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# Overview

- Tool Steel Failures
  - Define Tool Steel Properties.
  - Determine Modes of Failures.
  - Identify Probable Failure Causes.
  - Recommend Solutions.

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# Important Properties of Tool Steel

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- **Harden Ability** – Ability of steel to through harden and form martensite.  Proper heat treating is essential.  Carbon is a key element in hardening.
- **Wear Resistance** – Resistance to abrasion and erosion. More carbides and higher hardness improve wear resistance. Vanadium, molybdenum, and chromium all contribute to wear resistance.
- **Compressive Strength** - Ability to withstand a constant load without deforming or breaking.  Molybdenum contributes to compressive strength

# Important Properties of Tool Steel

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- **Toughness** – Ability to absorb impact energy without breaking and chipping.  An increased volume of silicone improves toughness.  High volumes of large, poorly distributed carbides reduce toughness.

- **Fatigue Strength** – Ability to withstand repeated load cycles without cracking.  Large uneven distributed carbides structure and carbides are detrimental, fine carbides, evenly dispersed are highly beneficial.

- **Temper Resistance**  - Ability to maintain hardness as surface temperature becomes elevated while having surface treatments applied or while in use. Molybdenum and tungsten contribute to temper resistance.



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# Failure Modes of Stamping Dies

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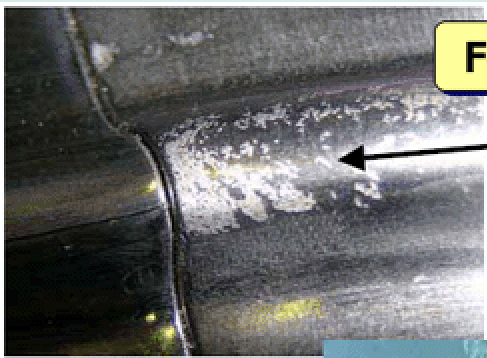
| Punch & Die | Failure modes | Cause |
|---|---|---|
| Forming | Seizure | · Increased contact load<br>· Surface softening by deforming heat |
| Trimming | Wear · Chipping | · Increase applied stress by high strength steel sheet |
| Punch | Wear · Breakage | |

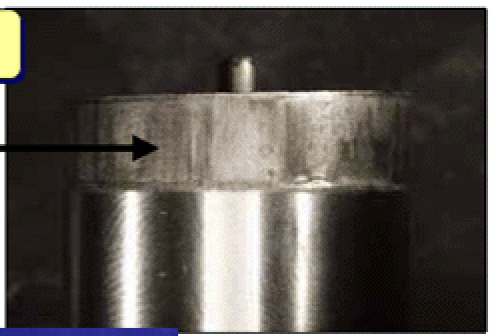


Forming die

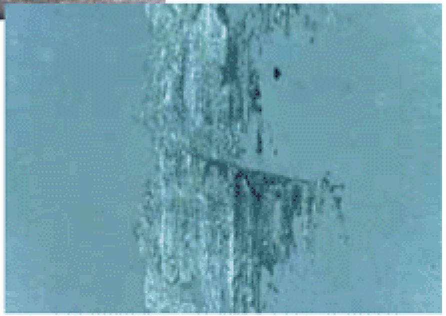
Peeled off coated layer

Punch

Wear



Seizure



Breakage

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# Properties Required for Stamping Dies

| Failure Modes | | Related Properties |
|---|---|---|
| Wear | Abrasion | Carbide Content |
| Galling | Adhesion | Obtainable Hardness |
| Bending | Deformation | Manufacturing Process |
| Breakage | Large Deep Cracks | Compressive Strength |
| Chipping | Edge Cracks | Impact Toughness |
| Flaking | Surface De-lamination | Fatigue Strength |
| | | Temper Resistance |

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# Properties Required for Stamping Dies

## Failure Modes

| | |
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## Related Properties

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# Properties Required for Stamping Dies

