# Two-body abrasion of nitrocarburized steels for hydraulic cylinders

Engineering

# Introduction

Nitrocarburising is a thermochemical diffusion process where Nitrogen, Carbon and a small degree of oxygen diffuse into the surface of steels to improve hardness thus forming a compound layer. Two body abrasion behaviour of hydraulic cylinders was studied for different Nitrocarburised steels. Three methods of nitrocarburizing was adopted namely salt bath, gas and plasma techniques. The steel substrate used were mainly Unalloyed steels (St 52-3, Ck 45), Low Alloyed steels (42 CrMo 4, 30 CrNiMo 8), and Chromium steel (X 20 Cr 13)

## Process parameters used for Nitrocarburising –

### Base Material Nitrocarburising techniques

Salt bath Q Salt bath QPQ Gas Plasma

Unalloyed Steels 580◦C for 1. 5h, oxidation at 400◦C for 30min 580◦C for 1. 5h, oxidation at 400◦C for 15min; then polishing and oxidation at 400◦C for 30min 580◦C for 12h 520◦C for 16h; then oxidation at 520◦C for 20min

Low alloyed Steels 580◦C for 2h, oxidation at 400◦C for 30min 580◦C for 1. 5h, oxidation at 400◦C for 15min; then polishing and oxidation at 400◦C for 30min 580◦C for 12h 520◦C for 16h; then oxidation at 520◦C for 20min

Chromium Steels 630◦C for 2. 5h, oxidation at 400◦C for 30min 630◦C for 1. 5h, oxidation at 400◦C for 15min; then polishing and oxidation at 400◦C for 30min 580◦C for 12h 380◦C for 48h; then oxidation at 380◦C for 20min

## The parameters were selected to achieve a compound layer of 12µm

### Experimental tests

- Thickness and Porosity measurement using Optical microscopy
- Structure using X-Ray diffractometer
- Roughness using Stylus Profilometer
- Abrasion wear using 6mm pin on table machine and wear mechanism observed using Scanning electron microscope (SEM)

### Results and Discussion

- Thickness and Porosity

Gas treated samples exhibited higher thickness due to higher treatment temperatures and longer time to produce compound layer. Lowest compound thickness was observed in plasma treated X 20 Cr 13 steel

Microporosity was more prevalent in gas treated samples than salt-bath and plasma. Higher nitrogen concentration in atmosphere can lead to more porous compound layer which raises initial wear of the material if not well lubricated

### Structure

Structure of the compound layer of salt-bath and gas treated samples composed mainly of the ε-$Fe_{2–3}N$ phase however a polyphase (ε-$Fe_{2–3}N$+ g0-$Fe_4N$) was produced on the surfaces of the plasma treated samples. A higher nitrogen concentration in the treatment atmosphere increased the percentage of ε-$Fe_{2–3}N$ in the compound layer

## Roughness

Nitrocarburising increased both the average roughness value (Ra) and the peak-to-valley height value (Rt) compared with those of the base materials in case of salt-bath and gas treated samples. Plasma treated samples had almost the same roughness as they have a uniform layer of deposition

## Abrasion wear

Abrasion wear of nitrocarburized steels were lesser in comparison to base materials but increased with increase in wear length same as that of base material. Least improvement was observed in plasma treated unalloyed steels due to its compound layer structure and core hardness. In low alloyed samples, QPQ salt-bath treated samples showed lowest wear rate. However, on comparing all steels, the salt-bath and gas treated samples of the X 20 Cr 13 steel exhibited the lowest abrasion rate

## Conclusion

On conducting investigations on three carburising methods on five different steels, the following conclusions can be made

- The nitrocarburizing processes improved the abrasion resistance of steels
- On comparing on various factors, it was observed that salt-bath and gas treated samples of chromium steel showed the most abrasion resistance whereas Unalloyed steels showed the least
- Thinner compound layer and high porosity lead to lower abrasion resistance

- Hardness and structure of the compound layer influenced the abrasion wear of the steels as higher the hardness, greater is the resistance.