# Shot peening of gear wheels

## Gear teeth are put under load by bending stress, Hertzian stress and rolling and/or sliding friction.

### These loads lead to

- cracks at the tooth root
- pitting at the tooth profile
- wear at the tooth profile

### Shot peening

- improves tooth root strength
- improves tooth profile strength
- reduces wear at the tooth profile
- reinforce gear wheels which are affected by notches, decarburization or coarse grinding

### Shot peening changes

- the residual stress distributon
- the superficial structure
- the hardness in the surface layer
- the microstructure of the surface layer

# Shot peening of gear wheels

## Advantages of shot peening of gear wheels

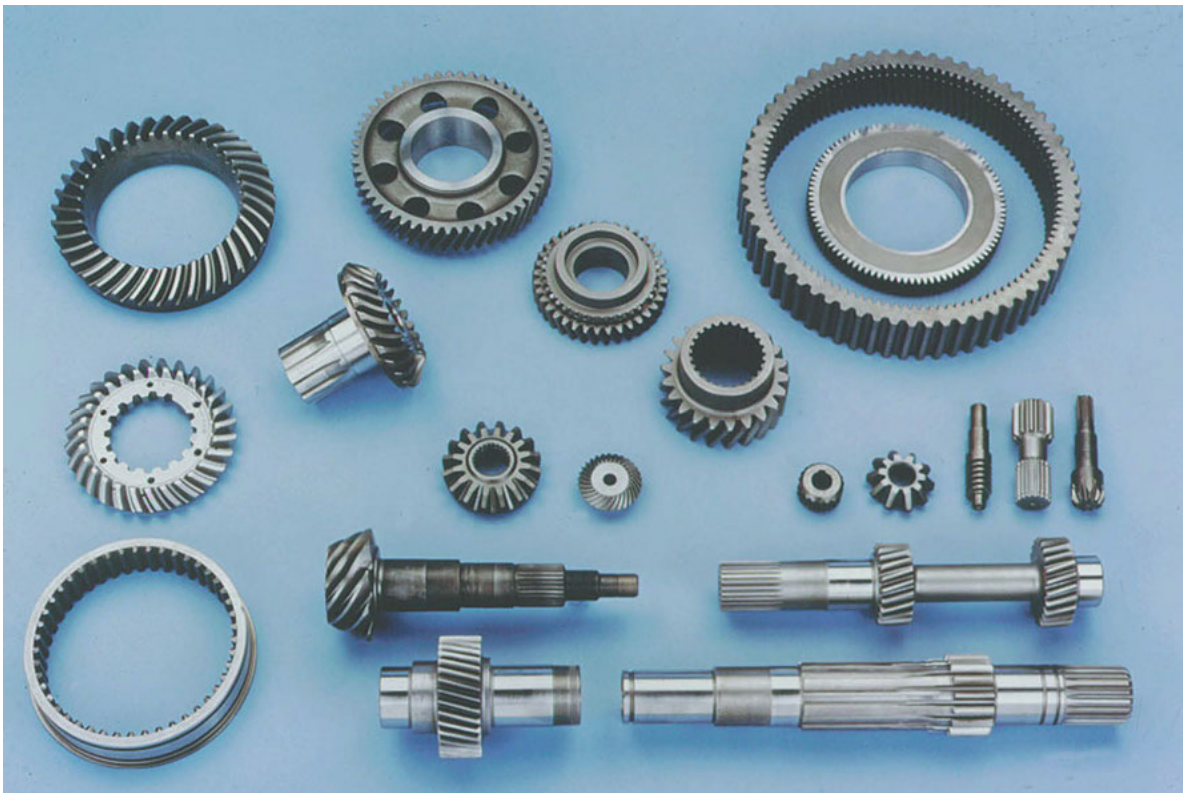
Gear wheel teeth are loaded simultaneously by bending stress, Hertzian stress and wear. These different loads lead to different failure due to cracks, pitting and wear. Cracks and pitting can be prevented by a compressive residual stress layer at the surface. Wear can be reduced by increasing the hardness at the surface layer and by improving the lubricating film.