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## Related Properties

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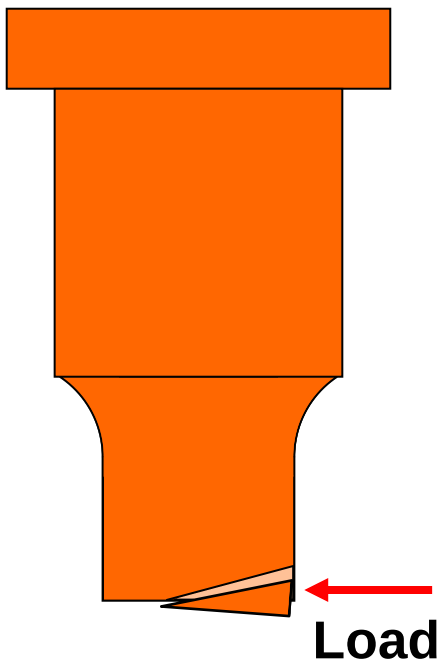
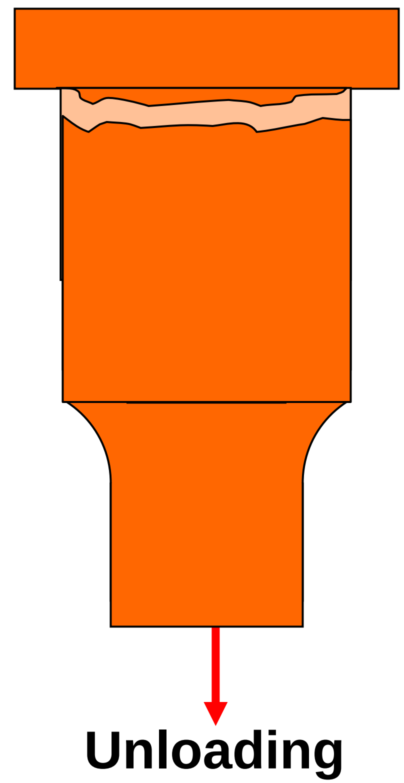
# Toughness Failures

## Face Chipping




## Head Breakage

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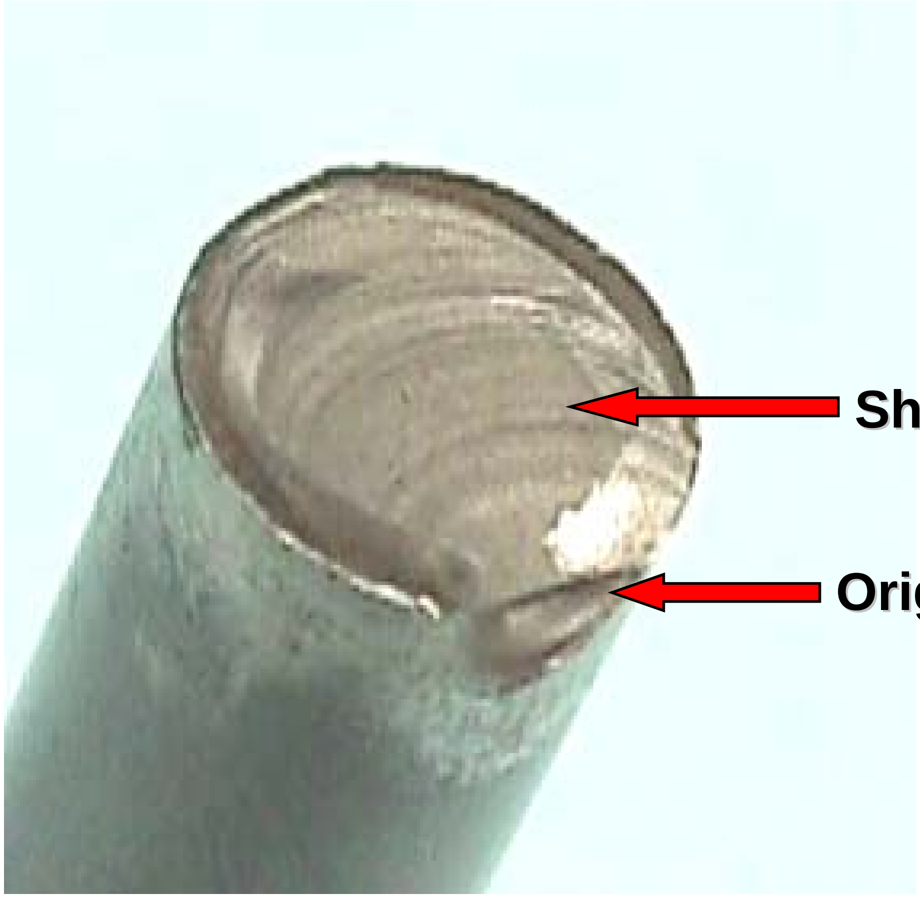
• Punch failures attributed to lack of tool steel toughness.

