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# TURNING HARDENED STEEL USING ROTARY CUTTING TOOLS

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# Objective

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Develop a robust process by optimally combining suitable grades of PCBN with rotary cutting action, for continuous and interrupted cutting

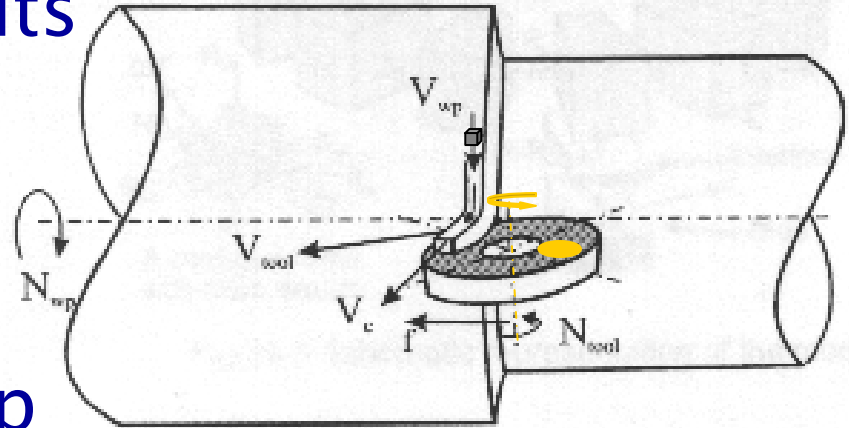
# Introduction

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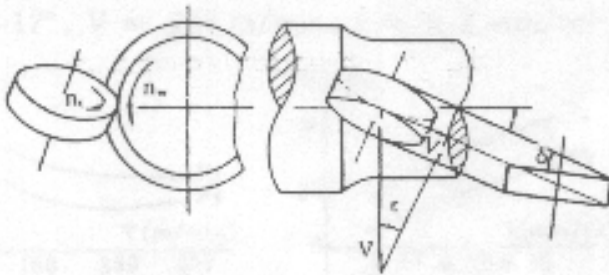
- Hard turning replacing grinding
- Need for longer tool life – economics
- Better tool material is one way – KB9640, BNX250, binderless CBN
- Spreading wear over the entire edge is another – rotary cutting tool
- Round insert rotates about its axis supported by bearing – spreads wear
- Optimal combination of the two

# Rotary Cutting Action

- Insert rotates about its own axis as it cuts
- Can be driven externally, or,
- Self propelled by chip – requires obliquity



Sketch source: Journal paper by H. A. Kishawy



Sketch source: Journal paper by Chen Wuyi et al.



Movie source: [www.lambtech.com](http://www.lambtech.com)

# Proposed Tasks:

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1. Identify, acquire–modify/design–build a spindle assembly for rotary cutting tool
2. Testing to select best cutting tool grade and edge geometry
3. Process modeling
4. Model validation
5. Tool life testing and optimization
6. Surface integrity characterization
7. Case study

# Progress to date

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- Literature search
- Identified new grades of PCBN for testing
- Commercial rotary cutting tool
- New tool design in progress

# Literature highlights

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- Rotary action used as early as 1868
- First reported modeling work in 1952 by M. C. Shaw
- Several investigators have tried on difficult-to-machine materials (Titanium alloy, Inconel alloy, Al/SiP composites, hardened steel, Iron)
- On interrupted cutting (e.g. alternator rotor)
- Reported successes
- Two patents exist for tool design

# Literature highlights

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- Modeled as equivalent oblique cutting with the rotating action inducing an inclination of the chip
- Recent work done in thermal modeling – not experimentally verified
- No reported work in modeling dynamics
- No reported work in modeling tool wear
- No reported work in surface characterization



# Literature highlights

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- Reported lower temperatures and tool wear compared to conventional cutting with WC, Carbides, PCBN
- Hardened steel:
  - Saw toothed chips not observed
  - Rotary speed of tool is linearly proportional to cutting velocity; more steeper at higher rake angles
  - Flank wear more dominant than crater wear
- Surface waviness reported

