Aeromedical Assessment of Cockpit Control— 'Canopy Jettisoning Handle'

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Abstract

SUBJECTIVE assessment of a cockpit control 'Canopy jettisoning handle' in Ajeet Trainer Mockup has been discussed. An objective method has been devised to measure the loading given to the control from study of integrated electromyography (IEMG) during its operation. This technique has been found useful in the overall assessment of cockpit control and may be utilised by aircraft designer during modification for effective operation.

Introduction

The efficiency of an aircrew in a close loop control system of man-machine complex depends upon interaction of various subsystems of human operator and the aircraft. The pilot should be able to operate all controls in the cockpit efficiently and accurately with speed and safety[1].

The cockpit layout and control display are basically designed after human engineering considerations including anthropometric parameters. However, certain compromises are often made for factors like space, weight and the cost of aircraft. These compromises in positioning and operational efficiency of controls can affect the reach of a pilot and may encourage a tendency of keeping his harness loose to ensure a better reach and operation of controls. This practice can lead to dangerous consequences in the event of an ejection[3]. Hence it becomes imperative that the layout of cockpit controls and its effective operation are critically assessed at every stage of development of an aircraft.

Subjective assessments are often incomplete and can be variable depending on many individual factors. During one such assessment of Ajeet trainer(T) aircraft at the development stage a number of pilots experienced difficulty in operating the canopy jettisoning handle. Hence a need was felt to develop an objective method of assessment in addition to subjective evaluation.

Canopy Jettisoning Handle

This is a secondary emergency control which is meant for jettisoning the canopy in the event of smoke in the cockpit or prior to crash landing when the pilot decides to jettison the canopy alone without arming the ejection seat. Its operation may also be required when the primary handle fails to jettison the canopy. The control is located on the horizontal panel of left hand console of the front cockpit of Ajeet trainer a/c (Fig. 1). The control is a D shaped handle with 3" grip bar wirelocked with load of 0.5 kg breaking strength. The control has a mechani-

Fig. 1
Location of the Canopy Jettisoning Handle in the Universal Cockpit. Subject is seen pulling the handle.

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cal linkage and is a spring loaded system. The loading of the system may vary from 15 40 lbs from aircraft to aircraft. Its operation involves a blind approach to hold the handle with left hand in prone position, unlock the wirelocking and operate the control with a jerky pull keeping the shoulder joint as a pivot.

Methods and Observations

(*a*) *Selection of subject :* Ten experienced aircrew covering 5th to 95th percentile of standard Indian pilot population were selected as subjects. Their static anthropometric dimensions were measured. For this study, their sitting height, total arm reach and elbow-to-grip reach were specifically noted.

(*b*) *Cockpit trials :* Using the standard flying overall the subject harnessed himself in the aircraft seat and adjusted his seat position as per the eye datum point. He was then asked to assume ejection posture, approach the control handle blindly and pull it backward in one thrust. The clearance of elbow from the canopy thruster was observed before and after operating the handle (Fig. 2). The total length of the control cable pulled was measured and subjective comments were noted. Subjective comments after conduction of similar trials in Gnat aircraft were 'satisfactory' in every subject.

(*c*) *Subjective assessment :* Findings of subjective assessment in Ajeet (T) cockpit are given in Table I. Almost all aircrew noticed that the location of the control in Ajeet (T) is more backwardly positioned in relation to seat reference point compared to the Gnat a/c. Operation of control was more stressful in Ajeet (T) compared to that in Gnat. Aircrew in higher percentile group showed very little clearance from canopy jack. Their elbow hit against canopy jack and their shoulder grazed against the left longeron. In addition, they could not extract full length of the control cable during operation. Aircrew in lower percentile group observed that their elbow hit hard against the canopy jack as soon as the control handle was operated, but they could extract full length of the control cable.

(*d*) *Objective assessment :* In order to measure the maximum load required to pull the control and to determine whether the position of the hand, either pronation or supination, could affect the performance, an objective method of assessment was devised in the Universal Cockpit.

