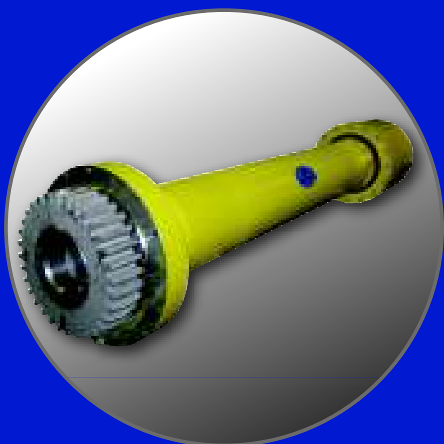
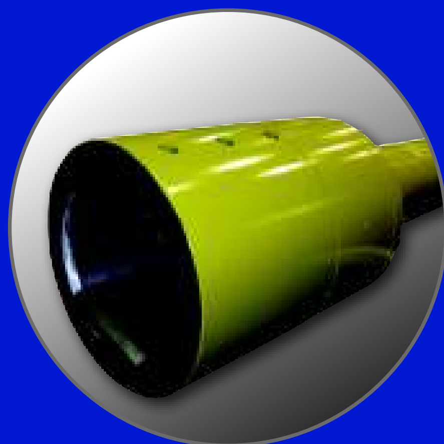
AJAX Mill Spindles





Carburized and Nitrided Designs

Crowned and Barrelled Teeth with Tooth-Tip Piloting

High Power Density

Roll End Piloting

Tight Fitting Spline Connections With Long Life

Custom Compound Tooth Curvature

RENOLD

Superior Technology

Contents

Facility

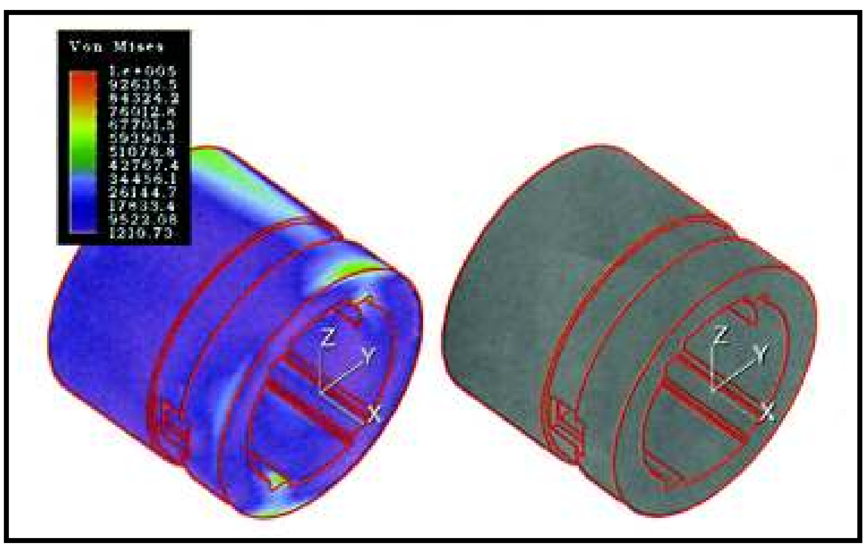
▲ **Renold Ajax manufacturing plant in Westfield, New York**

Renold Ajax... Leaders in Innovation

For more than 60 years, Renold Ajax has been an industry leader in designing and manufacturing custom gear spindles, gear couplings and special gearing. Its Westfield, New York, plant is just one of a world-wide operation that includes sales and manufacturing subsidiaries in sixteen countries and sales agents in more than seventy countries, all specializing in power transmission products.

Renold Ajax's success in the primary metals industry can be attributed to design innovations like continuous circulating oil lubrication, roll end piloting, and compound tooth curvature. The company has invested heavily in the Westfield plant with state-of-the-art CNC machinery, and has also incorporated manufacturing cell technology. This combination allows Renold to offer a high quality product at an extremely competitive price.

Continuing research and development, including Finite Element Analysis and solid modeling design methods assure our customers that their equipment will be optimized for their application.