**Surface hardening followed by shot peening does exactly what is needed.**

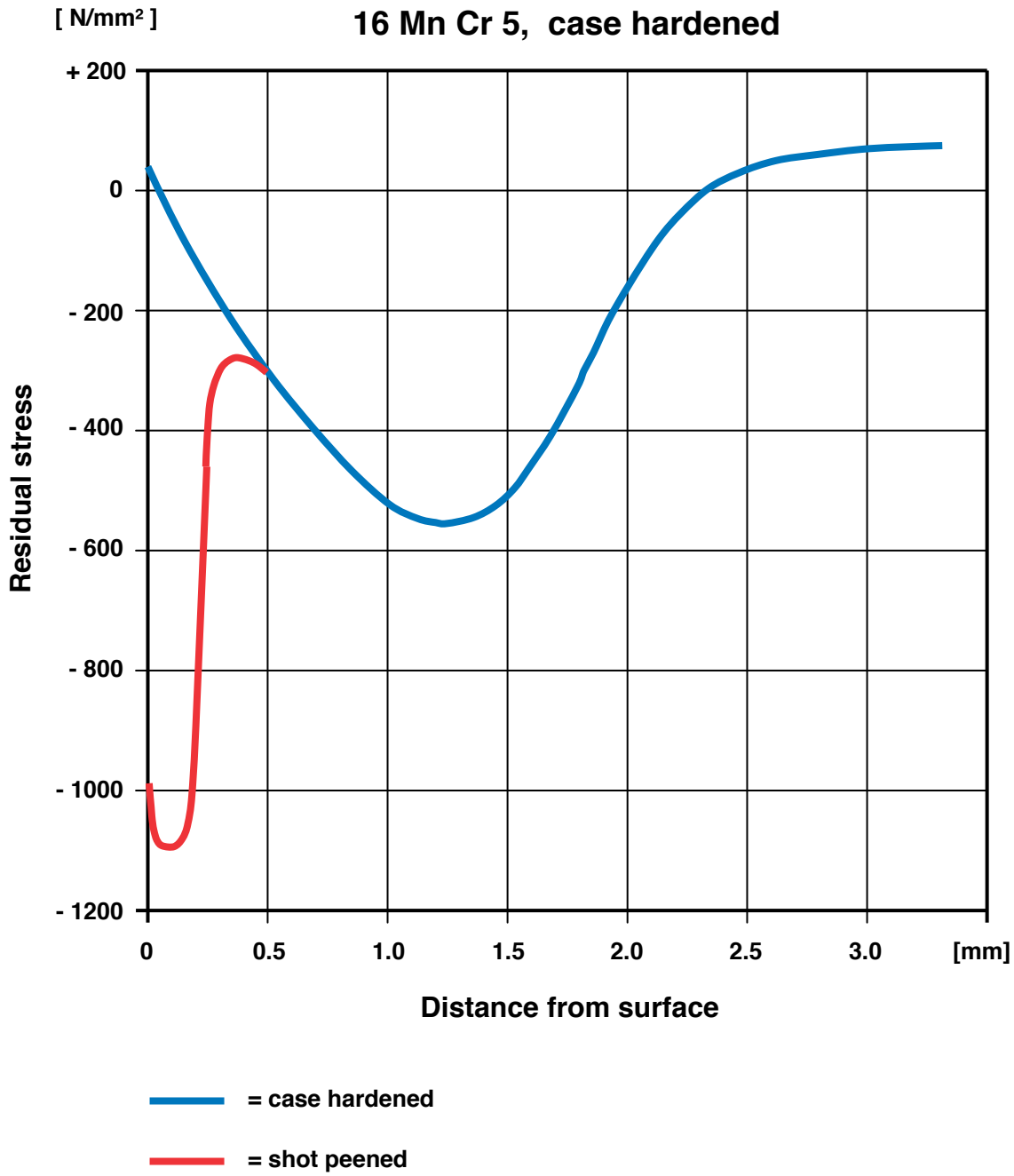
It is standard engineering practice to surface harden the tooth profile of gear wheels normally by case hardening. This process induces compressive residual stress to the depth which is needed to prevent cracks in the tooth root produced by bending stress and pitting at the tooth profile produced by Hertzian stress. Case hardening of the tooth profile reduce wear over the area of contact. A disadvantage, however, is the low level of compressive residual stress at the surface.

Shot peening enhances the amount of compressive residual stress in the surface layer (see page 42) and is consequently extremely effective at high bending and Hertzian stress. Shot peening changes the surface topography (see page 48) and builds up a better lubrication film to improve running properties. Shot peening enhances the surface hardness by work hardening (see page 44) and changes retained austenite in the surface layer into martensite (see pages 43).