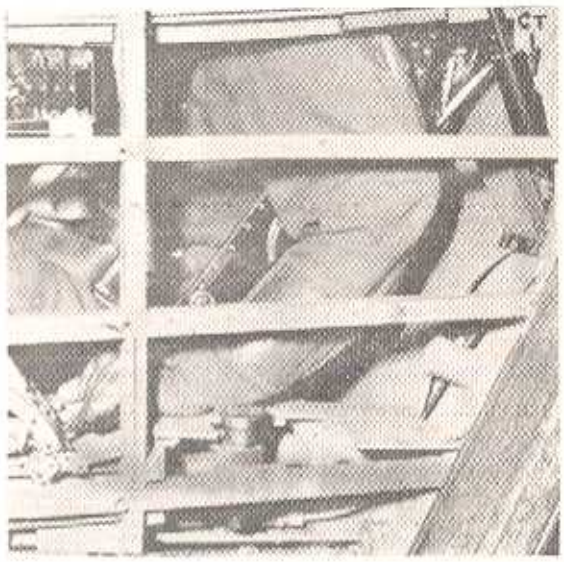

Fig. 2(a)

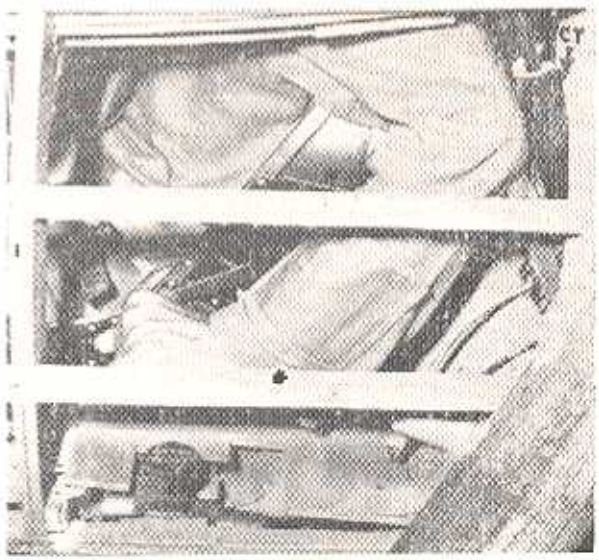

Fig. 2(b)

Clearance of elbow from the canopy thruster, marked as CT. (a) before and (b) after operation of the handle. Note that the elbow hits against the canopy thruster after operation.

Three dimensional (3D) measurements in coordinates of horizontal distance, vertical height and angular position of the control and other relevant structures of a/c in relation to the seat reference point were obtained from Gnat and Ajeet (T) cockpits. These were obtained after removal of ejection

TABLE I

Subjective assessment in Ajeet (T) cockpit

Sl. No.	Elbow-to-grip reach (cms)	Distance between elbow to canopy jack		Subjective comments on control operation
		Before operation of handle (cms)	After operation of handle (cms)	
1	43.5	Nil	Nil	Difficult to operate
2	38.0	5.00	,,	Elbow hits against the jack
3	40.0	3.00	,,	—do—
4	36.0	7.00	,,	Just satisfactory
5	37.0	6.00	,,	—do—
6	38.0	5.00	,,	Elbow hits against the jack
7	37.0	6.00	,,	Just satisfactory
8	36.5	6.00	,,	—do—
9	43.0	Nil	,,	Difficult to operate
10	38.0	5.00	,,	Elbow hits against the jack

seat with the help of "Cockpit Caliper" as discussed in detail elsewhere[3]. The data is given in Table II.

TABLE II

Three dimensional measurements of canopy jettisoning handle in the aircraft

Sl. No.	Aircraft Type	Horizontal distance (cms)	Vertical distance (cms)	Angular distance (degrees)
1	Gnat	33	26	60
2	Ajeet(T)	32	22	70

Using the 3D measurements, Universal Cockpit was set up with special attachments of left longeron, backside of cockpit wall and canopy thruster[1,3]. The canopy jettisoning handle was fabricated as per its exact specifications. The handle was connected with a miniature electronic load cell for measuring the loads during operation of the control. The load cell was calibrated with standard weights and dynamometers.

Subjects participating in the aircraft cockpit trials were taken for trials in Universal Cockpit. The reference point of the seat in the Universal Cockpit adjusted for Ajeet(T) and Gnat aircraft separately. Muscular activity during the pull of the control was recorded with three silver electrodes of 1cm diameter. After adequate skin preparation and using electrode jelly, two electrodes were placed over the left biceps muscle at 2 cm and 5 cm above the elbow joint while the ground electrode was fixed on the forearm. The electromyograph (EMG) signal was integrated and the integrated EMG (IEMG) was recorded on one channel of a 4 channel DC polygraph. The output from the load cell was recorded on another channel of the polygraph. Each subject pulled the handle with maximum force keeping his hand in three different positions—vertical(I), pronated(IIP) and supinated(IIS). Thus a simultaneous recording of IEMG and the load pulled were made with three positions separately for Ajeet(T) and Gnat aircraft settings (Fig. 3). After completion of the tests each subject gave his preference out of the three hand positions.

Results are given in Table III. Choice of hand position for operating the handle has been statistically worked out by scoring one to subjective choice, one to minimum IEMG and one to maximum load pulled. Best choice was found to be IIP in both the aircraft with maximum load pulled in that position.