▲ **Finite Element Analysis and Solid Modeling**

Capabilities

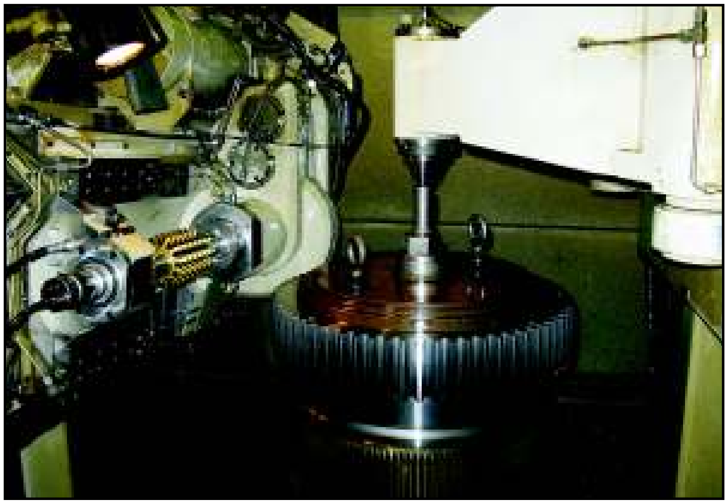
▲ New CNC machinery

▲ Gear shaping machine

▲ New electro discharge wire machine

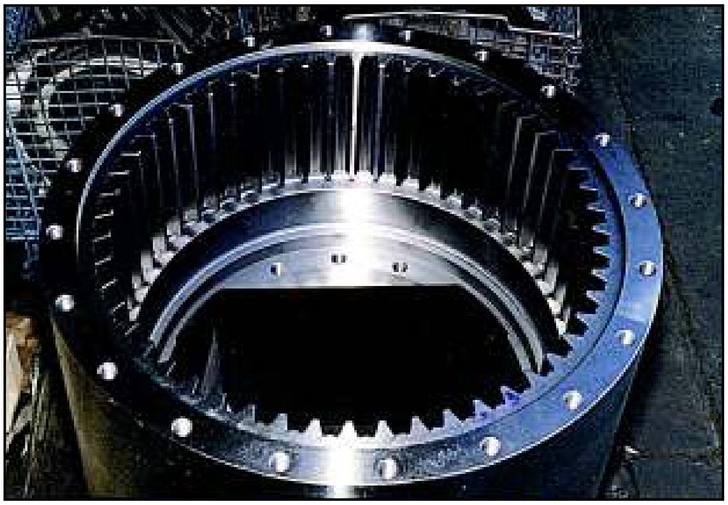
▲ New CNC machinery

▲ Cell manufacturing approach



▲ CNC hobbing machine

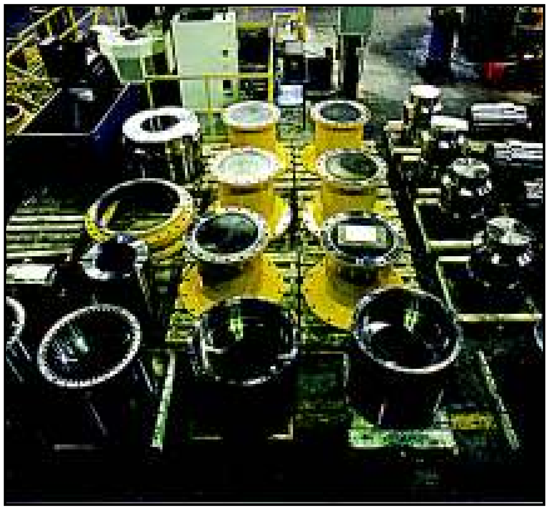
Spindle Parts and Assembly



▲ Type 1 roll end ring gear

▲ Spindle in paint booth

▲ Advanced load-sharing tooth design

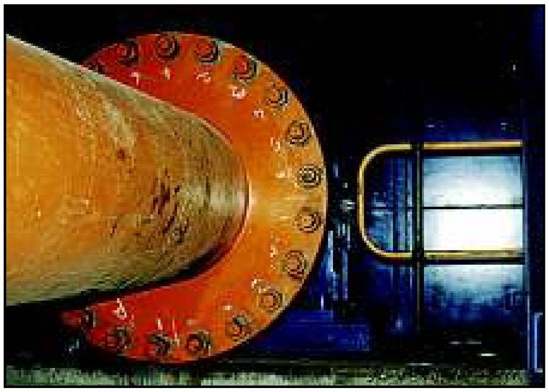


▲ Finished parts staged for assembly

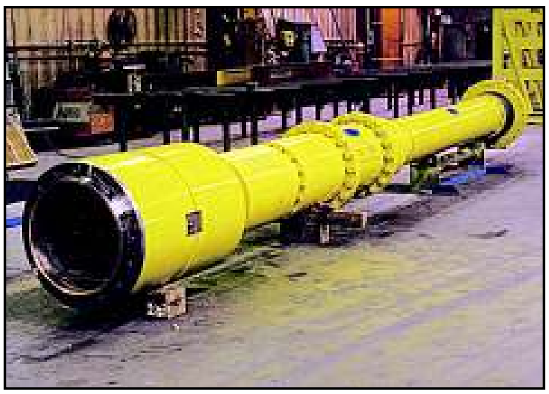