Note: **Shot peening is no substitute for heat treatment but an additional and extremely valuable process to increase fatigue life, reduce wear and improve the running properties of gear wheels.**

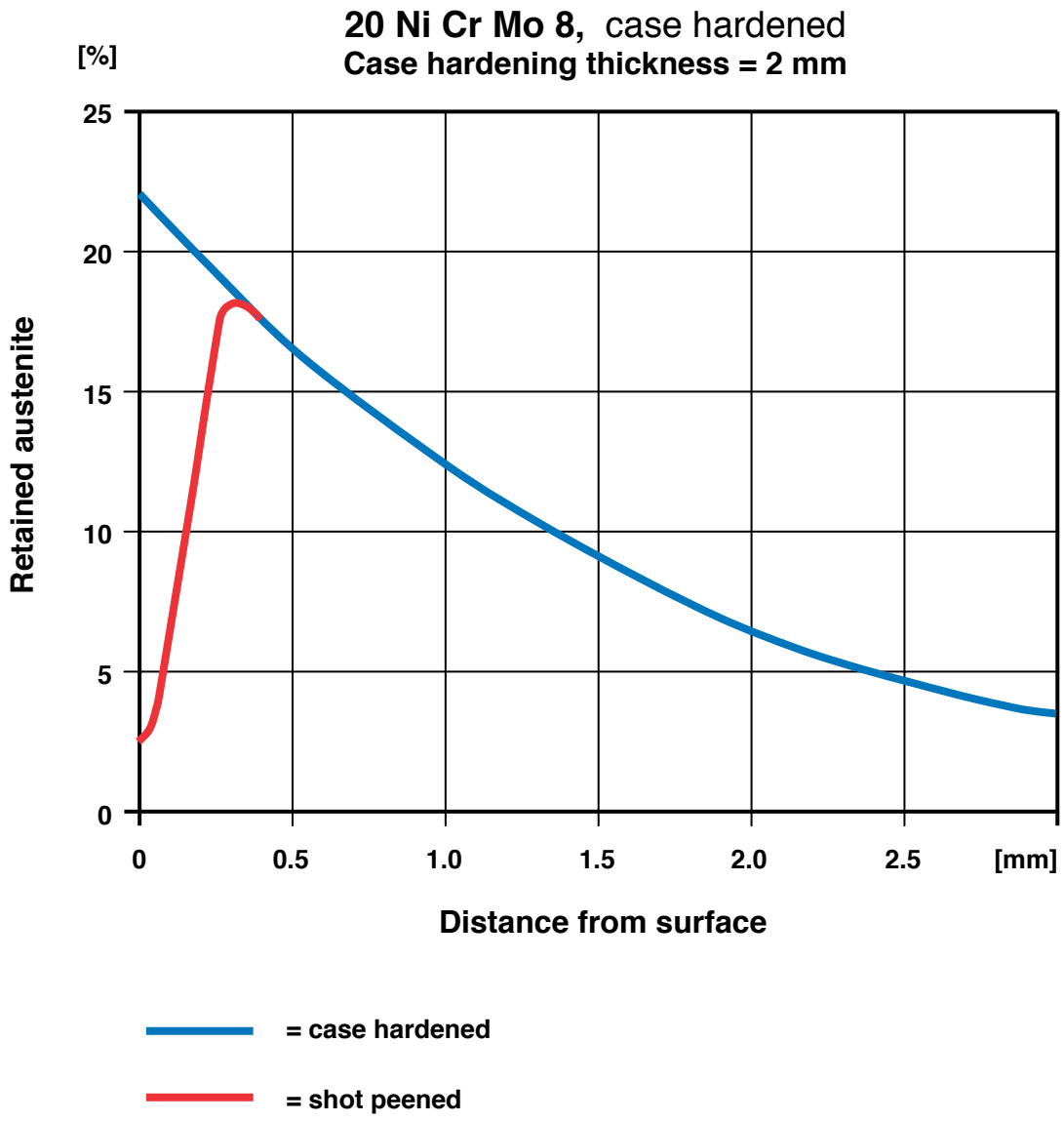


# Distribution of residual stress after case hardening and shot peening

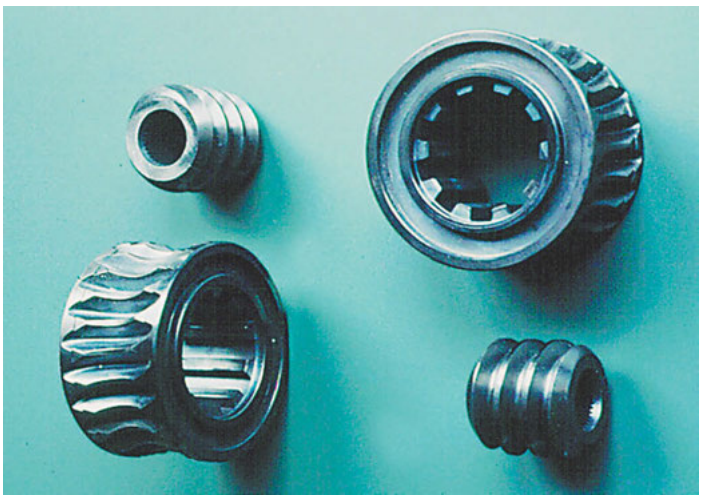



Very high compressive residual stress in the surface layer induced by shot peening is extremely valuable under bending, torsional and percussive loads.
