferred to switch it off. The utility of PBG is proven among the other twin seater fighter aircraft and therefore training of aircrew must start on the PBG, to ensure optimal utilization of the aircraft capabilities.

IASM 2000; 44(2) : 51-55

Keywords : PPG, Positive pressure breathing, G-tolerance

The maneuvering capabilities of modern fighter aircraft have exceeded mans tolerance to high G forces. The vexed issue of increasing man's tolerance has limited the aircraft's capability for maneuvers; the pilot has now become the limiting factor in aircraft capabilities. With the addition of a sophisticated, state-of-the-art, multi-role SU-30 aircraft in he IAF, this problem has become more acute. Analysis of the G profile of SU-30 aircraft 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 2.6. 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 [1].

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

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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 cases out, attention over the air situation reduces. A combat situation may suddenly develop, when the pilot actively controlling the aircraft may maneuver 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 maneuver. The aircraft designers have, provided Positive Pressure Breathing as an effective means to combat the G forces, as also to warn the second crewmember of imminent aircraft maneuvers. 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. Counter-pressure is applied to the anterior chest wall by simultaneously inflating bladders of the BKK-15 suit. The influx of oxygen at 40mm HG automatically forces the pilot to carry out the AGSM involuntarily [2]. However, during informal surveys, it was revealed that this system is usually switched off in flight, due to to a host of reasons.

This paper aims to highlight the subjective acceptance of the PBG system by the pilots of SU-30 aircraft, and the reasons for its non-use in flight.

Materials and Methods

An anonymous survey was conducted among all airecrews who were or are posted to the SU-30 squadron, or have flown the aircraft as the first/second pilot. The questionnaire was designed for simplicity and clarity with multiple choice questions or graded answers. The questions were designed to determine the comfort, fit and availability of the BKK-15 suit, level of comfort with PBG, symptoms due to high G forces and Positive Pressure Breathing as well as subjective assessment of system during various sor total of 47 questionnaires were admin aircrew currently operating the aircraft or flown the aircraft.

Results

Of the 47 questionnaires given out, re for received from 44 aircrew, 43 of the re were from the F(P) branch and one from F aircrew were from a varied Background, wi of combat aircraft, including MiG-21, MiG-2 29, Jaguar and Mirage aircraft. 11 re among the aircrew had supervisory status. flying hours on SU-30 was 277.37h, ran a low of 20h to a maximum of 620 hours. of the pilots were issued with a BKK-15 their size. None of the pilots had any tra the PBG system.

Table 1 : BKK - 15 Suit: Comfort Lev

Parameter	Response
Comfort	Well Fitting
	Ill Fitting
Ease of Donning Suit	Easy
	Cumbersome
Head Load in Summer	Unacceptable
Heat Load in Winter	Unacceptable

Table 1 indicates the comfort levels BKK-15 suits. 72% of the pilots found the s fitting while only 11% found the suit ill These figures are for the suits available pilots who could be fitted into the availab For the pilots who could wear the avilabl 94% found them to be easy to wear wh found it to be cumbersome. The heat load the cotton - capron fabric, made it unco

all pilots, irrespective of the climate.

Table-2 tabulates the use of PBG on the ground and air for the aircrew. All the respondents wished it off in air, 97.7% found it difficult to communicate on RT, if used and 72.7% were uncomfortable with the system at all times, making use on ground. These results were based on multiple choice questions and the pilots were free to choose answers, thus the graded response.

Table-2: Use Of PBG in Flight or Ground

Parameter	Response
Uncomfortable	72.7%
Difficulty in RT Communication	97.7%
Prefer to Switch it off	100%

Table-3: G-Related Injuries/Incidents among Aircrew

	Total Number of Incidents	
Injury/Incident	Front seat	Rear Seat
Neck Ache	16.7% (2)	83.3% (10)
Back Ache	2	Nil
Grey Out	35.8% (19)	64.2% (34)
Black out/GLOC	3	2

Table-3 illustrates the incidence of G-related injuries among aircrew, while flying from the front and rear seat separately. 16.7% of the incidents of neck ache were while flying from the front seat while 83.3% of the incidents were while flying in the rear seat. 35.8% of the incidents of grey out were from the front seat while 64.2% of the grey out were wile flying in the rear seat. There were 2 incidents of backache and 5 incidents of GLOC. The pilots had reported multiple episodes of G Related injuries/Incidents.

Table-4 : Fatigue Leveles: Average Figure on Training/Combat/Long Duration Sorties

Fatigue Levels	Front Seat	Rear Seat
Average Level of	2.9	4.3
Fatigue on a scale	Maximum 4	Maximum 7
of 1-10	Minimum 1	Minimum 1

Table-4 relates to the fatigue levels among pilots, on a subjective scale of 1 to 10. 1 on the scale was least tiring ("after a good nights sleep") while 10 was most tiring ("travelling unreserved in an overnight train"). The front seat average fatigue levels were rated as 2.9, with a minimum of 1 and maximum of 4. The rear seat average fatigue levels were rated as 4.3, with a minimum of 1 and maximum of 7. However, there was a large variation in pilots from strike aircraft background viz. Jaguar and MiG-27, as compared to pilots of ASF class of aircraft viz. MiG-29, while flying from the rear seat.