▲ Type 3 roll end adaptor

▲ Finished hot strip mill spindles

Spindle Parts and Assembly



▲ **Main drive for large reversing mill**



▲ **Large telescopic spindle**

▲ **Finished hot strip mill spindles**

▲ **Roughing spindle ready for shipment**

▲ **Large gearbox flex halves**

▲ **Finished assemblies head to overseas packager**

▲ **Various parts ready for assembly**

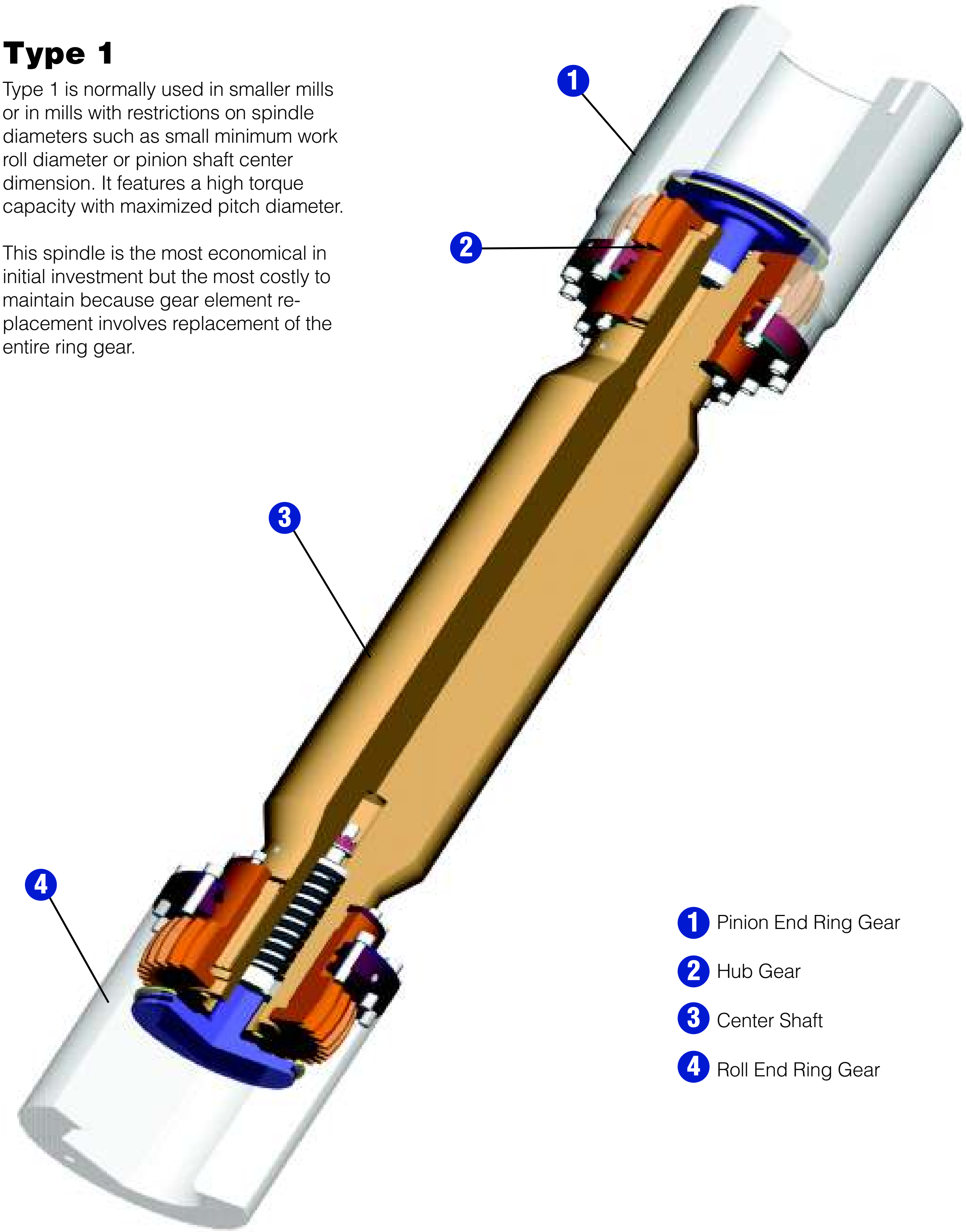
Spindle Design Types

Design and construction characteristics balance the cost of the initial investment versus the cost to maintain the spindle over years of services. Renold offers basic designs.

