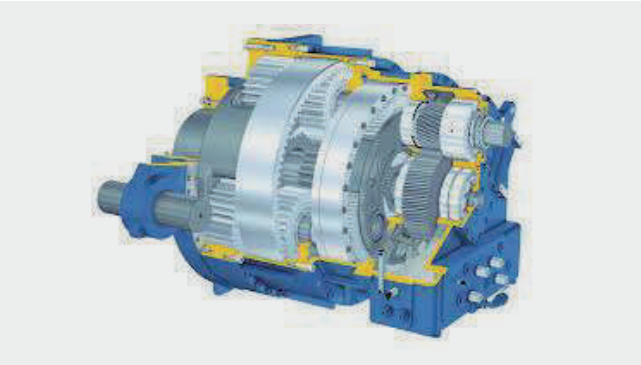
# ACERIUM Steel

## Steel for large Carburized Gears

sidenor steel

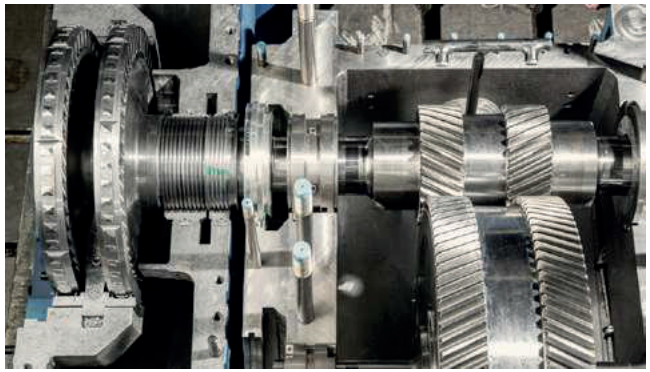
# Applications and Features of Large Gears

## Wind Turbine Drives



Main drive, pitch and yaw control

## Industrial Heavy-Duty Drives

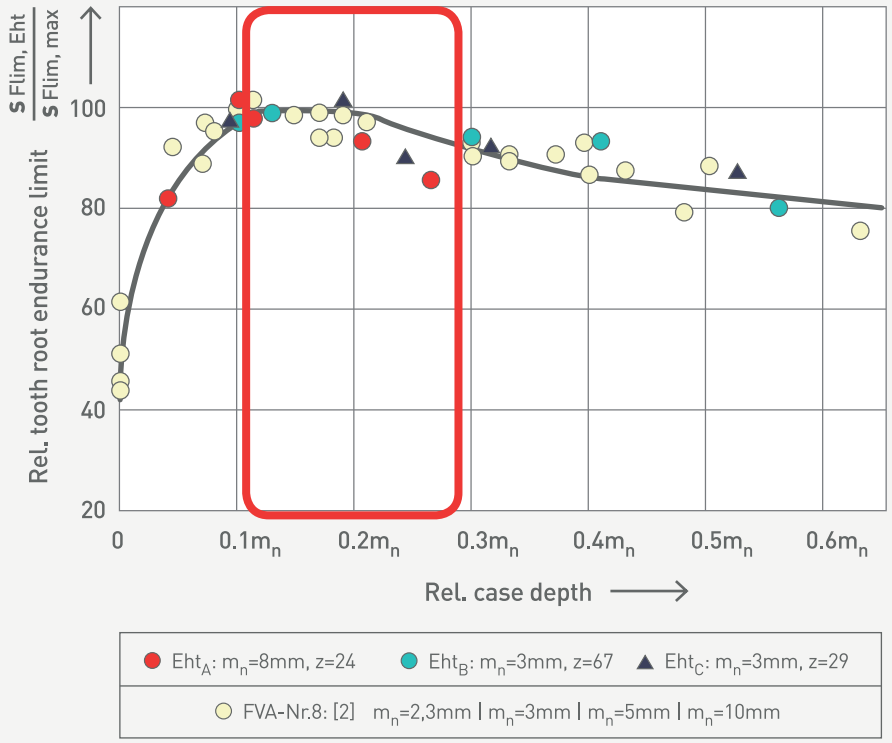


Low speed drives for steel rolling mills, rubber, plastic, paper and cement industries; High speed drives for energy generation

