THIRD WAVE
AdvantEdge™
TECHNOLOGY FOR MACHINING SOLUTIONS

Case Study #40
Improving Tool Life

Problem:

An increase in tool life is desired in a 316 stainless steel turning operation. There should be no sacrifice of other productivity measures.

Why is Third Wave *AdvantEdge*™ needed?

To determine the optimum speed and feed without costly trial-and-error machining tests that will interrupt production.

Discussion:

Third Wave *AdvantEdge*™ can determine tool temperatures at various cutting speeds and feeds. Tool life is then compared or estimated based on the tool temperature profiles. The combination of cutting speed and feed that maintain MRR but result in the lowest tool temperature profile demonstrate operating conditions to increase tool life. We assume that maximum tool temperature is the predominant factor affecting tool wear because:

1. Higher temperatures reduce the tool's yield strength causing reduced tool hardness and increased tool plastic deformation failure.
2. Crater wear occurs mainly by a diffusion mechanism. Higher temperature will cause a higher diffusion rate, which, in turn, results in faster tool wear.

Based on the current tool wear rate, the tool/chip interface temperature is estimated to be around 700°C (Refs 1, 2). For a carbide tool, if the tool/chip interface temperature is reduced from 700°C to 600°C, the crater wear rate will be reduced by more than 100%, and the tool life is expected to increase by approximately 100%. Therefore, identifying a combination of cutting speed and feed that can reduce the tool/chip interface temperature to below 600°C will be a critical step towards increasing tool life.

Objectives:

Determine the cutting speed and feed that will:

1. Maintain the original material removal rate
2. Reduce the tool/chip interface temperature by at least 100°C.
3. Minimize the cutting forces and the stress at the tool tip to avoid tool breakage.

Project Setup:

Model the cutting process at the following three equivalent MRR conditions:

1.	Speed (sfm)	2. Feed (in.)	(sfm) and (in.) units
a)	550	0.004	the original condition
b)	425	0.005	23% decrease in speed 29% increase in feed
c)	300	0.007	45% decrease in speed 83% increase in feed

3. Depth of cut : 0.050 inches
4. Rake angle: 20°
5. Clearance angle: 8°
6. Cutting edge radius: 0.001 inches
7. Tool insert material: Tungsten carbide
8. Workpiece material: 316 SST

Results Analysis:

1. **Temperature, crater wear and tool life.** When the cutting condition is changed from a) to c), the tool/chip interface temperature is reduced from about 700°C to below 500°C (Figure 1). The tool life is expected to increase by more than 100% (Ref. 1, 2).

2. **Cutting force and flank wear.** When the feed increased from 0.004 inches to 0.007 inches, the total cutting force increased by about 40% (Figure 2). However, Third Wave *AdvantEdge*™ analysis indicates no