# Face Chipping

NEXT >




- Caused by lateral force.
- The Shell Pattern indicates the point of origin.

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# Wear

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- Caused by tight clearance and punch over entry.
- Wear is the abrasion and erosion of the punch material.

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# Galling

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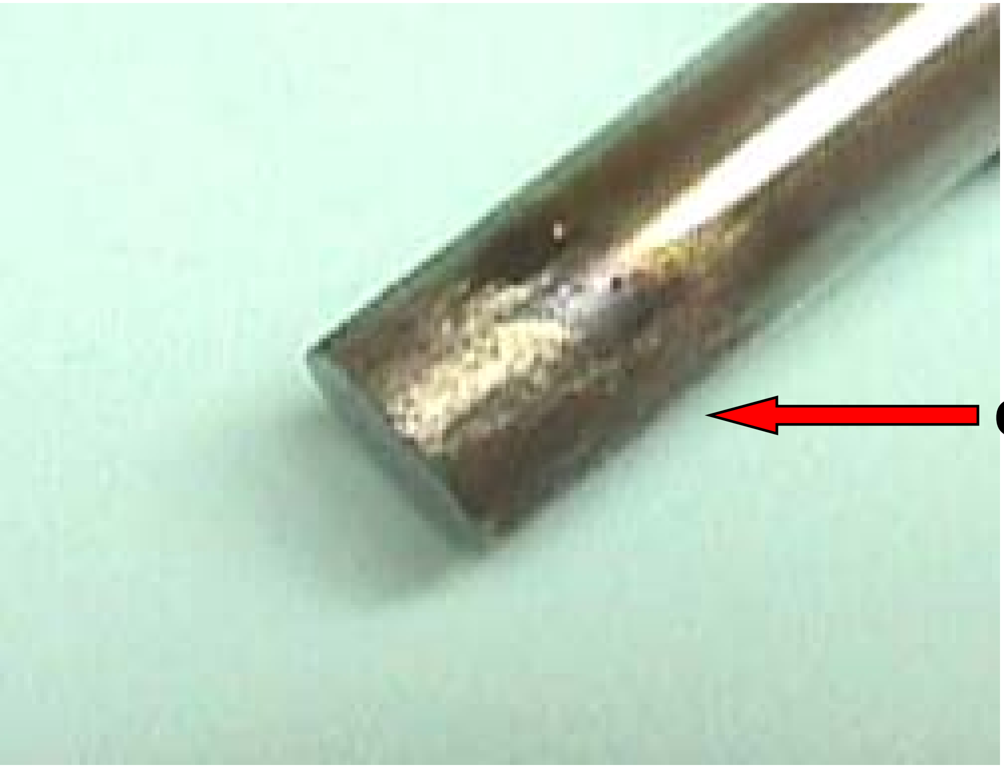

Galling

• Caused by excessively tight clearance and punch over entry.
• Galling is the welding and part material pick-up on the punch.