Type 1

Type 1 is normally used in smaller mills or in mills with restrictions on spindle diameters such as small minimum work roll diameter or pinion shaft center dimension. It features a high torque capacity with maximized pitch diameter.

This spindle is the most economical in initial investment but the most costly to maintain because gear element re-placement involves replacement of the entire ring gear.



1 Pinion End Ring Gear

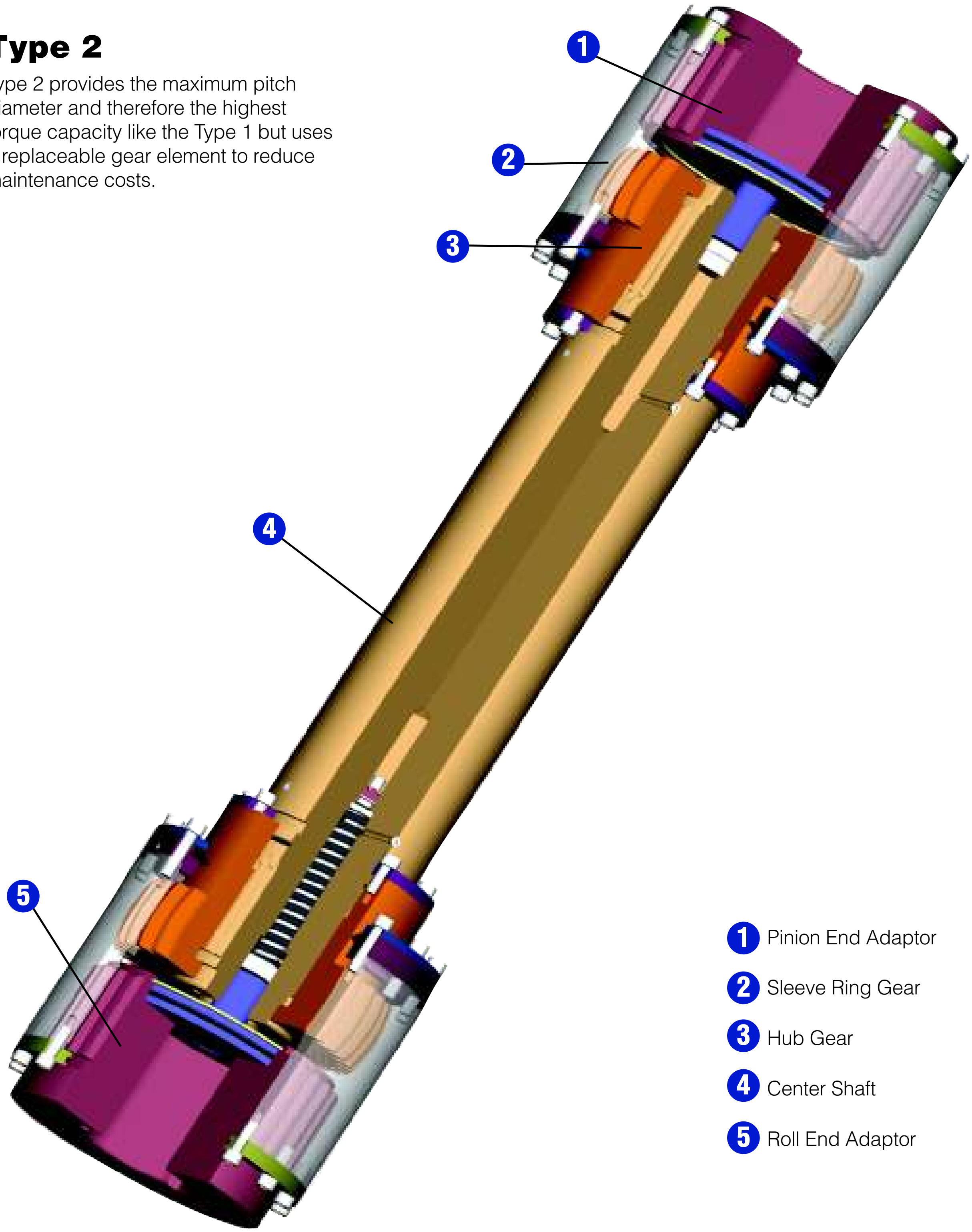
2 Hub Gear

3 Center Shaft

4 Roll End Ring Gear