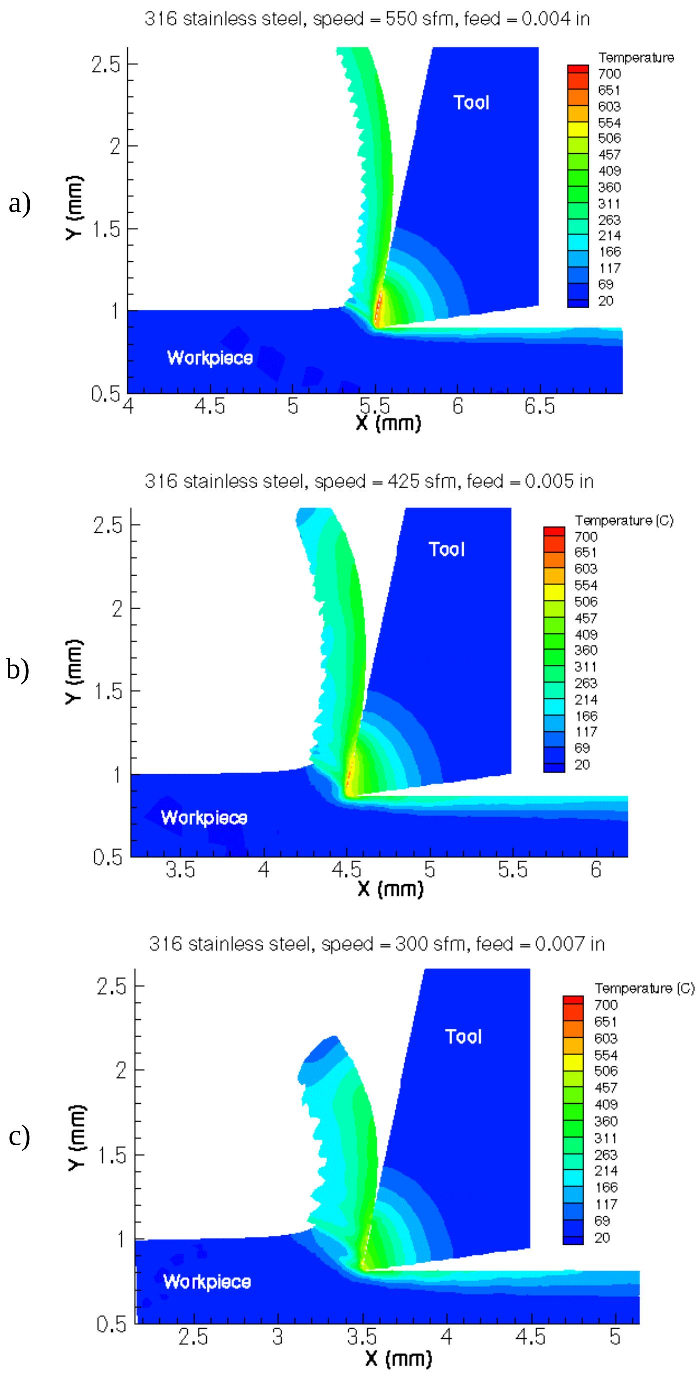

Figure 1: Predicted temperature distribution in chip and tool under 3 different cutting conditions using Third Wave *AdvantEdge*™.

significant increase in the maximum value of tension or the maximum value of pressure on the rake face. It will increase the area on the tool where the maximum tension and the maximum pressure act. Therefore, tool breakage should not be greatly aggravated under the new machining conditions.

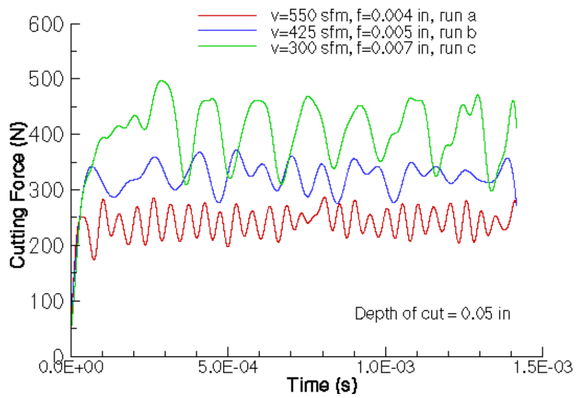

Figure 2: Predicted cutting forces under three different cutting conditions using Third Wave *AdvantEdge*™.

Conclusion:

Changing the cutting condition from a) to c) will increase tool life by more than 100% while maintaining the same material removal rate.

Recommendation:

Third Wave *AdvantEdge*™ is a valuable tool to determine**:**

- cutting force and temperature to investigate tool life,
- possibilities to increase material removal rate, (ref. Case Study #30) and
- work hardened surface layer as it relates to surface integrity.

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1. S. Kalpakjian, Manufacturing Engineering and Technology, Addison-Wesley Publishing Co., 1992, pp. 614-625.
2. E.M. Trent, metal Cutting, Butterworths, 1984, pp. 128-138.