Analysis of Selected Tractor Seats for Seating Dimensions in Laboratory

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ABSTRACT

The tractor seat is one of the important component / assembly as far as the human machine system and comfort of tractor operator are concerned .With this in view, a field survey and laboratory study were conducted of selected popular tractors and tractor seats, respectively, with particular reference to seating dimensions. Dimensions for seat pan and backrest were measured and analyzed, according to BIS recommendations. The results highlighted that seat pan width was found 10.9% less, seat height was found 15.3% in excess, no vertical adjustments and backrest width was also found 20.4% less. This may cause discomfort for smaller as well as higher percentile tractor operators. Based upon the design of mounting arrangement of different tractor seats – a common device i.e. seat base plate was developed. This plate may serve as a base for providing isolators for vibration attenuation. Also, this arrangement may be quite useful in testing of different tractor seats, under the constraints in availability of different makes of tractors at a time for experimental study or testing work. The study also highlighted that present tractor seats need minor modifications / improvements in seating dimensions as per BIS recommendations. The development of a common seat base plate may prove to be a step forward in the direction of long awaited tractor standardization. The information thus obtained can be utilized in seat design, work place lay out as well as adapted by agriculture engineers for better work environment.

Keywords: Tractor seat, seating dimensions, workplace layout, free point 3 D digitizer, India.

1. INTRODUCTION

Mechanization in agriculture has changed the characteristics of labour and has also influenced the work load (Salokhe *et al*. 1995). Presently, in India also, with a relatively good monsoon and farmers switching over to mechanized farming, tractor volumes are picking up. The current population of tractors in India is around 3.0 million and more than 0.25 million tractors are added to Indian agriculture every year. India stands as the largest manufacturer of tractors in the world (Singh and Doharey, 1999). At the same time, though tractorization has reduced the drudgery involved in the farm operations, but it was evident that tractors had ergonomic shortcomings (Dupuis, 1959; Fairley, 1995, Balasankari *et al*., 2004).

Tractor seat is one of the important components / assembly as far as human machine system is concerned. Each tractor has its own seating arrangement in order to provide better

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maneuvrability, control and comfort, for example - steering of tractor, looking backward to observe and control the machine / implement, and force required to operate clutch, brake and hydraulic control lever. The task and workplace determine the postures and create a pattern of loading on the structures of the body of the individual. An attempt has been made to observe the pattern of seating dimensions as per Indian Standard 12343: 1998 (version of ISO 4253 : 1993), by mounting seats of different makes on a selected tractor. Thus, this paper describes the analysis and comparative study of different makes of tractor seats in a field survey as well as laboratory study.

1.1 Objectives

1. To conduct field survey and laboratory measurements for seating dimensions of available tractor seats.
2. To compare different tractor seats for their seating dimensions, as per BIS standards.

2. MATERIALS AND METHODS

The following experiments were carried out under this study –

2.1 Field Survey

A field survey was carried out to collect information on seating dimensions and mechanisms of different makes of new tractor seats. Relevant anthropometric seating dimensions – seat length, seat width, seat height, back rest width and back rest height etc., feasible and suitable for field work were measured with the help of measuring steel tape, scale etc. Fig. 1 to 3 show the mechanisms adapted for Indian tractor seats. Seating dimensions thus measured and recorded were compiled for seating comfort as per the dimensions of the Indian standard for comparative study.

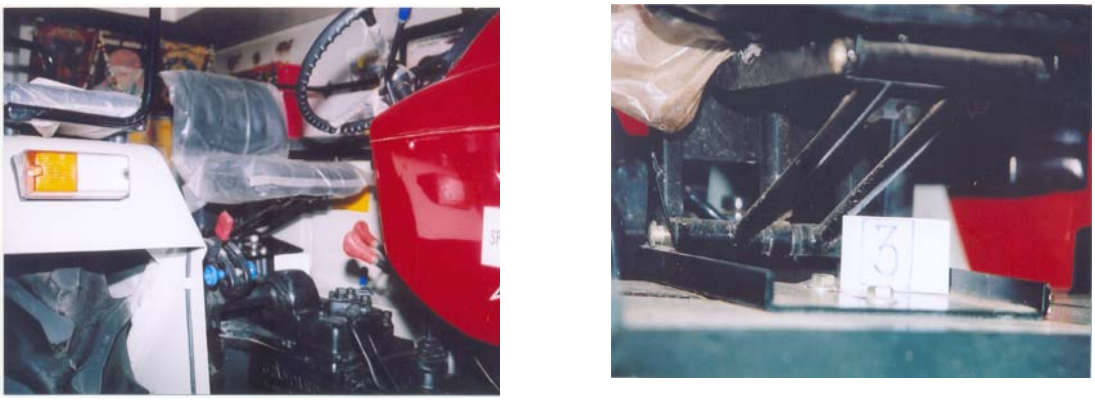

Figure 1. View of tractor seats during field survey

2.2 Laboratory Seating Dimensions Measurement

A set up, as shown in Fig. 4, was used for measurement in the laboratory. Measurement of various seating dimensions was made by a Freepoint 3D-digitizer instrument precisely. This