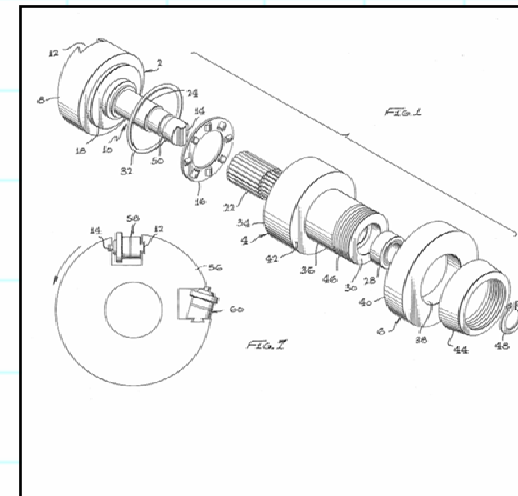
# PCBN grades for testing

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- New grade from Kennametal – KB9640
- Sumitomo grade BNX250
- Sumitomo's binderless CBN – not available commercially

# Commercial Rotary Tools

- Rotary Technologies Corporation
- Milling tools available as standard products
- Lathe tools made if requested
- Special insert geometry (annular ring – 1 inch OD, 0.5 inch ID)
- Fixed inclination angle



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# Need for design changes

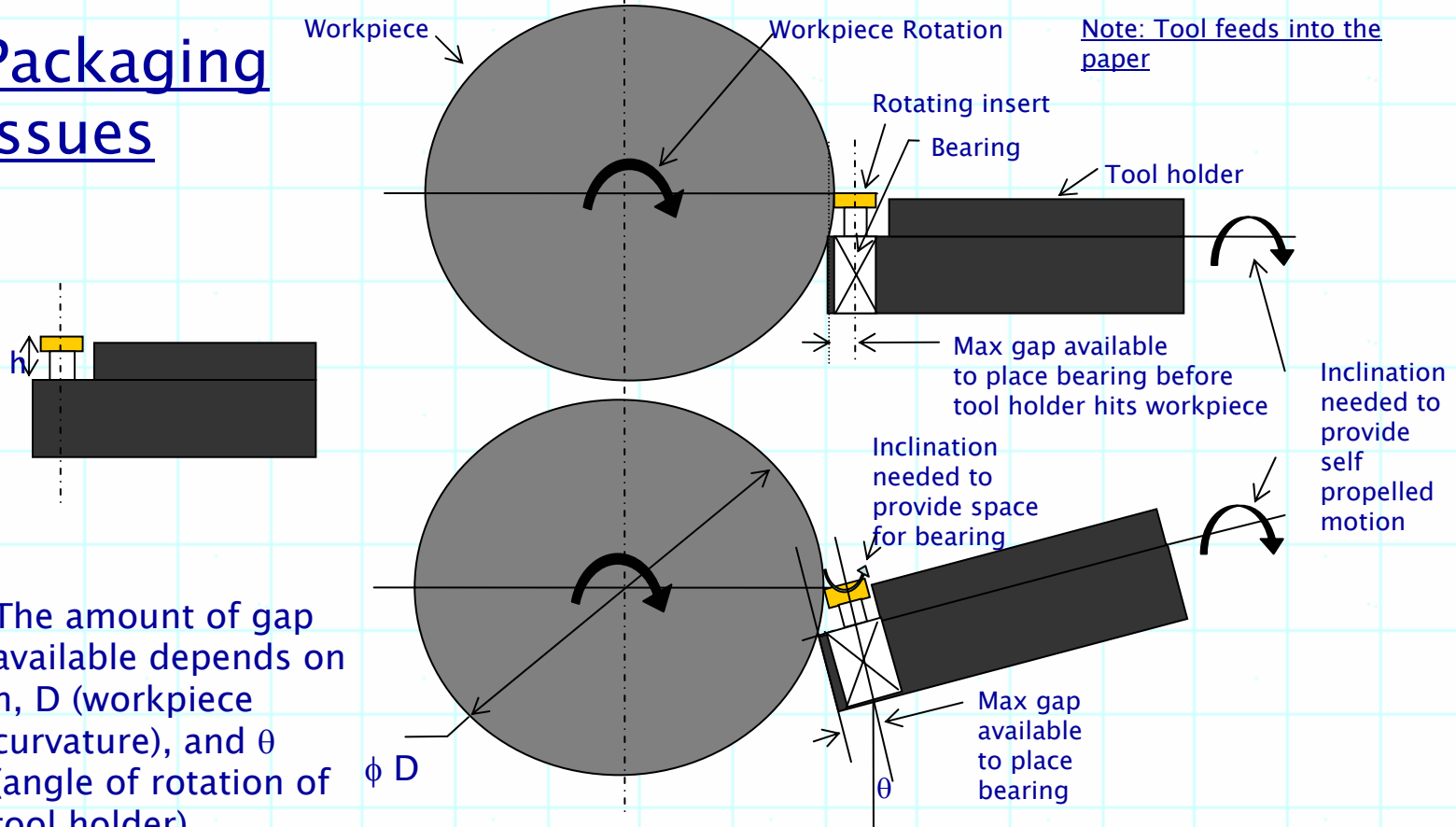
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- Incorporate standard round inserts
- Need for flexibility to change inclination angles for experimentation purposes