The compressive residual stress induced by shot peening acts additionally to the compressive residual stress induced by case hardening.

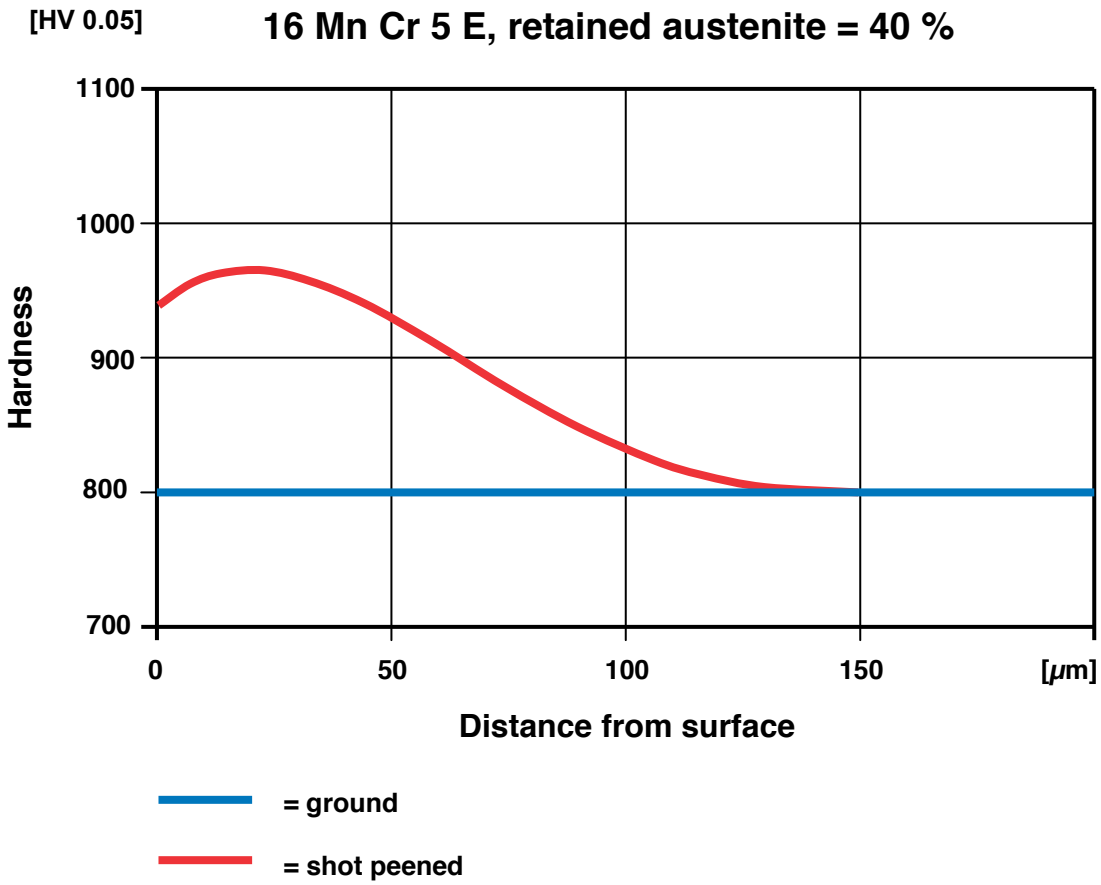
# Retained austenite after shot peening




Shot peening changes the retained austenite in the surface layer into martensite by cold working. Hence the hardness and resistance to wear increase without losing fatigue strength or enhancing the brittleness and notch sensitivity.