# Applications and Features of Large Gears

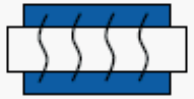
## Great Power Transmission, High Torque and Large Module Teeth

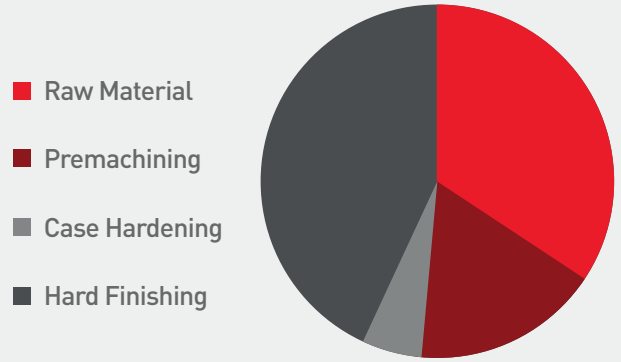
Large gears must transfer a great power and provide a high torque. Teeth need a large module to cope with usual loads and, consequently, the carburized case is substantially thicker

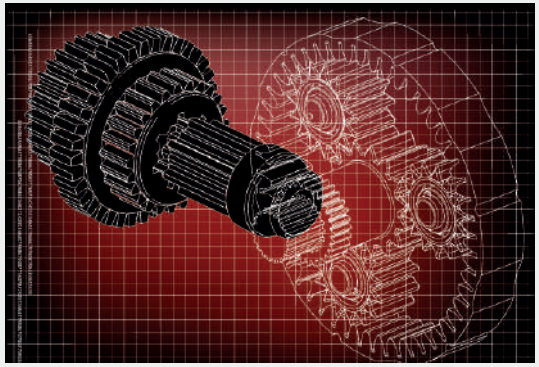



Tobie et Al. "Systematic Investigations on the Influence of Case Depth on the Pitting and Bending Strength of Case Carburized Gears", Gear Technology (2005)

# Manufacturing Steps

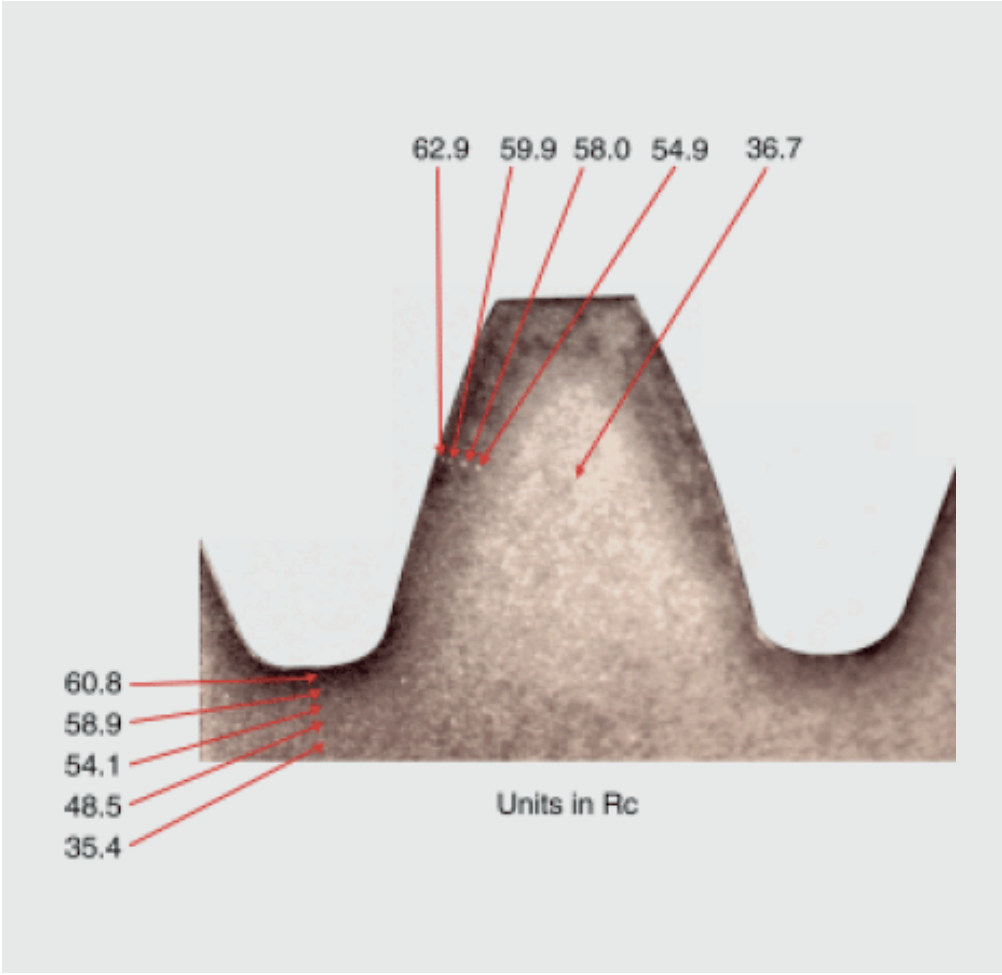
| Steelmaker | Forging & Rolling | Pre-Heat Treatment | Rough Machining | Carburizing | Hard Finishing |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| Ingot Casting<br>-<br>Continuous Casting | Hot Forging<br>-<br>Hot Rolling<br>-<br>Ring Rolling | Annealing<br>-<br>Quenching & Tempering | Rough Machining and Hobbing | Case Hardening | Hard Finishing and Grinding |
| Raw Material Supplier | Raw Material Supplier | Gear Manufacturer | Gear Manufacturer | Gear Manufacturer | Gear Manufacturer |