# New tool design

## Packaging Issues

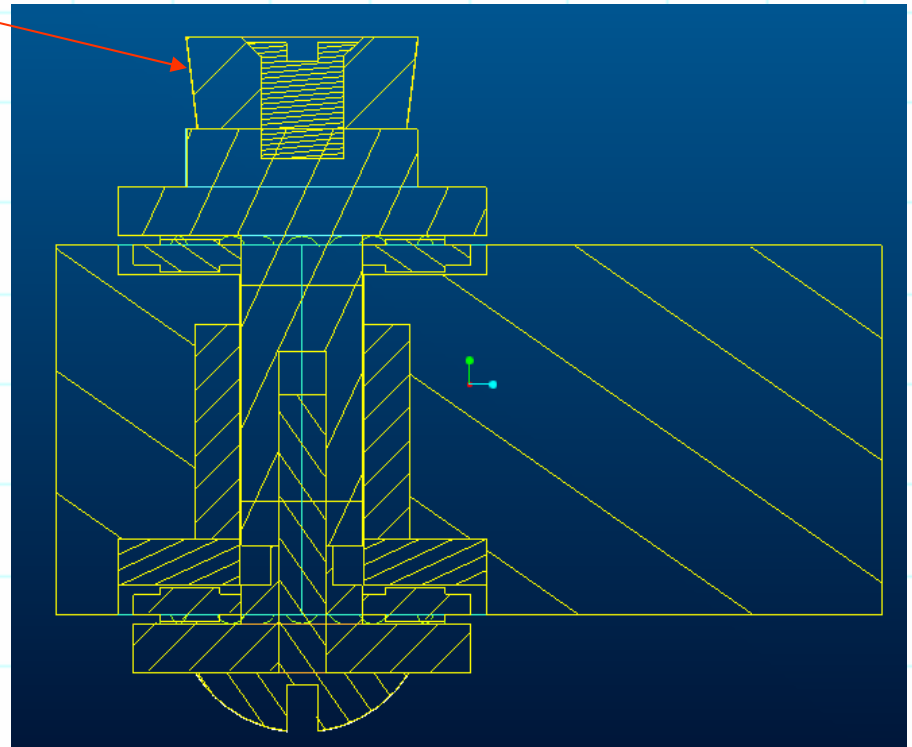
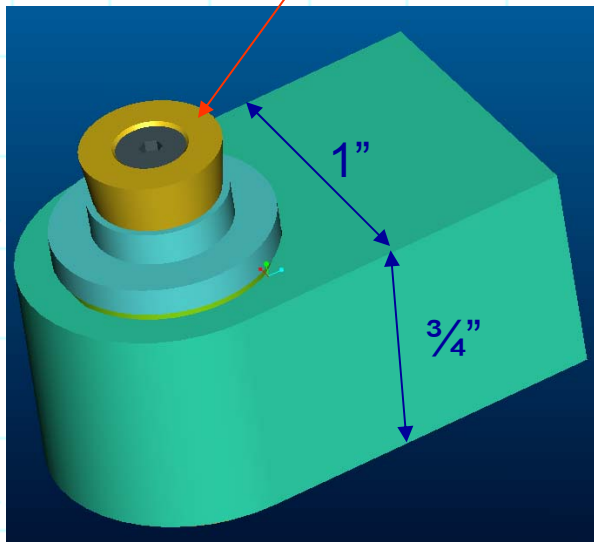
Note: Tool feeds into the paper