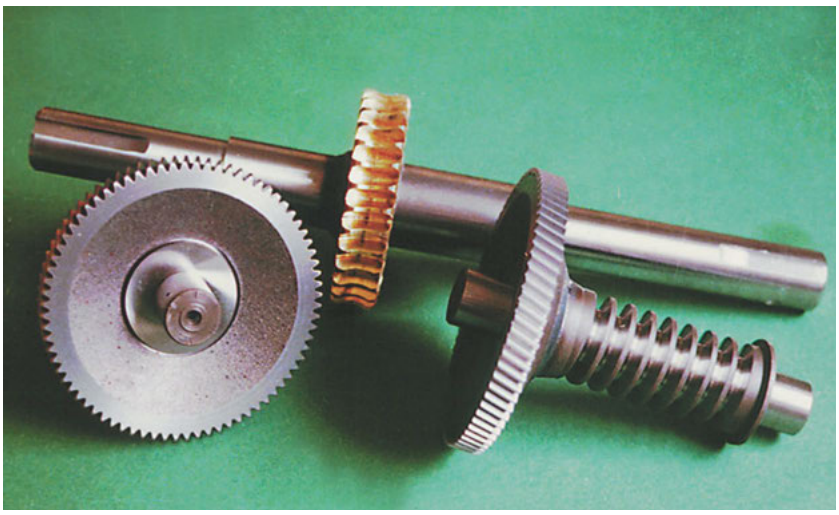


# Hardness in the surface layer after shot peening

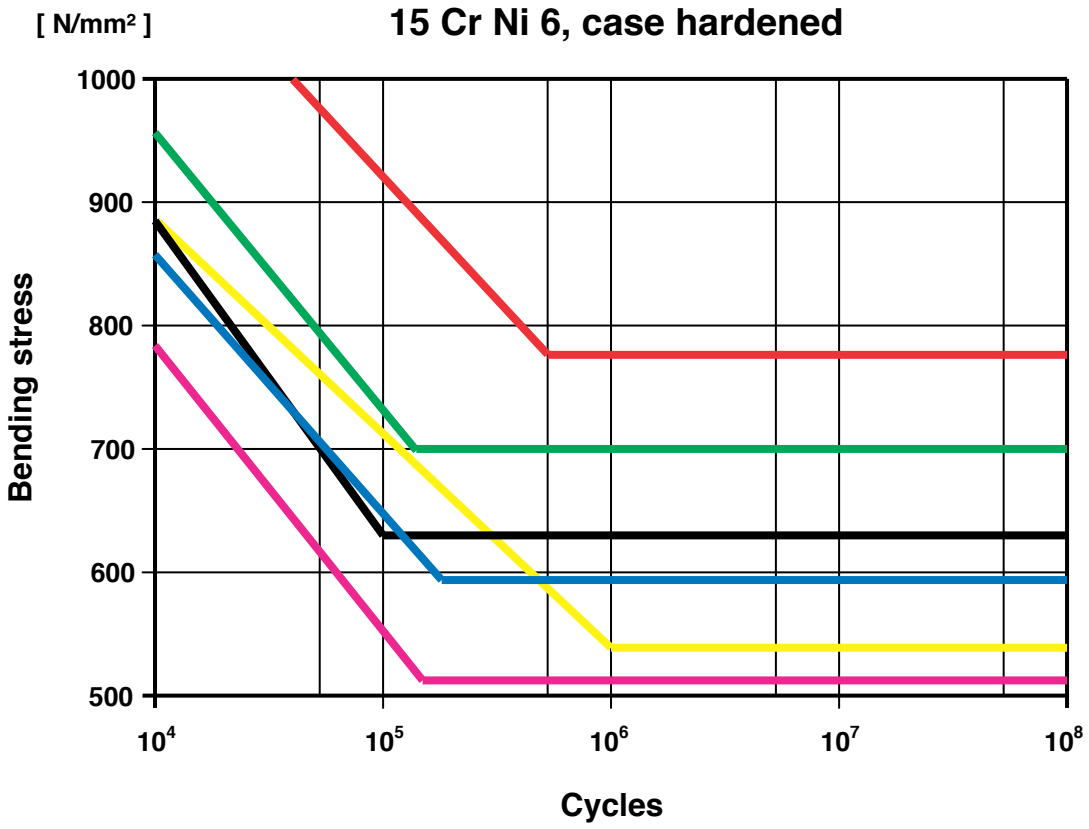



## Shot peening parameters

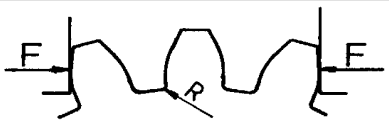
**Shot peening media : cut wire, spherical (G3), 0.6 mm Ø, 60 HRC**
**Coverage : 2 x t 98 %**
**Intensity : 0.18 - 0.22 mm A**



# Tooth root strength after shot peening



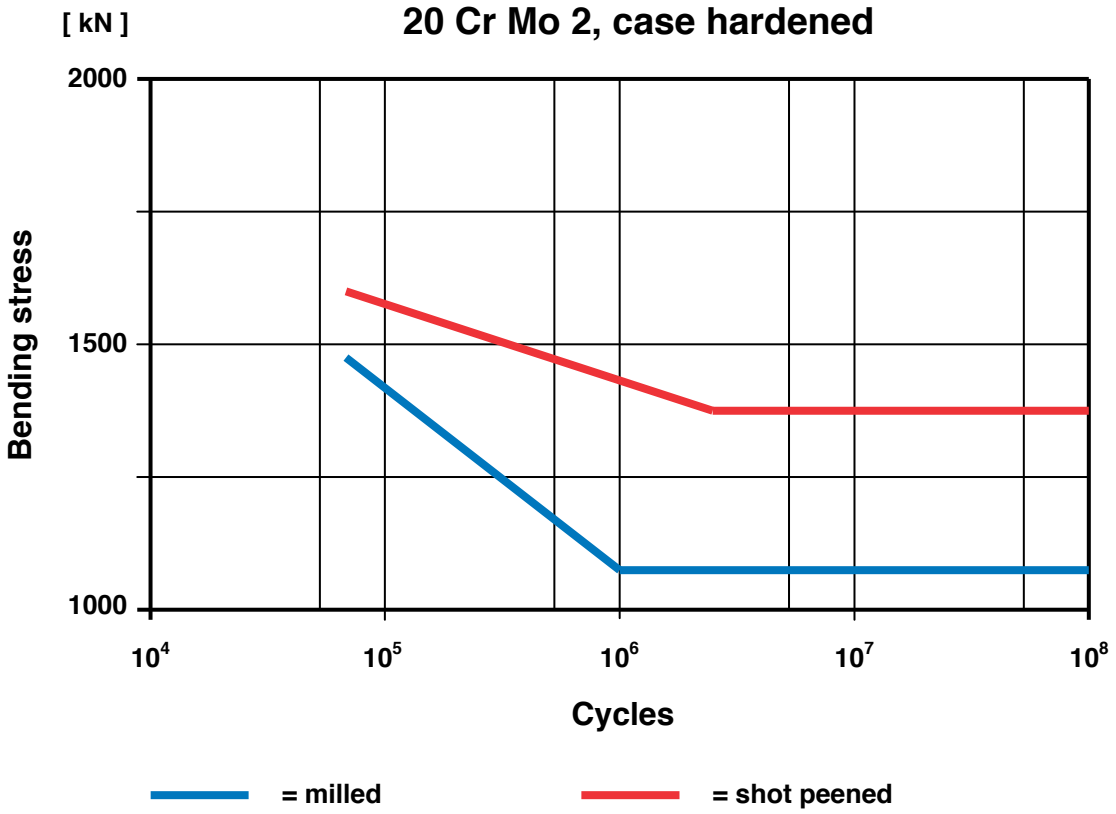

| Line | Radius R [mm] | Treatment | Shot peening media | Media hardness [ HRC ] |
|---|---|---|---|---|
| | 1.0 | Milled | ——— | ——— |
| | 0.6 | Milled | ——— | ——— |
| | 1.0 | Shot peened | Cut wire, spherical (G3) | 48 |
| | 0.6 | Shot peened | Cut wire, spherical (G3) | 48 |
| | 0.6 | Sand blasted | Steel shot | 45 |
| | 0.6 | Shot peened | Steel shot | 55 |

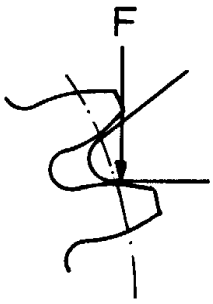



Single tooth bending test

**The shot peening media should be at least as hard as the parts to be shot peened.**
The shot peening media should be spherical, equal sized, equally hardened and dustless.
Only shot peening media of the correct quality will produce the required result.

