DEFORM™ Application #353

Redesign of a Face Mill Insert

Background:

Continuing advances in high performance cutting have placed ever increasing demands on cutting tools. The design of these cutting tools influences the efficiency of material removal as well as the surface finish of the part.

New computer simulation technology reduces the amount of experimentation needed to test and optimize a new cutting tool, and thereby improves performance and time to market.

The design process for new cutting tools is complex, time consuming, and expensive. New designs are based on prior experience, but several design iterations may be required before all design goals are achieved. Traditionally, each iteration involves the manufacturing and testing of a prototype insert.

DEFORM™-3D finite element simulation predicts important parameters such as chip flow, stress, and temperature in the cutting tool as well as force and power requirements. Insert designs which do not meet targets can be eliminated without ever manufacturing a physical prototype.

Case Study:

Kennametal used DEFORM™-3D simulation in conjunction with an experiment to study the effect of redesigns on a milling cutter insert. The FIX PERFECT milling cutter with Polycrystalline Diamond (PCD) tipped inserts is a standard Kennametal product. It is used for machining aluminum alloys in the automotive and general machining market segment (Figure 1).

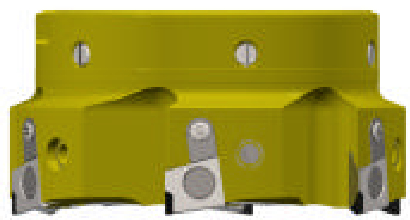

Figure 1: A Kennametal fix perfect milling cutter is shown with inserts.

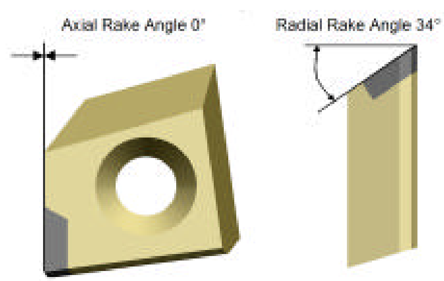

Figure 2: The geometry of current standard product is shown.

The geometry of the standard insert is shown in Figure 2. It features a 0° axial rake and a 22° effective radial rake when mounted in a 100 mm diameter milling cutter body. Because of the extremely sharp cutting edge, ductile aluminum alloys like AL7075 tend to form long chips during milling. If these chips come between the cutter body and the workpiece, it can adversely affect surface quality of the workpiece.

To maintain product quality, Kennametal proposed two possible redesigns of this insert. Both involved adding axial rake to pull the chip away from the workpiece and improve evacuation. The standard insert, as well as the two redesigns, were simulated using DEFORM™-3D. To validate the simulation results, prototype inserts were manufactured and tested at Kennametal facilities.

Figure 3 and Figure 4 show the current production design. As the chip forms, it tends to drag along the face of the workpiece. From a product quality standpoint, this is a concern because chips which are not evacuated properly may tend to become ensnarled under the cutter body and adversely impact product surface finish.

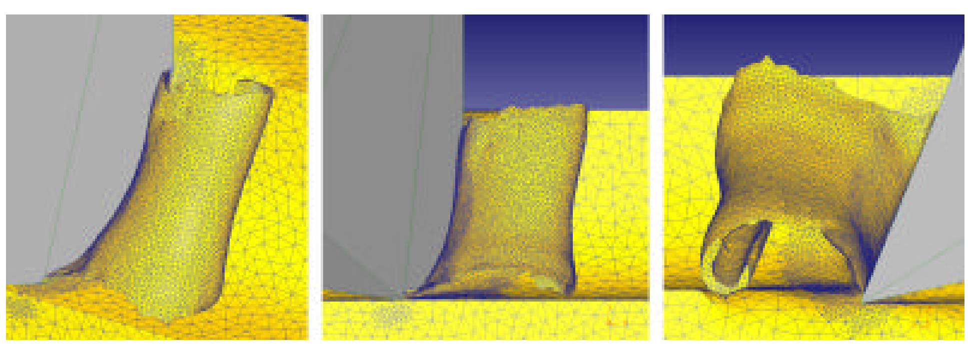

Figure 3: This simulation shows the chip form from the current standard insert. Isometric, radial and axial views are shown left to right.

