# Girth Gear Inspection — Pre- and Post-Manufacture

Email your question—along with your name, job title and company name (if you wish to remain anonymous, no problem) to: *jmcguinn@geartechnology.com*; or submit your question by visiting *geartechnology.com*.

## QUESTION

**What are the ins-and-outs of quality inspection of girth gears, from both a manufacturer and buyer perspective?**

**Girth gear specifications:** DP = 6.327.12 mm, Module = 30, Number of teeth = 208, Teeth width = 600 mm, Dim. = 6.367/4.900 × 760, Material = GS34CRMO4, Rep. = 1.3 to 13

**Response No. 1 provided by HMC Inc.:** There are many quality control requirements involved with girth gears. The process begins in manufacturing and continues through installation, run-off and ongoing monitoring.

### Manufacturer perspective:

- During manufacturing:
  - ***Raw material**: incoming checks and inspections*
    - ◊ These include, but are not limited to, material certifications with full reports from forging and plate vendors, dimensional inspection and hardness testing upon arrival, and ultrasonic inspection of the forgings.
    - ◊ Dimensional reports.
    - ◊ NDT hardness testing and verification.
  - Fabrication (welding)
    - ◊ Stress-relieving oven; digital charting (thermal reports).
    - ◊ Dimensional checks.
    - ◊ Magnetic particle testing; ultrasonic testing of welds.
    - ◊ CWI (certified welding inspector) visual checks.
  - Machining/tooth inspections
    - ◊ In-process dimensional, run-out and surface finish checks for any significant process.
    - ◊ On-board lead, pitch and profile checks on the teeth are performed.
  - Final inspection
    - ◊ During the final inspection everything is dimensionally inspected and thoroughly reviewed to make sure all items and inspections are up to the specifications.
    - ◊ Mesh test between gear and pinion (contact pattern).
- During installation and alignment:
  - Over the years, HMC has seen misalignment cases where companies get in a hurry and/or have a lack of proper supervision and instructions. The girth gear driving pinion ends up getting aligned to the reducer, causing a misalignment issue between the girth gear teeth and the driving pinion teeth (Fig. 1).
  - Proper alignment should consist of: axial and radial alignment of the girth gear to the center line of kiln/mill; center line of the driving pinion is aligned to the center line of the girth gear; center line of the reducer output shaft with coupling is aligned to the center line of the girth gear driving pinion; finally, the center line of the motor is aligned to the center line of the reducer input shaft with coupling.
- Run-off and ongoing monitoring
  - Proper oil inspection and selection
    - ◊ Oils and other lubricants are often stored in the same area. And often the numerical and alphabetical identification numbers that identify the different gear/transmission oils and the heavier, open-gearing lubricants are very similar, thus inviting employees to potentially use the wrong lubrication materials. This could prove to be a disastrous situation for the operating quality of your girth gear. Proper selection and continuous inspection of the girth gear's lubrication selection falls in parallel to both proper alignment of the gearing and start-up monitoring/inspection, as mentioned above.
    - ◊ By routinely inspecting the quality of the oil lubricating the girth gear system an effective 'double-check' on proper alignment would be created. In the event of an improper initial alignment inspection, the results from a girth gear oil sample inspection

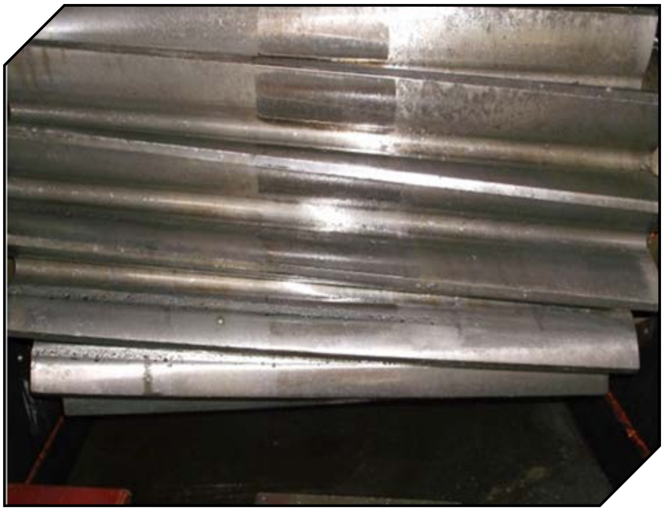

**Figure 1 Example of girth gear misalignment: girth gear driving pinion end is aligned to the reducer, causing misalignment between the girth gear teeth and driving pinion teeth (courtesy HMC).**