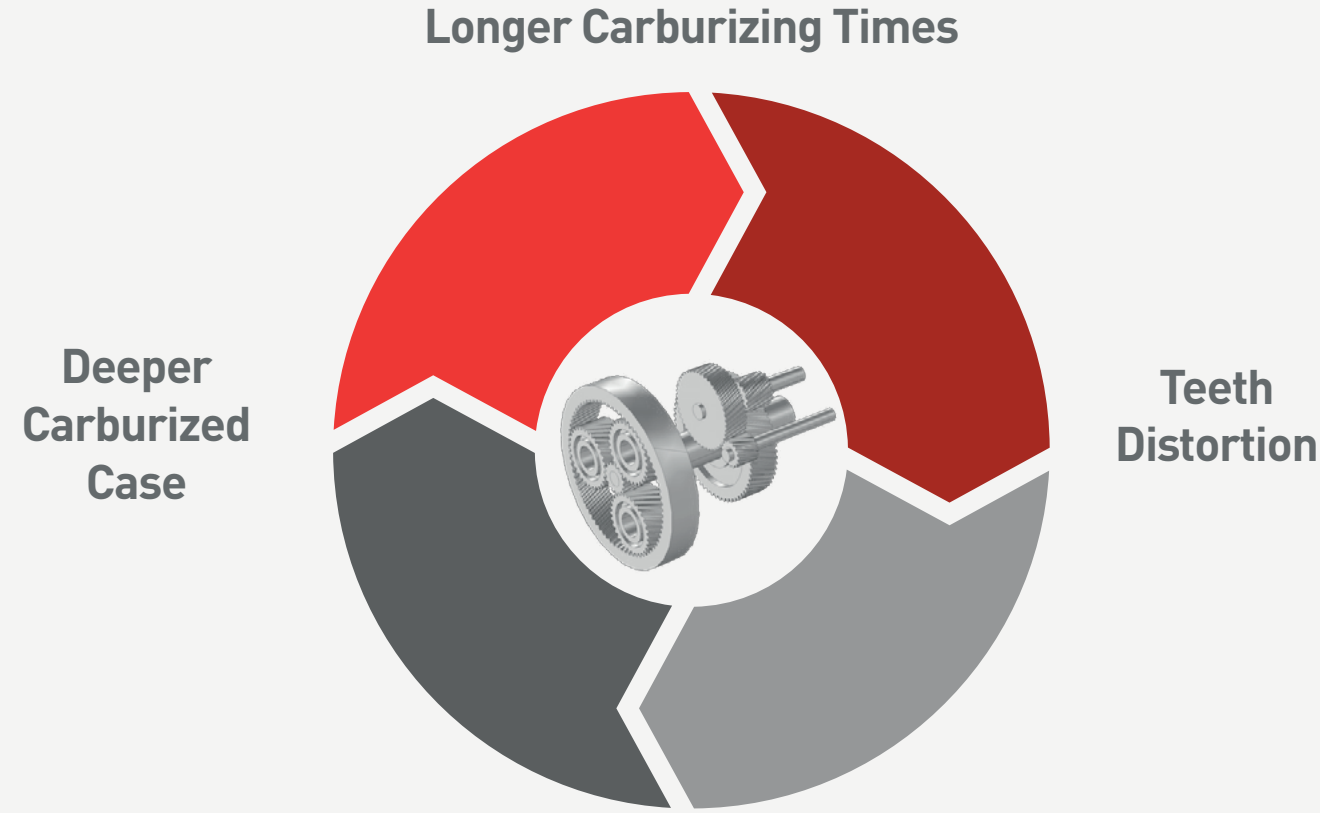
# Problem to Solve

- Large gears with large module teeth (i.e., 16 mm) need an effective carburized case proportionally deep (2,5 mm), but due to tooth distortion and further grinding to correct geometry, hardened cases are much deeper (**up to 4-5 