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# Compressive Failures

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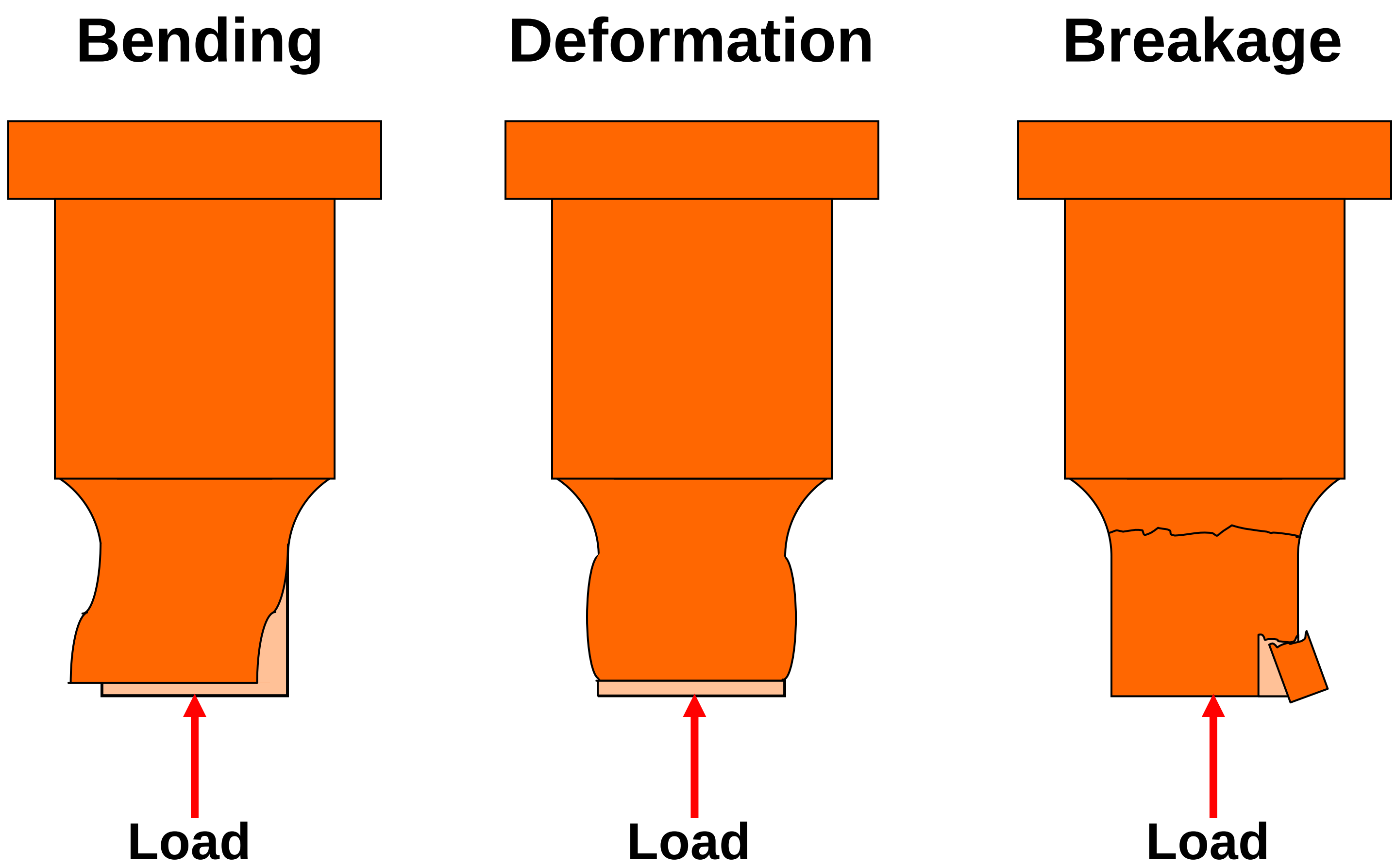


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• Punch failures attributed to high compressive loading typically affect the point area