instrument works on reflection of radiations emerged from point under consideration and provides measurement in all the three coordinates. A Freepoint computer software was also installed.

Five commonly adapted tractor seats (S1, S2, S3, S4 and S5), as shown in Fig. 5, of different makes were procured for precise measurement with the instrument installed. The Seat Reference Point (SRP) and Seat Index Point (SIP) (SRP & SIP were determined as per the IS 11806, 1986 and IS 11113, 1985, respectively standards) were located by SRP device, as shown in Fig. 6. Various angular measurements, shape, seat mounting base area etc. were also worked out.

Figure 2. Tractor seat view showing suspension mechanism and inclined seat base plate

Figure 3. Overall view of a tractor seat without open space for backrest

Figure 4. Setting up triangle detector array of freepoint-3D digitizer measurement set-up

Figure 5. Selected tractors seats for laboratory study

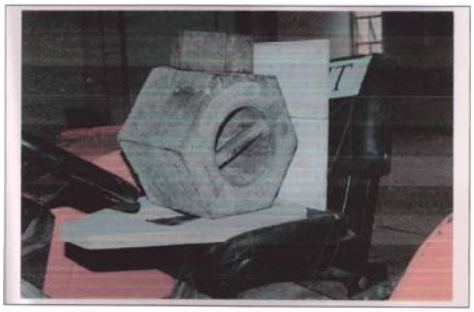

Figure 6 Determining the location of SRP as per IS:11806, 1986

2.3 Development of a Common Seat Mounting Base Plate

On the basis of seat mounting arrangement and seat type mounting dimensions, mechanism etc., a M.S. (mild steel) plate having size 310 x 240 x 10 mm, was taken and 12 mm. diameter holes were drilled on this plate, as per seats mounting dimensions layout, so it may accommodate all the seats under laboratory study. On the bottom of the plate, proper nuts were welded, so as to have easiness and rigidity in tightening seat bolts. Thus, different makes of tractor seats could easily be fitted for comparative study and analysis.

3. RESULTS AND DISCUSSION

Results of field survey of eight tractor seats and laboratory study of five selected tractor seats have been discussed as below –

3.1 Field Survey

Seating dimensions of eight different tractor seats were measured in a field survey as presented in Table-1. On comparing from the prescribed anthropometric measurements as per Indian Standards, revealed that – Seating dimensions of eight new popular commercially available tractors at dealer's workshop were measured in a field survey. The seating dimensions of 8 different tractor seats are given in Table 1. The obtained results indicated, that seat lengths of T1 and T5 tractors were found within the range as per IS 12343:1998, while, other tractors seating dimensions were observed slightly less; i.e. 0.3 to 2.6%. Seat width of T1 tractor was found in the range but for other tractors, seat width was found less, i.e. 0.5 to 10.9%. This variation may lead to discomfort for tractor operators. Seat heights in most of the tractors were found to be too high, i.e. 0.6 to 15.3%. This should be a consideration in redesigning tractor seats. Seat pan concavity was found between 18 to 38 mm. As regards seat adjustment, longitudinally about 50 to 100 mm was provided in all the tractor seats, while only in T2 and T8 tractor seats could be adjusted longitudinally as well as vertically about 17 to 46 mm, by virtue of inclined seat mounting arrangement. As regards, the back rest width, none of the tractor seats were found to be in conformance to the Indian standards i.e. > 450 mm. Table results indicated that it was found less, i.e. 7.1 to 20.4% in all seats. Back rest height as per IS should be independently adjustable and kept more than 260 mm. In almost all the tractor seat, it was found as per anthropometric data of Indian operators, except in T5 seat, where there was no open space provided to accommodate the sacrum and fleshy parts of buttocks of the operator, just above the seat pan, by which this

backrest height was comparatively more as compared to other seats. Backrest concavity was found from 18 to 36 mm.
The field survey results indicated that still there is a need for modifying tractor seat design in the areas of seat height, seat vertical adjustment and back rest width, as per Indian standard anthropometric considerations.