mm**). So, carburizing times are extended even more (typically **80 hours @ 960ºC**) what increases distortion, which finally produces an inhomogeneous case



# Problem to Solve

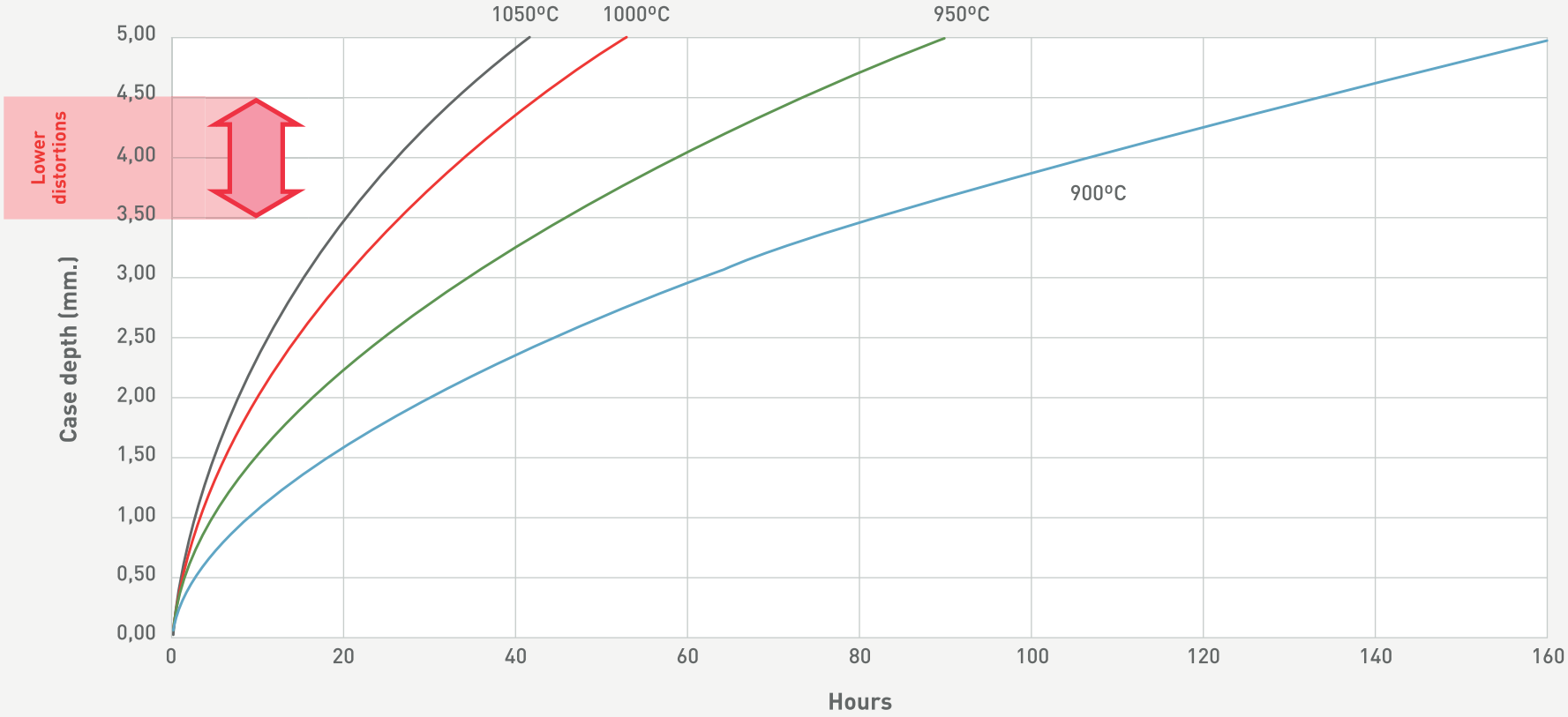
- Deeper carburized cases require longer carburizing treatments