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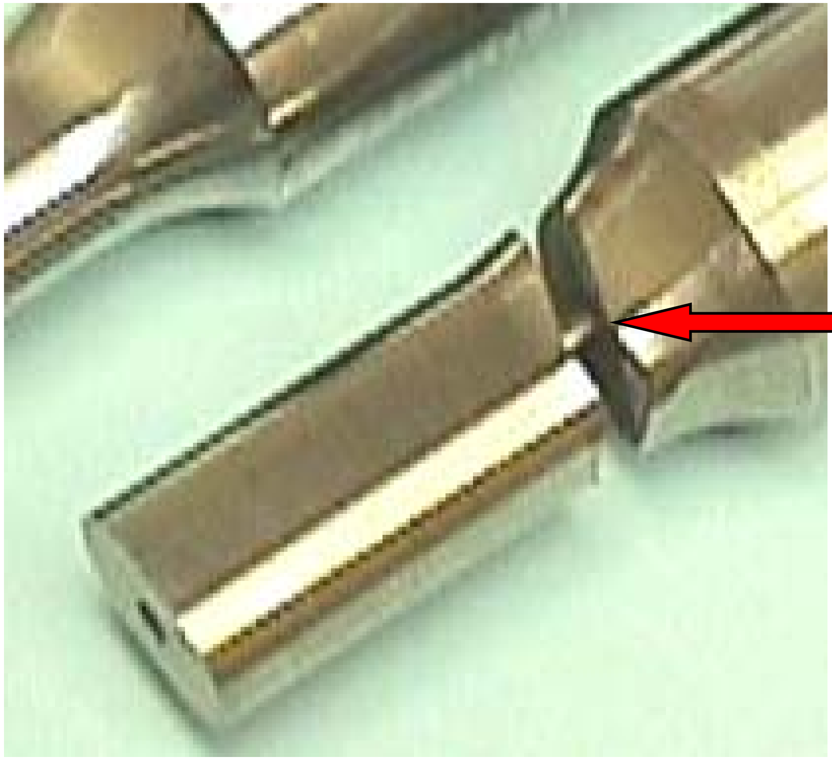
# Load Breakage



**Point Breakage**

- Caused by excessive compressive load.
- The load is concentrated where the point blends with the shank.

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# Perforating Force Formula

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## P = T x L x S

- F = Perforating Force
- T = Thickness of Part Material
- L = Length of Shear (Pi x Dia = Circumference)
- S = Shear Strength of Part Material

## Example

- T = .180”
- L = .281” Diameter (3.14159 x .281 = .882)
- S = 78,300
- F = .180 x .882 x 78,300
- F = 12,442 Lbs.

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- Be sure to account for stripper pressure when calculating total tonnage of the die.

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# Punch Load Formula

## P = F / A

- P = Point Load (Psi)
- F = Perforating Force
- A = Punch Point Area (Pi x $Rad^2$ = Area)

## Example

- F = 12,442
- A = .281” Diameter (3.14159 x $.140^2$ = .0616)
- P = 12,442 / .0616
- P = 200,626 Psi.

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• Be sure to account for stripper pressure when calculating total tonnage of the die.

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# Compressive Strength

| Tool Steel Grade | Compressive Strength | 60% of Strength |
|---|---|---|
| S7 (57HRC) | 265,000 PSI | 159,000 PSI |
| A2 (60HRC) | 305,000 PSI | 183,000 PSI |
| D2 (61HRC) | 315,000 PSI | 189,000 PSI |
| DC53 (62HRC) | 340,000 PSI | 204,000 PSI |
| M2 (62HRC) | 375,000 PSI | 225,000 PSI |
| A11 (63HRC) | 400,000 PSI | 240,000 PSI |

- Commonly used tool steels and their rated compressive strength
- Compressive failures typically start at 60% of the tool steels rated strength