3.2 Laboratory Study

A free point 3D digitizer instrument was used to measure the seating dimensions of five selected tractor seats. Seating dimensions of different seats were compared with the above Indian standard. The results, as shown in Table 2, indicated that the seat lengths were found to be almost within the range, as prescribed by the IS i.e. 350 to 450 mm. But, in case of seats S1, S3 and S4 it was found to be slightly less then as required, i.e. -1.4 to 4.3%. Seat widths of S2, S3 and S5 tractor seats were found within the prescribed range as per Indian standard, while S1 and S4 seat widths were found slightly below i.e. 2.2 to 7.3%. This may contribute to discomfort for the tractor operators, particularly those in the higher anthropometrical percentile population. As regards, the seat adjustment, it was observed that the none of the seats were provided with vertical adjustment facilities but have longitudinal adjustment in between i.e. 50 to 140 mm for different seats. Seat pan cushion thickness and angle of seat pan inclination with seat surface were found within limits.
Back rest seat widths of different seats were not found as per the Indian standard. All the seats were found below the prescribed limit, i.e. 7.8 to 17.1%. While, back rest height of seats were found within the range of Indian standard, by including the maximum vertical open space above the top of the compressed seat, so as to accommodate bulged seat and fleshy portion above the seat surface. Seat suspensions mechanisms operator's weight range, back rest concavity, cushion thickness, inclination of back rest axis with vertical was found within the range. As regards mounting arrangement of different seats on a tractor and utilized space was concerned, it was found strikingly different for the tractors under study. Above results also revealed that seating dimensions of tractor seats for Indian operators still need modifications by improving the tractor seat design.

Table 1. Field survey - seating dimensions of different types of tractor seats and comparison with Indian standard

S. No.	Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Comments as per IS : 12343, 1998 (mm)
1.	Seat length (mm)	362 (-)	341 (-2.6)	338 (-3.4)	348 (-0.6)	354 (-)	341 (-2.6)	349 (-0.3)	348 (-0.6)	Buttock popliteal length 5^{th} percentile = 400 $\pm$ 50
2.	Seat width (mm)	455 (-)	428 (-4.9)	448 (-0.5)	441 (-2.0)	412 (-8.5)	401 (-10.9)	407 (-9.6)	428 (-4.9)	Hip breadth sitting 95^{th} percentile $\geq$ 450
3.	Seat height (mm)	555 (+2.8)	568 (+5.2)	543 (+0.6)	572 (+5.9)	458 (-)	622 (+15.2)	623 (+15.3)	520 (-)	Sitting popliteal height 5^{th} percentile : 540 (maximum)
4.	Seat pan concavity (mm)	38	30	28	30	30	22	18	26	-
5.	Seat adjustment									-
	a. Longitudinal (mm)	90	47	50	50	100	80	70	131	-
	b. Vertical (mm)	-	17 (inclined)	-	-	-	-	-	46 (inclined)	-
6.	Back rest a. Height (mm)	260 (-)	255 (-)	258 (-)	260 (-)	364 (-)*	260 (-)	265 (-)	262 (-)	Height should be independently adjustable $\geq$ 260
	b. Open space above the compressed seat pan	(55)	(58)	(52)	(75)	(0)	(45)	(50)	(68) (fix)	-
7.	Back rest width (mm)	415 (-7.8)	381 (-15.3)	407 (-9.5)	402 (-10.7)	381 (-15.3)	358 (-20.4)	418 (-7.1)	377 (-16.2)	Intersey breadth of 95^{th} percentile $\geq$ 450
8.	Back rest concavity (mm)	36	18	28	26	32	18	28	22	-

Note : Figures in parenthesis indicated comparative percentage drop (-) or increase (+) with respect to Indian operators anthropometric dimensions.