**Extensive and Expensive Grinding and Finishing Operations**

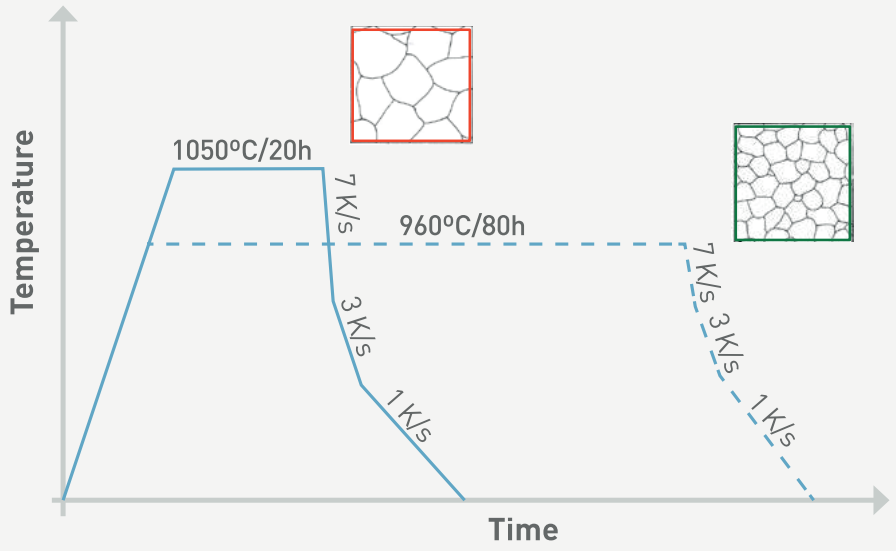
# Benefits of High Temperature Carburizing

- Shortening of carburizing treatment process
- Lower level of teeth distortions and narrower finishing allowance



# Challenging AGS Control during Carburizing

- Challenging **austenitic grain size** control during carburizing treatment
- Austenitic grain size grows linearly with holding time at high temperature, unless microprecipitates pin the grain boundaries.



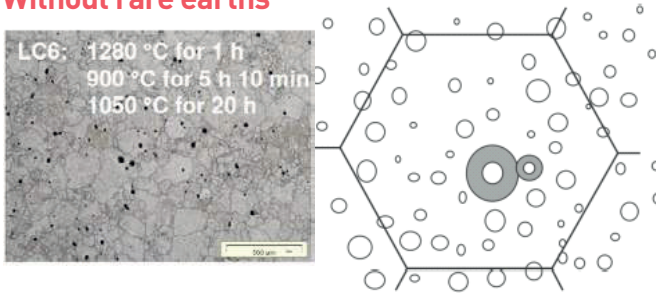

$$d^n - d_o^n = [A \cdot exp(-Q_{gg}/RT)] \cdot t$$

# ACERIUM Steel

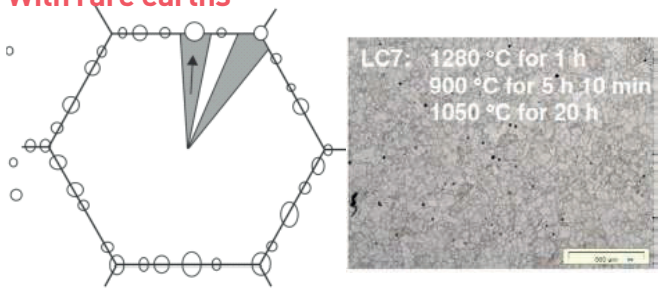
- ACERIUM steel has been developed by SIDENOR to **shorten the carburizing process**:
  - Through high temperature carburizing
  - Speeding up the carbon absorption and diffusion
- ...maintaining and **guaranteeing a very fine austenitic grain size**
  - Fatigue failures due to coarse grains become highly unlikely
- **Economical benefits** come from:
  - A substantial reduction of the carburizing process time
  - A reduced level of carburizing distortions, what influences noticeably on the case thickness to be hard machined or grinded after heat treatment