Design Environment for FORMing

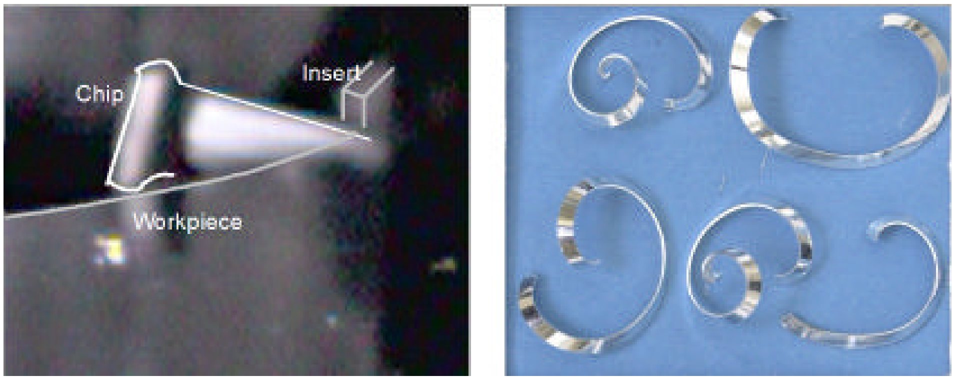

Figure 4: High speed video image on left shows chip formation. Chips from standard insert are shown on right with 0° axial rake and 22° effective radial rake.

Redesigns:

Two redesigns were proposed. The first featured an 8° axial rake angle and a 20° radial rake angle. The second featured a 7° axial rake angle, and a 9° radial rake angle. Both inserts were simulated, and it was observed that both effectively lifted the chip away from the workpiece.

Based on simulation results, the 7° axial rake, 9° radial rake insert was manufactured and tested. A comparison between simulation results and high speed video of the prototype is shown in Figure 6. The experiments with the prototype showed significantly improved chip flow and evacuation.

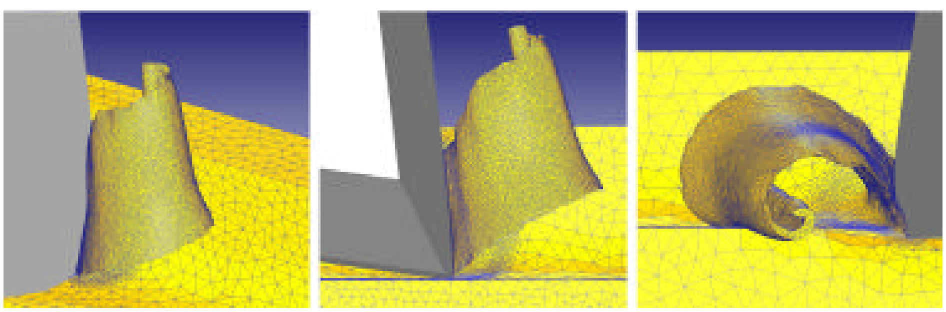

Figure 5: Simulation of redesigned insert (isometric, radial and axial views) shows chip lifting away from workpiece.

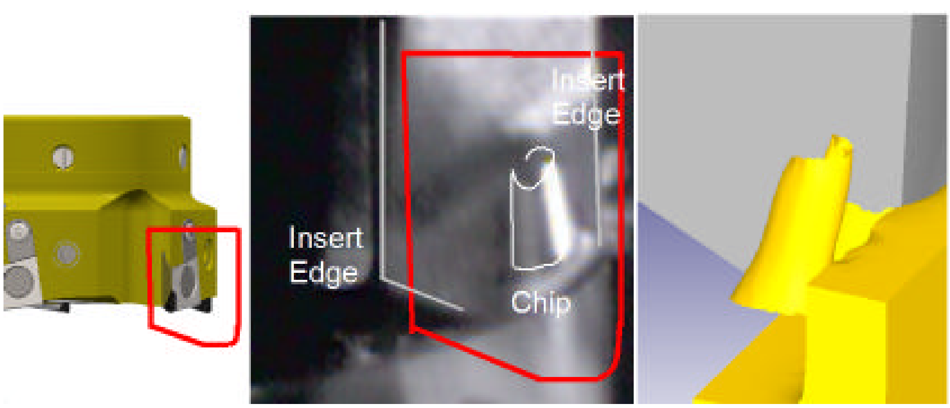

Figure 6: This comparison shows a CAD cutter model, an image from high speed video, and FEM simulation from the same orientation. The insert had a 7° axial rake and 9° radial rake.

Conclusion:

DEFORM™-3D has been used to predict the performance of a milling cutter insert before the insert was manufactured. Based on simulation results, decisions regarding cutter design were made, and the simulation results were validated with experiment.

Used in this manner, simulation offers the potential for significant cost savings and improved time to market for new or special cutting tool and insert designs.

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