Discussion

PBG was considered almost 45 years ago, as a counter measure against +Gz accelerative forces [3]. PBG with chest counter pressure ("Assisted PBG"), the technique not only increased G tolerance but also reduces fatigue due to frequent AGSMs. This also increases endurance due to minimal voluntary effort by the pilot for long duration combat sorties. Surveys of military pilots from the USAF indicate that the majority of reported GLOC incidents in-flight occur in novice aircrew of aircraft capable of rapid and sustained G forces. The greatest incidence of GLOC in aircrew surveys was reported in the non-controlling pilot flying in twin seater aircraft, usually the

trainee pilot [4, 5]. Most of the pilots reported subjectively most comfortable with PBG in the range of 30 - 45 mm Hg, during centrifuge trials [6]. In this study on the Indian pilot population having access to PBG, the pilots are fairly well experienced, with an average of 277h on the aircraft. The pilots did not use the system due to non-availability of the pressure jacket and severe discomfort, preferring to switch off the system during flight. Difficulty in RT communication was the main cause that forced almost all the pilots switch off the system in-flight. Primarily, the main cause is that the pilots were not exposed to the system, nor were they trained for it. It was also clear that the BKK-15 suits were in short supply and a number of pilots had to try and fit a suit of thier size. That is perhaps, the reason for 11% of the respondents not finding the suit well fitting. 94% of the respondents found the suit to be easy to wear and take off, reflecting on the superior design characteristics of the suit. The BKK-15 suit is made of cotton-capron fabric, is bulky and the heat load under Indian tropical conditions makes it unbearable. The air ventilated part of the suit works only after 85% engine RPM [2]; the 30-45 minutes of flight preparation time after wearing the suit and prior to take off, makes it extremely uncomfortable.

A positive pressure breathing system is operational in the USAF, in the F-15 and F-16 aircraft for use by aircrew, appropriately called COMBAT EDGE (COMBined Advanced Technology Enhanced Design G-Ensemble). This is a positive pressure breathing system anti-G system with counter pressure vest. Positive Pressure is automatically applied to the mask and vest at the rate of 12 mm Hg starting at +4Gz, up to a maximum of 60mm Hg at +9Gz. PBG passively assists the AGSM, thereby reducing the effort, resulting in reduced fatigue and increased endurance. The study conducted by Travis et al showed hat 66% and 88% of the F-15 and F-16 pilots respectively found it easier to pull G with COMBAT EDGE. 76% of the F-16 had red fatigue where as the figure for F-15 pilot 20.8% 84% of the F-16 pilots preferr COMBAT EDGE, while 70.8% of the F-15 preferred to fly without it. This may be expl on the basis of higher peak G levels in the as compared to the F-15, translating into a potential benefit. The incidence of neck pa grey out was significantly lowere in preferring to use PBG, as compared to the group, not using the system. There wa reported incidence of Acceleration Atelecta pilots using COMBAT EDGE. The occasion cough and pharyngeal irritation was due to the oxygen - air mix used for PBG [7].

In this study, a number on incidents reported for neck ache and grey outs. Signific neck aches were five times more common rear seat and grey out almost twice as comm the rear seat, as compared to the front seat. I SU-30, the G levels are enough to cause se neck injuries or even G-LOC, in suscep individual [1]. The PBG is threfore, also mea act as a warning system to the second crew-mem of impending aircraft maneuvers. Inflation o G-suit at +2Gz may not prove enough warning aircraft designers have therefore, provided Pos Pressure Breathing as an effective warning sys Whenever acceleration force exceeds +#Gz the operates automatically, increasing oxygen pressure and applying the same pressure to compensated expiratory valve of the mask. Co pressure is applied to the anterior chest wa simultaneously inflating bladders of the BKK suit [1]. The relevance of warning system for rear pilot can not be overemphasized; that the counter pressure garment may also ha splinting effect on the thoracic and lumbar sp thus reducing chances of injury [7].

The average higher subjective level fatifue in the rear seat may be because of a num of reasons, the most important being the

minimum levels required for anticipating aircraft maneuvers initiated by the front pilot, for doing the AGSM. In addition, the pilots from the strike aircraft background, like the Jagur and MiG-27, may not be used to the highly maneuverable SU-30, pulling G higher than these pilots have been routinely exposed to.

Conclusion

The SU-30 aircraft has Positive Pressure breathing incorporated to cut in at 3G, to warn the rear crewmember of aircraft maneuvers, 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. The significantly higher incidence of neck ache and grey out in the rear pilot emphasizes on the warning aspect as well as the protective aspect against high G-forces. 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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