# Micro-Alloying Strategy

### Without rare earths

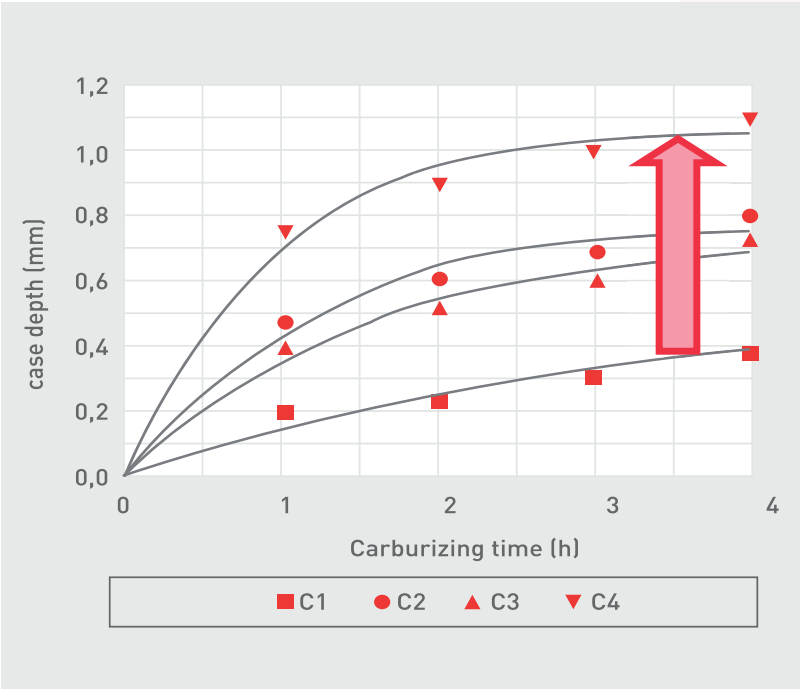



### With rare earths



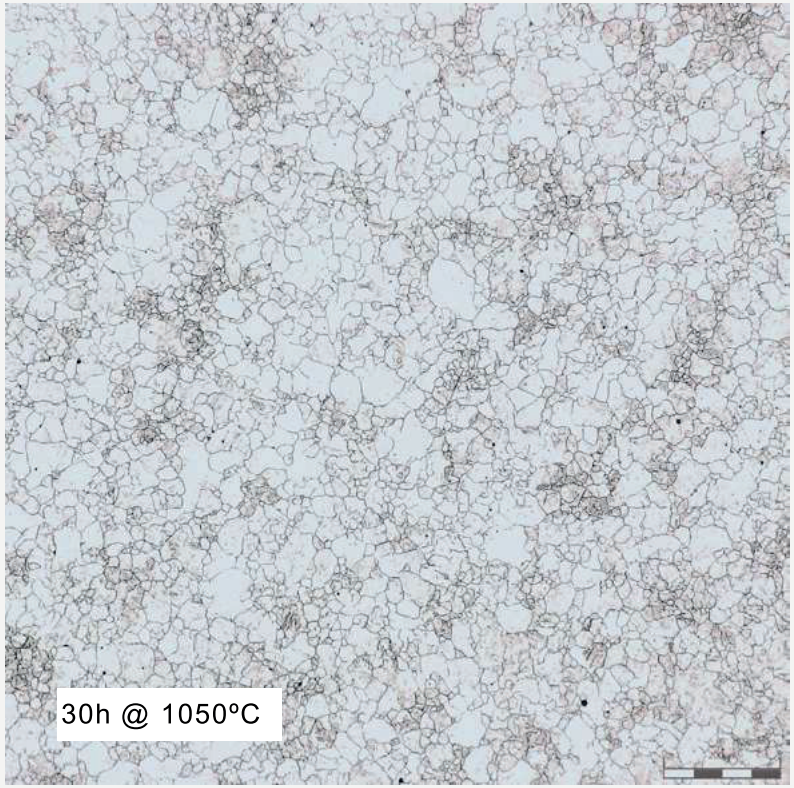

- The "rare earth" elements help to control the grain size and improve the carbon diffusivity during the carburizing process
- Nb & Al microalloying controls the austenitic grain size at high temperatures for long times

