Research In Progress

Injury Potential to a Seat-Belted Operator during a Rearward or Sideward Overturn of a ROPS-Equipped Farm Tractor

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Tractor overturns fatally injury more people than any other equipment-related incidents in agriculture. The use of roll-over protective structures (ROPS), in conjunction with a seat belt, is currently believed to be the most effective approach to reduce such deaths and serious injuries. However, a recent NIOSH study on the anthropometry of farm workers has raised a concern that the ROPS, based on SAE standard J2194, may not be able to protect a medium-to-large sized male operator in every overturn. This study evaluated the injury potential to a seat-belted 95th percentile male operator during rear or side overturns while the tractor is equipped with commercial ROPS (certified to SAE J2194) or size-expanded ROPS (commercial ROPS widened to 68 inches at the top).

The commercial ROPS were used in three rear and three side overturn tests whereas the size-expanded ROPS were used in three side overturn tests. All tests involved a Ford 4600 tractor and an Advanced Dynamic Anthropomorphic Manikin (ADAM) whose sitting height was comparable to that of a 95th percentile male. ADAM was restrained on the seat by a seat belt with each hand secured by masking tape on a handle close to each side of the steering wheel. Both the rear and side overturn tests were conducted in accordance to SAE standard J2194.

In all three rear overturn tests, the manikin's head impacted the ground after the ROPS struck the ground. The impact was within the tolerance range for head and neck injuries. The head injury index (HIC_{36}) was within the critical value of 1000. The neck injury index (N_{cf}) was less than the critical value of 1 and the peak neck compression was below the critical value of 4830 N. In all three side overturns involving the commercial ROPS, the manikin's head impacted the ground before the ROPS struck the ground. Severe lateral bending and extension of the neck was observed after the head strike in these tests. In all three tests, the HIC_{36} was within the critical value of 1000. But in one test, the peak compression exceeded the critical value of 4830 N, indicating possible severe neck injuries. During two out of three side overturn tests involving the size-expanded ROPS, the manikin's head impacted the ground after the ROPS struck the ground. In all three tests, HIC_{36} was within the critical value of 1000. But in one test, the peak compression exceeded the critical value of 4830 N, indicating possible severe neck injures.

The commercial ROPS functioned protectively for a 95th percentile male operator in rear overturns. During side overturns, the risk of severe injures existed for the same operator when the commercial ROPS was used. Increasing the width of the ROPS did not significantly reduce the neck injury potential, even though such size-expanded ROPS allowed the head to impact the ground after the ROPS did in two out of three tests. Further analyses on the manikin kinematics during the rear and side overturn tests and additional research on human kinematics during simulated roll-over conditions in the laboratory may shed more light in the design of more effective ROPS.