ABSTRACT

The seat cushioning material plays a dominant role in supporting operator posture, isolating vibration and improving ride quality. Most of studies on characterisation of cushion materials have been reported for automobile seats. Therefore, the present study was undertaken to identify the most suitable cushion materials for tractor seats in order to improve operator's comfort.

Ten commercially available seat cushion materials of different densities, thickness and compositions were procured for this investigation. The static and dynamic properties of the cushion materials for tractor operator comfort were determined in the laboratory. The density of PUF cushion materials varied from a low value of 9.30 kg/m^3 to a high value of 19.09 kg/m^3. The Dunlop type cushions material had the highest density of 69.72 kg/m^3 followed by coir type seat cushion materials laminated with medium density PUF. The force-deflection characteristics of the cushion materials were found to be non-linear and static stiffness constants decreased with increase in thickness of cushion materials. Dunlop type cushion material D_1 was the most resilient, and high density PUF H_1 and H_2 were the least resilient cushion materials. The percentage loss in thickness after 24 h of the dynamic durability test was 5.5, 13.24, and 6.53% for coir type composite cushion samples C_1M_1, C_2M_3 and C_1M_3, respectively. The vibration transmissibility was higher for coir based cushion materials as compared to PUF cushion materials. The dynamic modulus increased and dynamic hysteresis decreased with increase in flex time for most of the seat cushion samples.

The seat cushions were also evaluated for pressure distribution at seat-operator interface and subjective comfort assessment on a test seat under static condition. The mean pressure distributions were 4.58, 4.27, 4.14, 3.05, 1.77 and 1.20 kPa for seat pan cushions H_1, H_2, D_1, D_2, C_1M_1 and C_2M_3, respectively and were 2.22, 0.96 and 0.16 kPa for backrest cushion materials H_1, D_1 and C_1M_3, respectively for selected subjects. The mean pressure distribution decreased with increase in thickness of seat cushion materials. A tractor seat evaluation checklist (TSEC) was developed to identify features of tractor seats related to operator comfort under static and dynamic conditions. The subjective rating data were analysed using factor analysis, variance analysis and correlation coefficient analysis. The post hoc pair comparison was also done using Bonferroni multiple comparison test based on student's t test. The descriptors in the TSEC such as seat pan cushion, backrest cushion, thigh support, buttock support, overall seat pan support, lumbar support, overall backrest support, and overall comfort produced significant correlation with overall comfort, GCR and Lines scales.

A biomechanical model of a tractor operator was developed to predict compressive and shear loads at L4/L5 (lumbar vertebra) for the selected seat pan and backrest cushion materials. The maximum compressive forces at L4/L5 ranged from 943 to 1367 N and shear forces ranged from 422 to 991 N when tractor operator was steering the tractor with leg and hand control actions and occasionally viewing the implement at the rear.

The four seat pan and three seat backrest cushion materials were evaluated in a randomised order on a developed tractor seat during transport and ploughing operations. The heart rate of the tractor operators was measured at different exposure time periods and the developed tractor seat was also subjectively evaluated for comfort on different rating scales and checklists with a view to assess the cushion behaviour under actual field conditions. The most suitable cushion materials for seat pan and backrest were incorporated in the tractor seat. The performance of this tractor seat was compared with a pre-designed tractor seat called "IITKGP-95 seat" (Prasad, 1995). The newly developed tractor seat with optimised seat pan cushion material D_2 (thickness = 101.43 mm and ρ = 69.72 kg/m^3) and seat backrest cushion material C_1M_3 (thickness = 79.00 mm and ρ = 47.19 kg/m^3) was found to be the most comfortable on the basis of minimum energy expenditure by the drivers and subjective comfort evaluation under actual tractor operating conditions.

Key words: Tractor seat cushions, Operator comfort, Vibration transmissibility, Real time characteristics, Biomechanical model, Pressure distribution, Seating comfort, Heart rate, Field test.