# Tooth root strength after shot peening

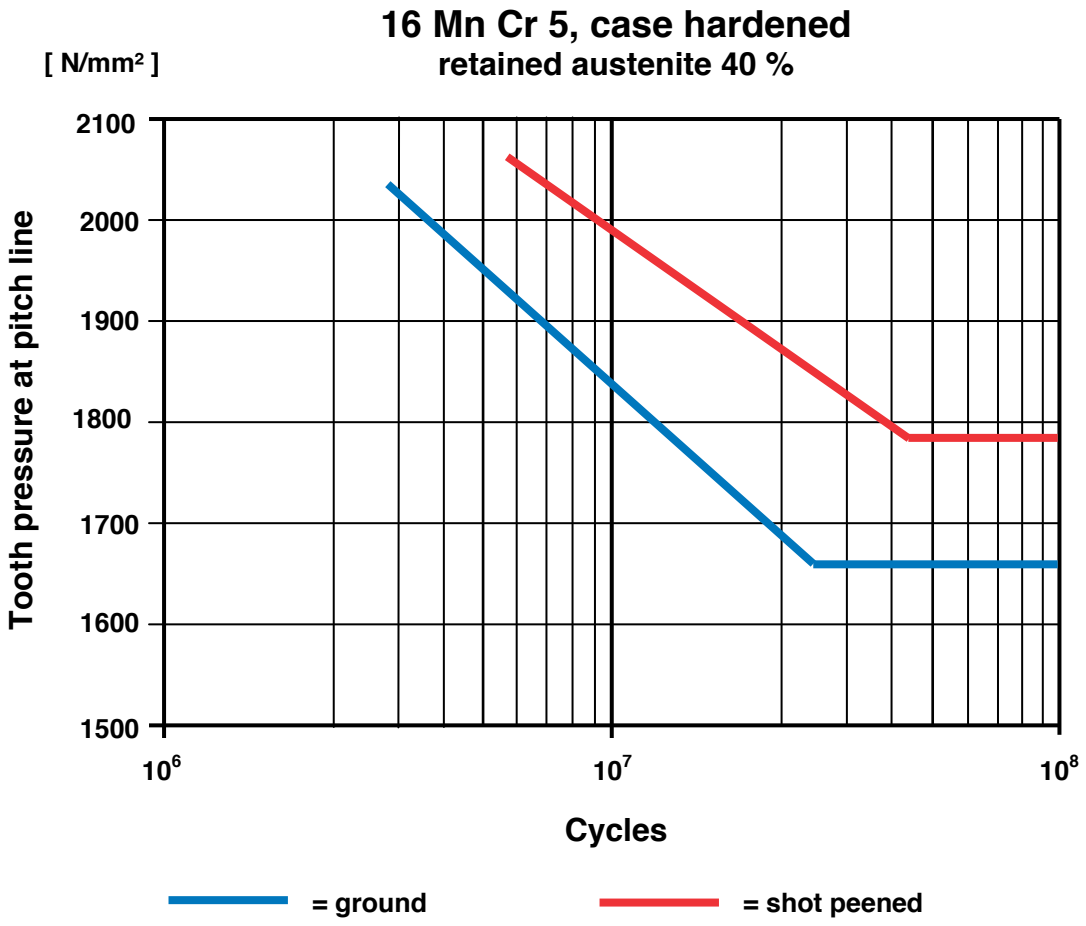



**Reversed bending test**

A reversed bendig test on a gear wheel with different root radii shows an increase in the root strength up to 50 %.
The actual increase depends on the formation and size of the radius (notch factor) in the tooth root and on the chosen shot peening parameters, especially the type and hardness of the shot peening media.

# Tooth profile strength after shot peening




## Shot peening parameters

**Shot peening media: cut wire, spherical (G3), 0.8 mm Ø, 60 HRC**
**Coverage : 2 x t 98 %**
**Intensity : 0.20 - 0.24 mm A**

### Test result

Different shot peening treatments and superficial structures produce an increase in tooth profile strength on a gear wheel up to 15 %.