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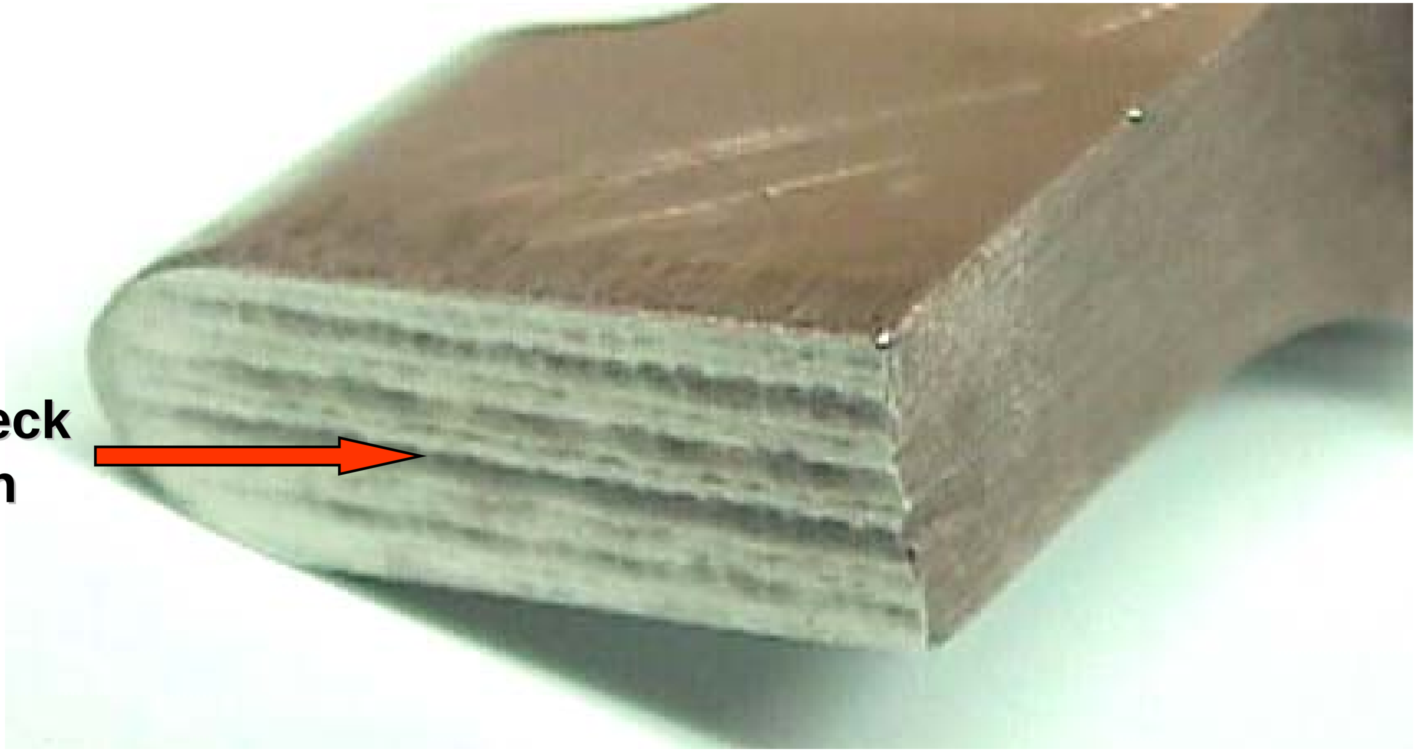
# Grinding Burn