would yield metallic contents due to the meshing contact breaking down and dynamic destruction occurring.
    - ◊ Proper start-up monitoring/inspection, specifically with emphasis on temperature recording, would be a significant indicator of proper oil selection. If the incorrect oil is selected for lubrication purposes, an unusually high temperature will be observed at initial start-up; this is due to the possibility that the oil selected has a viscosity under the requirements for a girth gear set. If the viscosity is not high enough to properly lubricate the meshing set, operating temperatures will increase. As these temperatures increase, the natural viscosity properties of the lubricating oil will continue to decrease, leading to damage of the girth gear set. As can be observed, this is a double-edged sword; i.e.: an improper, low-viscosity oil selection from the beginning will lead to high operating temperatures and an even lower operating viscosity in the gear set.
- Run-off and ongoing monitoring (cont'd.)
  - ***Two functions must be performed at start-up*:**
    - ◊ Monitor contact patterns, as the pattern could change under loading.
    - ◊ Verify the gear set is lubricated properly.
  - As soon as the machine is running, verify that adequate amounts of lubrication are conveyed and dispersed evenly and completely. A good suggestion is to run mill for eight hours under no load, then increase load slowly over a 24-hour period. Check contact pattern and lubrication patterns every 2-4 hours. When partially or fully loaded, some deflection will occur; continue to check contact and lube patterns every 2-4 hours and make alignment corrections as required. Continue checking until no farther adjustments are required and all pattern checks are satisfactory.
  - Check contact pattern and lubrication patterns approximately (30) days after start-up and take a lubrication sample. Make alignment adjustments as required and change lubrication as it becomes contaminated. A periodic maintenance schedule should be developed based on specific field conditions.

## Customer perspective:

Generally, customers require a final inspection report that may include, but is not limited to, a mesh check (contact pattern check), material certifications, dimensional inspection, run-outs, MT and UT reports. Some customers require quality inspection test plans. Customers perform full vendor audits.

*HMC responses were a team effort consisting of*

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**Response No. 2 provided by Frank Uherek, Rexnord Corp.**

## Manufacturer perspective:

When the gear is mounted on the mill, periodic inspections are required to check alignment of the pinion and gear. This can be done by measuring temperature differences between each end of the gear face as it meshes with the pinion. In addition, the teeth should be visually examined for pitting and wear damage. Magnetic particle inspection is a useful tool to detect surface separation (cracks) in the tooth surface. ASTM E2905 discusses a new method for performing this type of inspection. Confirming that the lubricant system is dispensing the correct amount of oil or grease at the proper spray interval is also important for long gear life. Reviewing bolt torques at the split joint and mill mounting flange is also required.

## Inspection steps—manufacturer side:

Given the critical service these gears perform, quality assurance is an integral part of the manufacturing process. The process begins with chemical analysis of the blank material, magnetic particle inspection of the cast blanks or fabricated rims, heat treat documentation records, and mechanical properties testing. Once the gear blank leaves the foundry or fabrication shop and is rough-machined, ultrasonic testing of the split-joint flange (where the gear is bolted together), the rim and the mounting flange to the mill is performed to ensure a sound base before cutting teeth. The hardness of the blank is also confirmed at this time. Dimensional checks are made to confirm interface dimensions. Run-out of the mounting flange, face width and outside diameter is taken to record the as-cut condition of the blank to enable the same mounting conditions on the mill as on the gear cutter. Tooth attribute inspections, such as profile and pitch, as well as tooth thickness, are recorded to confirm that the gear matches the design requirements of the engineer. A roll contact check, or fixed center contact check is also completed to confirm that the helix (lead) of the gear matches the pinion. Split joint closure is measured to confirm that the gear did not distort during the manufacturing process. Magnetic particle inspection of the finished gear teeth is typically conducted and the results reviewed by the design engineer to identify and relieve any surface indications present on the gear teeth from the raw material. The last step is to have the design engineer review all of this collected information to confirm that the finished product meets the specification and provides the client the performance they are expecting for the application.

## What is required of the customer?

The client should confirm that the mill is properly installed with a well-designed foundation and the required safety and electrical controls. A periodic preventative maintenance inspection program ensures that all controls, lubricant delivery systems and power transmission components—gear drive, couplings, pillow blocks and girth gear sets—are aligned, lubricated and performing to specification.

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