Table 2. Laboratory measurement - Seating dimensions of selected tractor seats by Free point 3D-digitizer instrument

S. No.	Dimension description with limits as per IS : 12343, 1998	S_1	S_2	S_3	S_4	S_5
1.	Seat length, mm (400 ± 50 mm)	343 (-2.0)	366 (-)	345 (-1.4)	335 (-4.3)	352 (-)
2.	Seat width, mm (≥ 450 mm)	417 (-7.3)	471 (-)	448 (-0.5)	440 (-2.2)	465 (-)
3.	Seat pan cushion thickness, mm	48-50	55-58	38-40	45-50	55-60
4.	Seat pan concavity, mm	30-32	38-40	30-32	5	30-33
5.	Seat adjustment a. Longitudinal, mm	100	90-200	140	50	50
	b. Vertical, mm	-	-	-	-	-
	c. Type	shifting	sliding lever / shifting	sliding lever	nut bolts	central sliding slit hole
6.	Angle of inclination of seat surface, degree (3 to 12° backward)	5	12	5	5	10
7.	Seat base mounting space size / area (L x W = cm^2) and position	33 x 14 = 462 back side of operator	16 x 9 = 144 moreoless below the operator	31 x 7 = 217 moreoless below the operator	25 x 23 = 575 moreoless below the operator	32 x 24 = 768 moreoless below the operator
8.	Back rest width, mm (≥ 450 mm)	373 (-17.1)	415 (-7.8)	408 (-9.3)	413 (-8.2)	400 (-11.1)
9.	Back rest height, mm (≥ 260 mm) max. vertical open space adjustment, mm (maximum)	240 75 (-7.7)	301 41 (-)	268 30 (-)	260 40 (-)	270 75 (-)

contd-

Remarks: All seats were equipped with parallelogram linkage mechanism with two helical coil springs and a shock absorber.

S. No.	Dimension description with limits as per IS : 12343, 1998	S_1	S_2	S_3	S_4	S_5
10.	Back rest concavity, mm	32-35	35-38	30-32	10-12	33-35
11.	Back rest cushion thickness, mm	30-35	32-35	32-35	45-48	20-22
12.	Back rest inclination (degree) from vertical (5 to 15^o)	19^O	7^O	10^O	10^O	8^O
13.	Angle of inclination between seat pan and back rest surfaces (degree)	104^o	85^o	95^o	95^o	88^o
14.	Seat suspension weight range (kg)	50-120	50-120	50-120	50-120	50-120
15.	Location of SRP on seat pan (x-axis)	38-40 mm	35-40 mm	18-20 mm	extremely at the back side of seat pan	15-17 mm
16.	Seat pan surface	Apparently medium ribbed, smooth corners, bulged sides	Apparently broad, ribbed, smooth corners, bulged sides	Apparently broad ribbed, smooth corners, bulged sides	Apparently flat and comparatively plain, smooth corners, slight bulged sides	Apparently broad, ribbed, smooth corners, bulged sides
17.	Back rest surface	ribbed	plain	Central portion ribbed	plain, unribbed, moreoless flat	plain

Note : Figures in parenthesis indicated comparative percentage drop (-) or increase (+) with respect to Indian operators anthropometric measurements.

S indicates the different seats of tractor under study.

4. CONCLUSIONS

1. Presently, all the seats (as surveyed) of Indian tractors are equipped with parallelogram linkage mechanism with two helical coil springs and a shock absorber.
2. The comparison of measured seating dimensions of different tractor seats with the recommendations of IS 12343 (1998) indicated that:
a) Seat pan lengths were within the recommended range of 350-450 mm.
b) The seat pan widths of some of tractor seats under the study were lower (up to 10.9%) than minimum BIS recommendations of 450 mm.
c) Seat heights of some of the tractors exceeded the BIS recommended maximum limit of 540 mm. It may cause excessive pressure on the underside of the thigh, which can reduce blood circulation to the lower legs.
d) Seat adjustment in longitudinal direction was within the BIS recommended range of ± 100 mm, while vertical seat adjustment was not provided in most of the seats. This may affect the hand and leg reach, and maximum actuating force of tractor operators for operation of frequently operated controls like brake pedals, clutch pedal, foot accelerator, steering wheel etc.
e) The backrest heights of most of the seats were within the BIS recommendation of more or than or equal to 260 mm. In most of the tractors seats, sufficient open area was provided below the backrest to accommodate sacrum and fleshy parts of buttocks just above the seat pan and to allow the lumbar region to fit firmly into the backrest.
f) The backrest widths of tractor seats under the study were lower (up to 20.4%) than minimum BIS recommendations of 450 mm.
g) Shapes of seat pan and backrest of most of the tractor seats were found alike, but there is a wide variation in cushion thickness, seat pan and backrest concavities and seat mounting arrangement on tractors.
h) Seat pan and backrest inclinations as well as suspension weight range were found the same for most of the tractor seats.
3. Tractor seats of different makes can also be fitted appropriately on the tractor by incorporating, a properly designed simple (MS plate) seat mounting base plate.

5. ACKNOWLEDGEMENTS

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