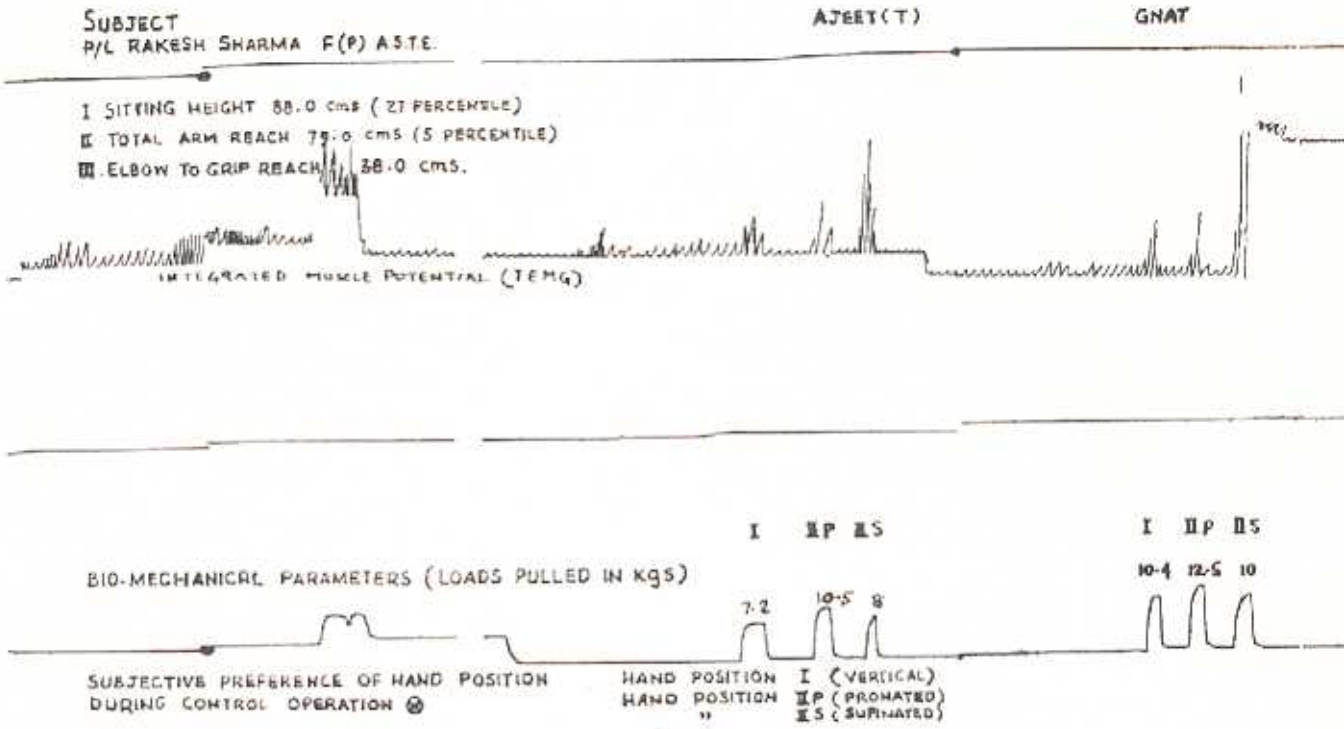

Fig. 3

Sample record of biomechanical parameters (loads pulled) vis-a-vis IEMG during operation of control handle with different hand positions.

The loads pulled in Gnat aircraft in all the 3 positions were higher than in Ajeet (T) due to adequate room for elbow to grip reach for the control. IEMG also showed similar trend with lower muscle potential in Gnat.

Conclusions and Recommendations

Canopy jettisoning handle in Ajeet (T) is less satisfactory and only partially effective compared to that of Gnat aircraft. This may be improved by providing a shorter extraction cable to ensure better operation of control by higher percentile pilot population. The control can be best operated by keeping hand in pronation. This method of objective assessment can be utilised for evaluation of control operation during mockup stage.

TABLE III

Mean values of pull loads in Kg along with their preferential scores in 3 different positions of the hand control operation in Gnat and Ajeet (T) aircraft (n = 10)

Position of control operation	Mean pull load (Kg)		Total preferential score		IEMG	
	Gnat	Ajeet (T)	Gnat	Ajeet (T)	Gnat	Ajeet (T)
I	9.44	6.73*	10	8	8.56	11.00‡
IIP	9.46	7.23†	15	13	6.22	8.34‡
IIS	9.04	7.21§	8	6	9.89	13.72‡

* $p < 0.001$ † $p < 0.01$ § $p < 0.05$ ‡ Not significant

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