Type 2

Type 2 provides the maximum pitch diameter and therefore the highest torque capacity like the Type 1 but uses a replaceable gear element to reduce maintenance costs.

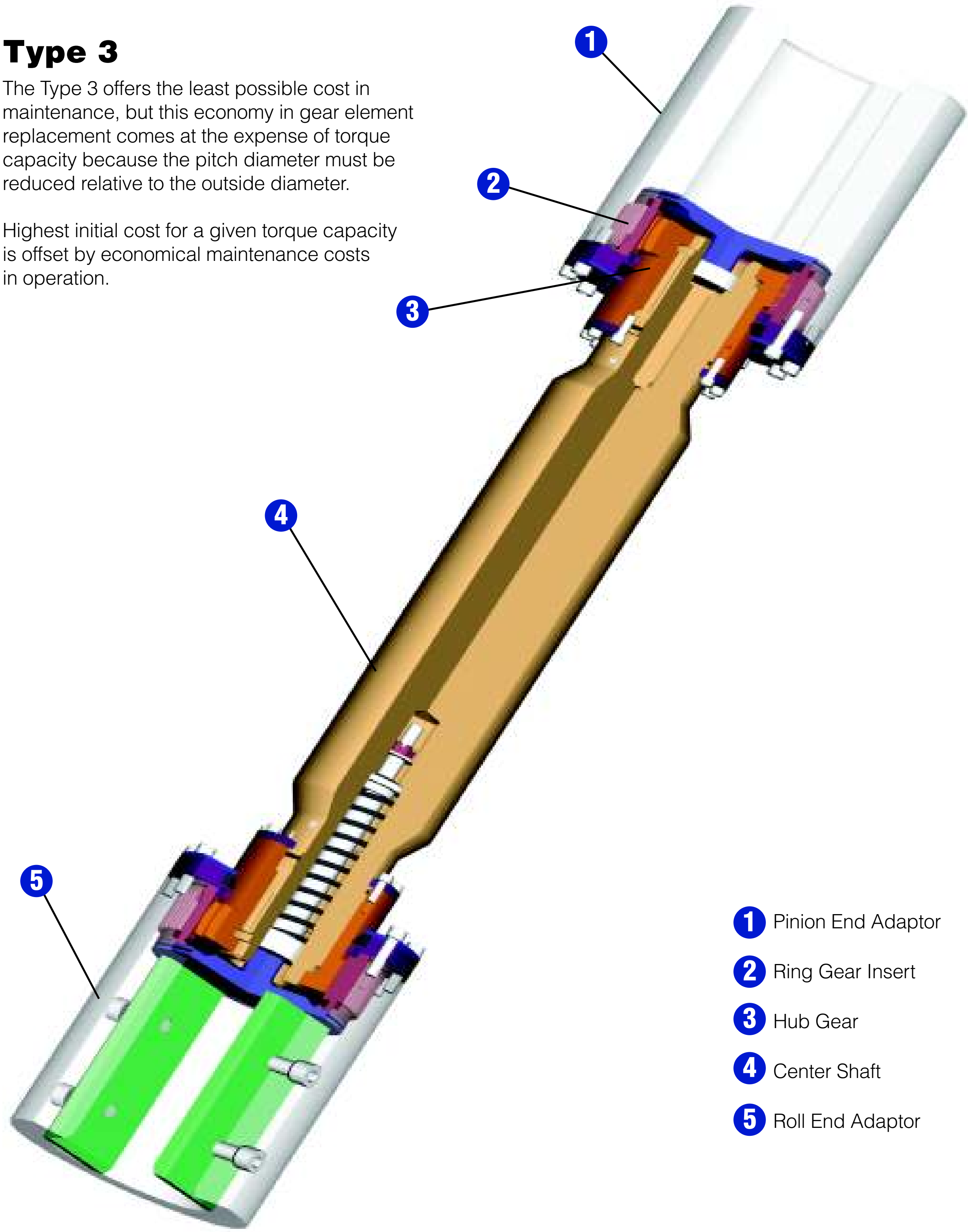


1 Pinion End Adaptor
2 Sleeve Ring Gear
3 Hub Gear
4 Center Shaft
5 Roll End Adaptor

Type 3

The Type 3 offers the least possible cost in maintenance, but this economy in gear element replacement comes at the expense of torque capacity because the pitch diameter must be reduced relative to the outside diameter.

