Simulation of three-dimensional turning

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Nanotechnologies

Motivation:

- Improve cutting performance of tools used in industrial turning processes involving difficult-to-machine advanced materials
- Examine advantages of dry lubrication by looking at the effects of reducing the coefficient of friction (**CoF**)
- We seek to reduce (i) forces acting on the tool, (ii) energy dissipation during the machining process, (iii) maximum tool temperature

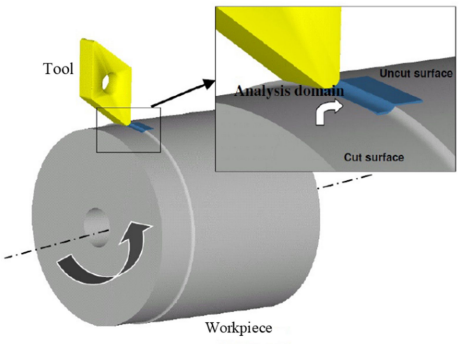

Figure 1: Industrial turning process

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Finite element analysis:

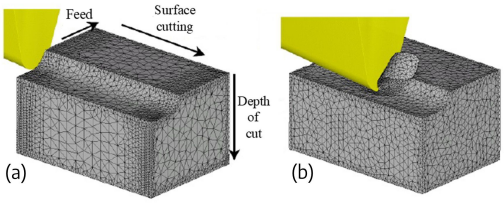

Figure 2: (a) Idealized model, and (b) chip formation

Scientific Forming Technologies Corp. (SFTC), *Design Environment for FORMing (DEFORM®) v13.0 System Documentation*, 2022

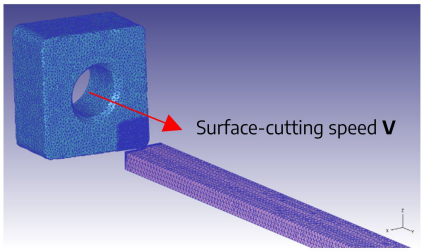

Figure 3: Finite element mesh

- Simulations performed using the commercial finite element code DEFORM-3D
- Tool geometry and machining parameters from experiments of project partners

Force results:

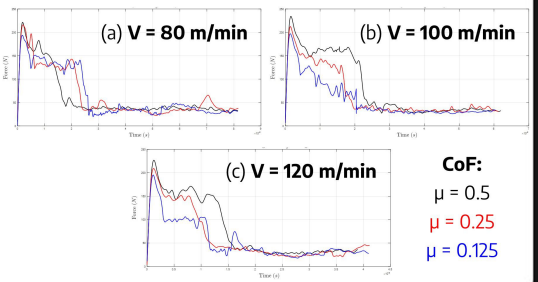

Figure 4: Surface-cutting-direction force **F** acting on tool

Temperature results:

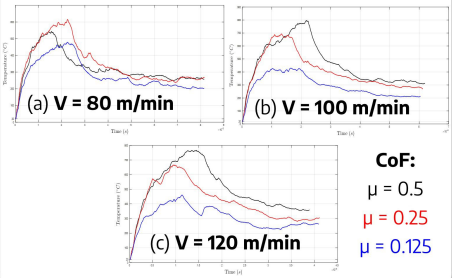

Figure 5: Maximum temperature of tool $\mathbf{T_{max}}$

Conclusions:

- Reducing the coefficient of friction from **μ = 0.5** to **μ = 0.125** leads to: (i) decrease in peak **F** by (a) **13%**, (b) **16%**, (c) **14%** ; (ii) decrease in dissipated energy **E** by (a) **-7%**, (b) **33%**, (c) **30%** ; (iii) decrease in peak $\mathbf{T_{max}}$ by (a) **12%**, (b) **46%**, (c) **40%**
- **Dry lubrication is most effective at sufficiently high surface-cutting speeds**
- At low surface-cutting speeds, dry lubrication can even be counterproductive

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