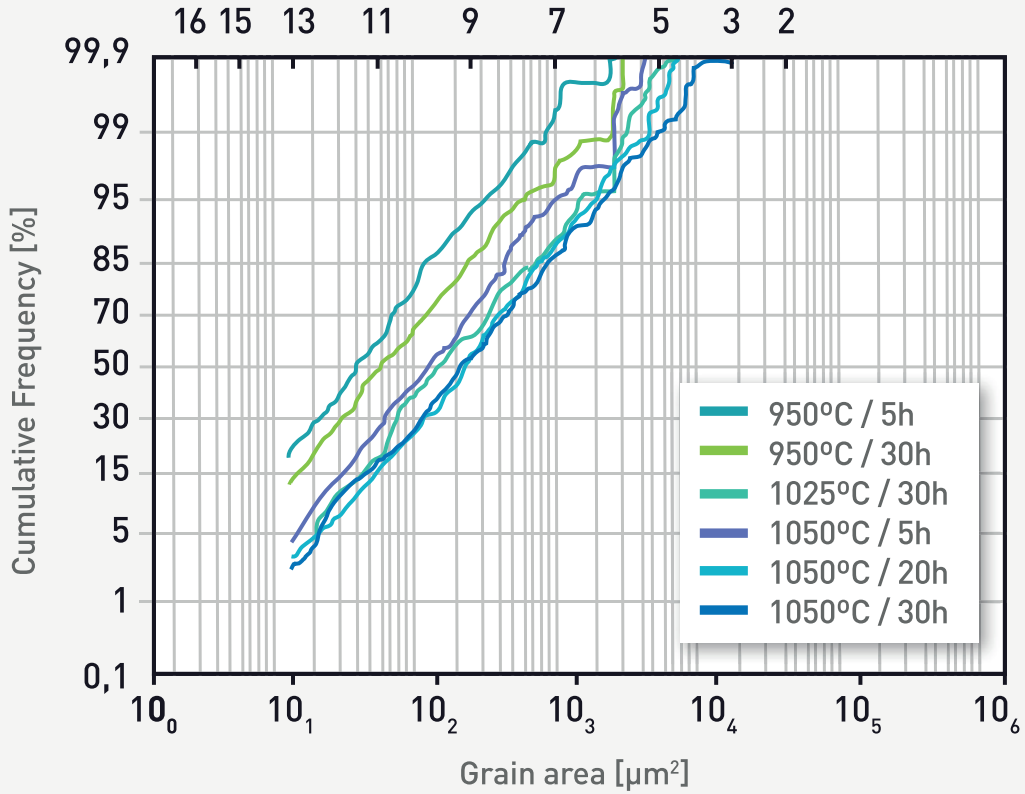
| Steel | C | Si | Mn | P | S | RE |
|---|---|---|---|---|---|---|
| 1 | 0,20 | 0,28 | 0,48 | 0,009 | 0,011 | - |
| 2 | 0,19 | 0,26 | 0,49 | 0,013 | 0,010 | 0,024 |
| 3 | 0,18 | 0,27 | 0,49 | 0,005 | 0,004 | 0,032 |
| 4 | 0,19 | 0,28 | 0,48 | 0,014 | 0,002 | 0,130 |



# Effective Austenitic Grain Size Control

- Austenitic grain size after carburizing process (30h @1050ºc) keeps very fine



# ACERIUM Applications

- ACERIUM Technology can be applied to any carburizing steel grade used for the manufacturing of large gears or other components, which, due to their big tooth module and total dimensions, must be carburized for extremely long times

# ACERIUM Benefits

- **Economical savings** and higher flexibility during gear manufacturing:
  - Shortening of carburizing process
  - Minimizing of hard finishing and grinding operations due to lower teeth distortions

- Higher **reliability**
  - Guarantee of very fine austenitic grain size

# Thank you!

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