# University of North Carolina at Charlotte Simulates Abrasive Wear of Tillage Tools

High energy requirements and rapid tool wear are two major issues of concern to farmers during soil-plowing operations. While the first issue has been more or less addressed by the advent of high-powered tractors, the second issue, namely, tillage tool wear, has received very little attention. Experimental work conducted at the National University of Colombia at Medellin shows that the tillage tools wear out rapidly with a wear-rate of almost 10 grams per kilometer of plowing. Such rapid rates limit the operating lifetime of these tools and result in significant downtimes for changing tools and therefore increase in tillage costs.

The experimental work being carried out at NUC-Medellin consists of three plowing assemblies, carrying one tillage tool each, attached to a tractor used for soil plowing. The speed of tractor is in the range of 3-5 km/h. A single tillage tool is 12 cm long and 6 cm wide and made of a heat-treated steel. The soil type used for experimental studies is a sandy soil in which the main particles are the sand particles that typically range from 0.5 mm to 2 mm in size. The observations from the experimental studies identify that the tool failure is primarily due to the sliding sand particles moving on the tool surfaces, although some wear due to gravel (particles that are of size greater than 2 mm) has also been observed. The worn-out tillage tools from the field tests indicate groove formation on the tool surface, confirming the material loss to be the material displaced from the groove.

Guided by the experimental work, research at the University of North Carolina at Charlotte has been focused on numerical simulations using Abaqus/Explicit to understand the effect various tillage parameters, such as the tillage speed, plowing depth, and sand properties, have on tool wear. As a first step towards understanding the wear process, a single sand particle sliding over the tool surface with a prescribed initial penetration depth is considered. The tool is modeled as an elastoplastic material and the sand particle is treated as a rigid cylinder with a hemispherical tip. The sliding process is carried out in three steps: an initial step to establish contact with the tool surface and initiate an indentation process, a second step to move the sand particle over the tool surface, and a third step to disengage the particle from the tool surface. Various parameters such as the particle speed, initial penetration depth, and particle size are varied over a select range of values (consistent with the experimental values). The motion of the sand particle over the tool surface results in a groove due to the plastic deformation of the tool. The groove geometry along with the classical ploughing theory is used to calculate the material removal rate due to the scratching of the tool surface by a sand particle. This is then used to obtain an average material removal rate due to multiple particles scratching a tool surface.

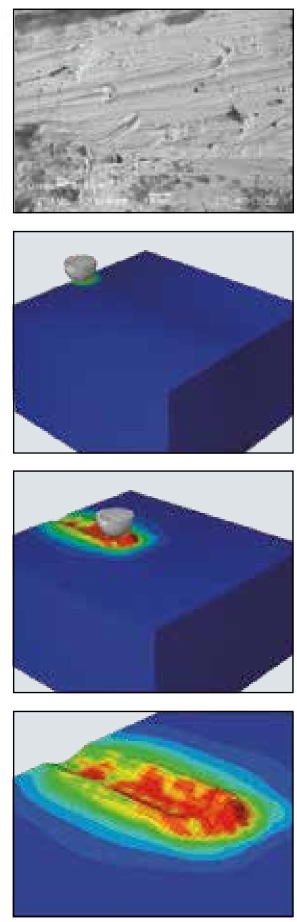
The numerical predictions for the material removal rates with sand particle sizes from 0.5 mm to 1 mm have been found to be in agreement with the experimental findings. Our results indicate that the finite element model, developed with Abaqus/Explicit, provides a robust tool for understanding the factors that are important in controlling tillage-tool wear during plowing operations.

a)

b)

c)

d)



*Tool wear during tillage operations: (a) The surface of a worn-out tool, (b) Simulated indentation on the tool surface, (c) Tillage tool deformation, (d) Tool surface deformation.*

### For More Information

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