# New tool design – concept

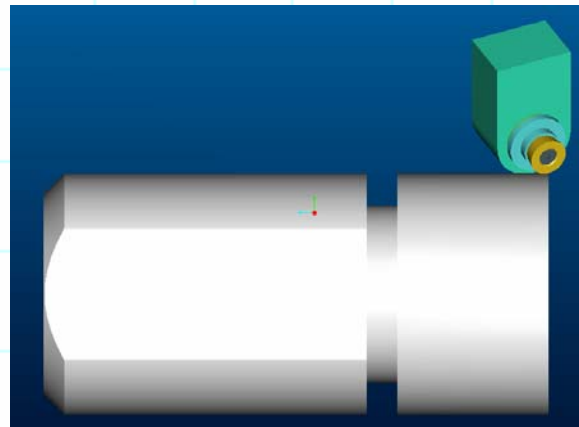
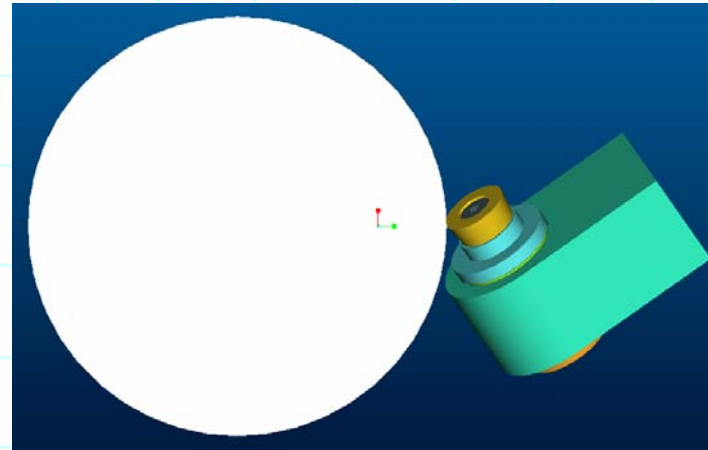
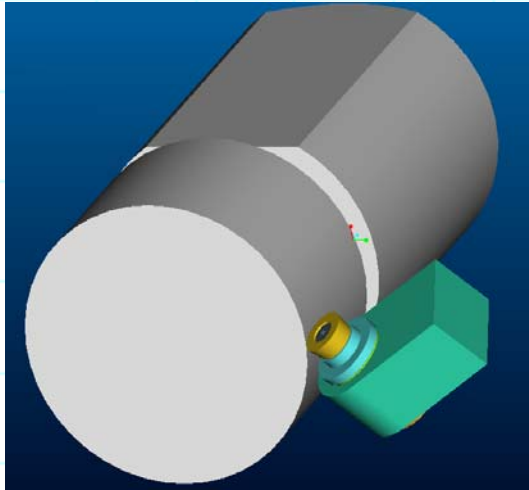
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Standard Insert



# New tool design

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# Next ...

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- Tool stress due to edge chamfer
- Analyze tool design
- Preliminary cutting with commercial tool to get feel for process
- Experiments to choose grade