Heat Check Pattern




• Heat check cracks and burn

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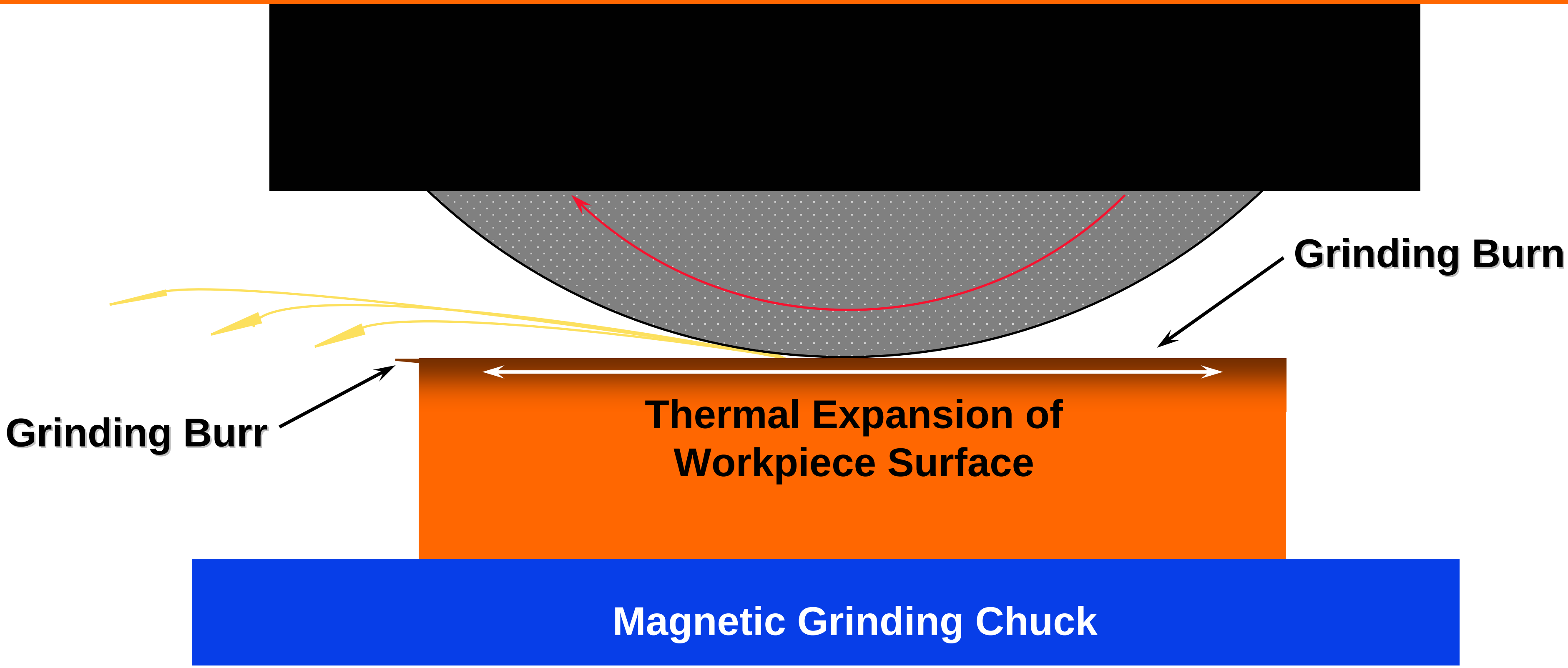
# Grinding Damage




- Use mist or flood coolant
- Keep depth of cut at a minimum
- Dress grinding wheel often
- Any discoloration is a sign of grinding stress

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# Things to look for:

- **S7** applications with hardness specified HRC 57 or higher. The higher hardness is sought after in an attempt to achieve higher wear resistance and strength however; toughness drops nearly 30% when going form HRC 56 to HRC 58. S7 has relatively low wear resistance, compressive strength, and temper resistance. DC53 has exceptional toughness as well as vastly superior wear resistance, strength, and temper resistance then that of S7.
- **A2** applications – When wear and high load are a concern. Also when applying surface treatments. DC53 has greater wear resistance, strength, and temper resistance to support surface treatments without sacrificing machining and grinding characteristics.
- **D2** application – DC53 almost ALWAYS outperforms D2. DC53 has greater toughness, wear resistance, compressive strength, and temper resistance as well as better machining and grinding characteristics.
- **M2** applications with hardness specified below HRC 60 or when additional toughness is needed. M2 will loose much of its strength and wear resistance when hardened below HRC 60 which presents opportunities. DC53 has superior toughness at equal hardness with nearly the same wear resistance.
- **A11** High vanadium PM (Particle Metallurgy) and **PM M4** applications experience chipping, cracking and or breakage where DC53 even at HRC 62–64 has vastly higher toughness than either grade.

START OVER >

# International Mold Steel

# Any Questions?

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