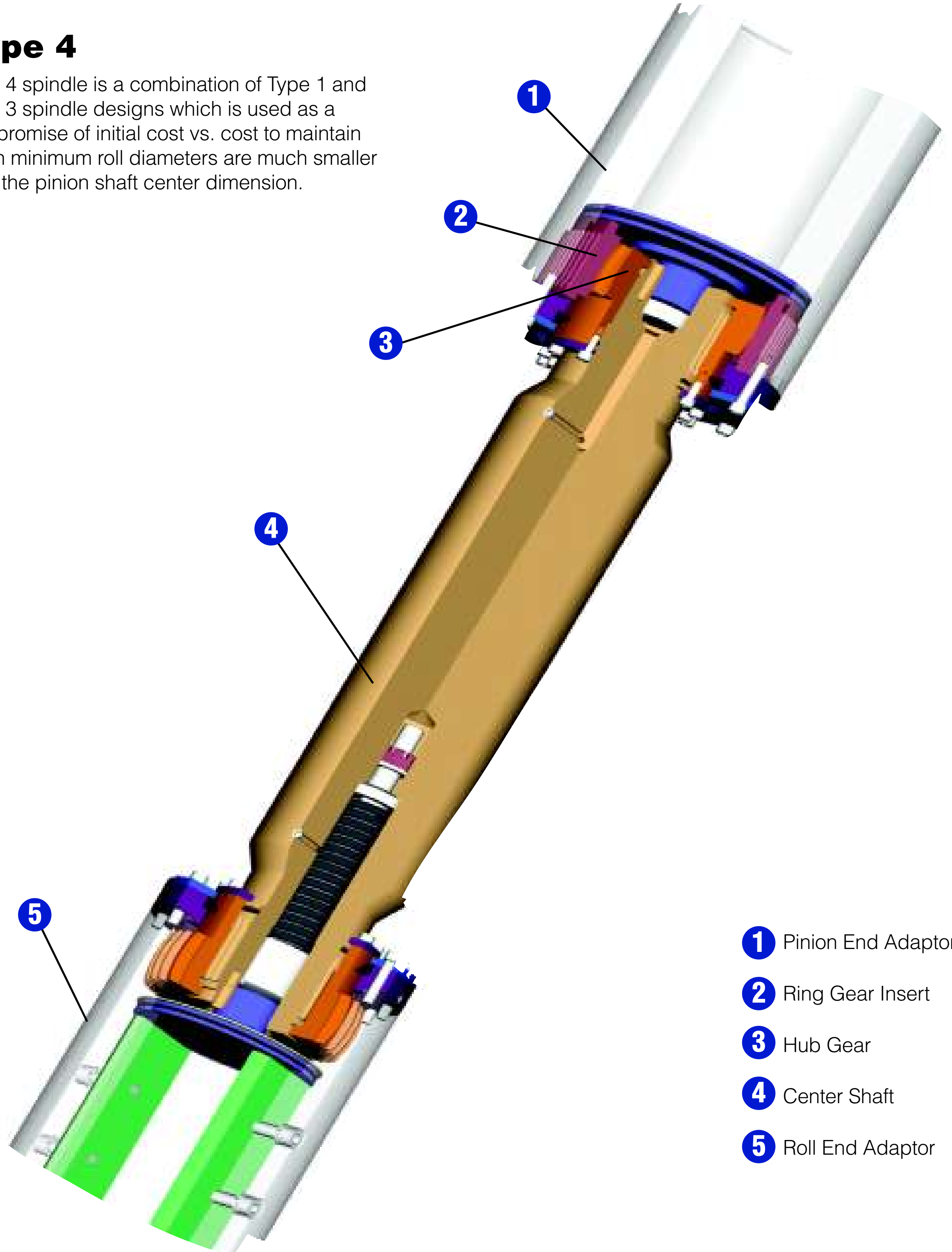
Highest initial cost for a given torque capacity is offset by economical maintenance costs in operation.



