Girth Gears: Theory and Technology
Fabricated Girth Gear
Forged and electro welded technology

Our choice is Fabricated Girth gear:

- The forged material structure excludes the risk of inclusions and request for repair welding of the body structure and e.g. grinding of toothed areas.

- The welding procedure exclude the need of patterns, reducing the lead time and ensure high quality product supply with customized design
Fabricated Steel

Advantages:

- Good physical properties in all directions.
- No micro-porosities such as gas holes, micro-shrinkage and pinholes.
- Absence of macro defects such as hot tears, shrinkage and sand inclusions.
- No weld repairs or “blend-outs” required in critical tooth areas or web.
- Very good metallurgical yield.
- Repeatability of dimensions and orientation.
- Uniform metallurgical chemistry.

Challenges:

- “Give me what I have (cast steel)”
Manufacturing procedure

- Forging Material process
- Welding process
- QA NDT Inspection
- Machining process
- QA Final Inspection
- Packing and shipping
Forging Material process

- Forging
- Final Rolling
- Furnace Cooling
- Control on production
- Water quenching
- Hardness testing
- Rough machining
- Ultrasonic Testing and Measuring
- Final inspection Certification
Certificate and Qualification

- WELDING PROCESS QUALIFIED
  Welding Procedure Approval Record – WPAR
  Procedure Qualification Record - PQR
  Welding Procedure Specification – WPS
  Welder Qualification Record – WQR

ACCORDING TO THE STANDARDS

ITALIAN AND INTERNATIONAL WELDING INSTITUTE
# Welding Procedure

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Welding process

- preparation of all web, ribs and junction plate with cutting software.

- Bending of external Rim + Hardness test
Welding process

- Fit-up and welding of complete internal web
- Preparation of chamfer
- Fit up and Weld external Rib with intyernal web plate
- Fit up and welding of joint flanges
Welding process

- NDT control before heat treatment
- PWHT Post weld heat treatment
Welding process

- NDT - QA inspection
- Sand blasting and paint
Certificate and Qualification

- NON DESTRUCTIVE TEST

ASNT - qualification 2° Level SNT-TC-1°
UNI EN 473 - ISO 9712 Qualification 2° Level

Ultrasonic testing
Magnetic particle
Penetrant testing
**Machining Process**

- Mill Split Joints and holes
- Assemble gear halves
Machining Process

- Plunge and rough cut teeth
- Open joint inspection
- Finish machining, drill
Machining Process

- Finish hob teeth
- QA Final inspection
Quality Inspection Test Plan

- QT Forged material - Chemical and mechanical properties
- certificate of HT
- Inspect gear rim hardness
- UT reports for rim material
- Welding procedures WPQR – WPS
- Welding map
- Stress relieving PWHT Diagram
- UT and MT 100% welding area before and After PWHT
Quality Inspection Test Plan

- inspect final girth gear run-out on gear cutter
- inspect tooth flank surface finish
- inspect pitch, profile and pitch line pattern
- MT test 100% teeth area
- Inspect joint flange tightness and Open joint
- final document review
Mounting Flange

- Layout of bolt holes
- Runout of flange
- Flatness of flange
- Alignment of gear dependent on accuracy of flange.
- Use of shims should be avoided.
Excessive Gear Runout

- Setup and support in vertical boring mill
- Setup and support in finish gear cutter

- FLSmidth tolerance for as-machined ø6.4m gear
  - Roller supported - axial 0.10mm, radial 0.13mm
  - Flange mounted – axial 0.08mm, radial 0.13mm

- FLSmidth installation tolerance for same ø6.4 gear
  - Roller supported – axial 0.53mm, radial 0.80mm
  - Flange mounted – axial 0.27mm, radial 0.40mm

- Why critical?
  - Indicator of gear set alignment and ultimately the achievable life expectancy of the gear set.
AGMA Tooth Quality Requirements

- **Flange mounted gear sets:**
  - Gear
    - Pitch Q10
    - Profile Q10
    - Lead Q10
    - Runout Q10
  - Case-hardened pinion
    - Pitch Q12
    - Profile Q12
    - Lead Q12
    - Runout Q12

- **Spring mounted gear sets:**
  - Gear
    - Pitch Q8
    - Profile Q8
    - Lead Q8
    - Runout Q8
  - Through-hardened pinion
    - Pitch Q10
    - Profile Q10
    - Lead Q10
    - Runout Q10
Profile quality control

Balance wheel after cutting

Balance wheel after grinding

Human hair

70 µm
Why quality is so important

Total Girth Gear installation cost survey

Calculation example:

Kiln size ø5.0 x 90 m
Production: 4500 tpd

- Estimated cost of parts: Girth gear + springs etc. EUR 450.000,- (27%)
- Est. mech. erection costs: EUR 130.000,- (8%)
  29% of parts cost
- Estimated consequential loss: EUR 1.080.000,- (65%)
  EUR 4500/hour in 10 days
- Total installation costs: EUR 1.660.000,- (100%)

Conclusion:

- The cost of the Girth Gear is only a "piece of the cake" compared with the total substantial installation cost.
- Long term solution with high FLSmidth quality is the best solution to ensure a beneficial investment.
Reference List

Mill - Girth Gears
### Reference List

#### Mill - Girth Gears

**1975 - 2011**

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**Total** 857
Reference List

Kiln - Girth Gears
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**Total Kiln – Girth Gear**: 234
THANK YOU