1. Pinion End Adaptor
2. Ring Gear Insert
3. Hub Gear
4. Center Shaft
5. Roll End Adaptor

Type 4

Type 4 spindle is a combination of Type 1 and Type 3 spindle designs which is used as a compromise of initial cost vs. cost to maintain when minimum roll diameters are much smaller than the pinion shaft center dimension.

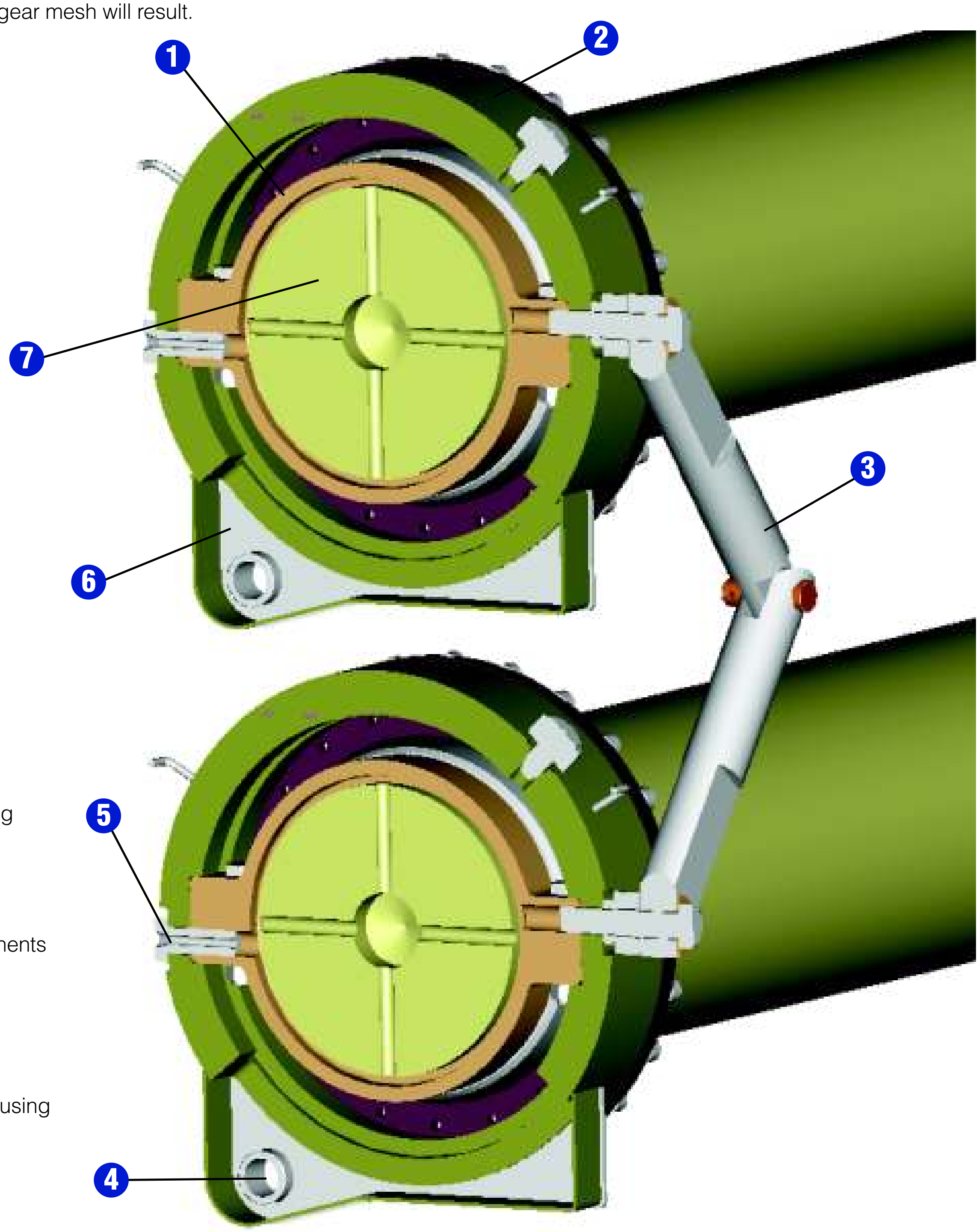


1. Pinion End Adaptor
2. Ring Gear Insert
3. Hub Gear
4. Center Shaft
5. Roll End Adaptor

Continuous Circulating Oil Lubrication

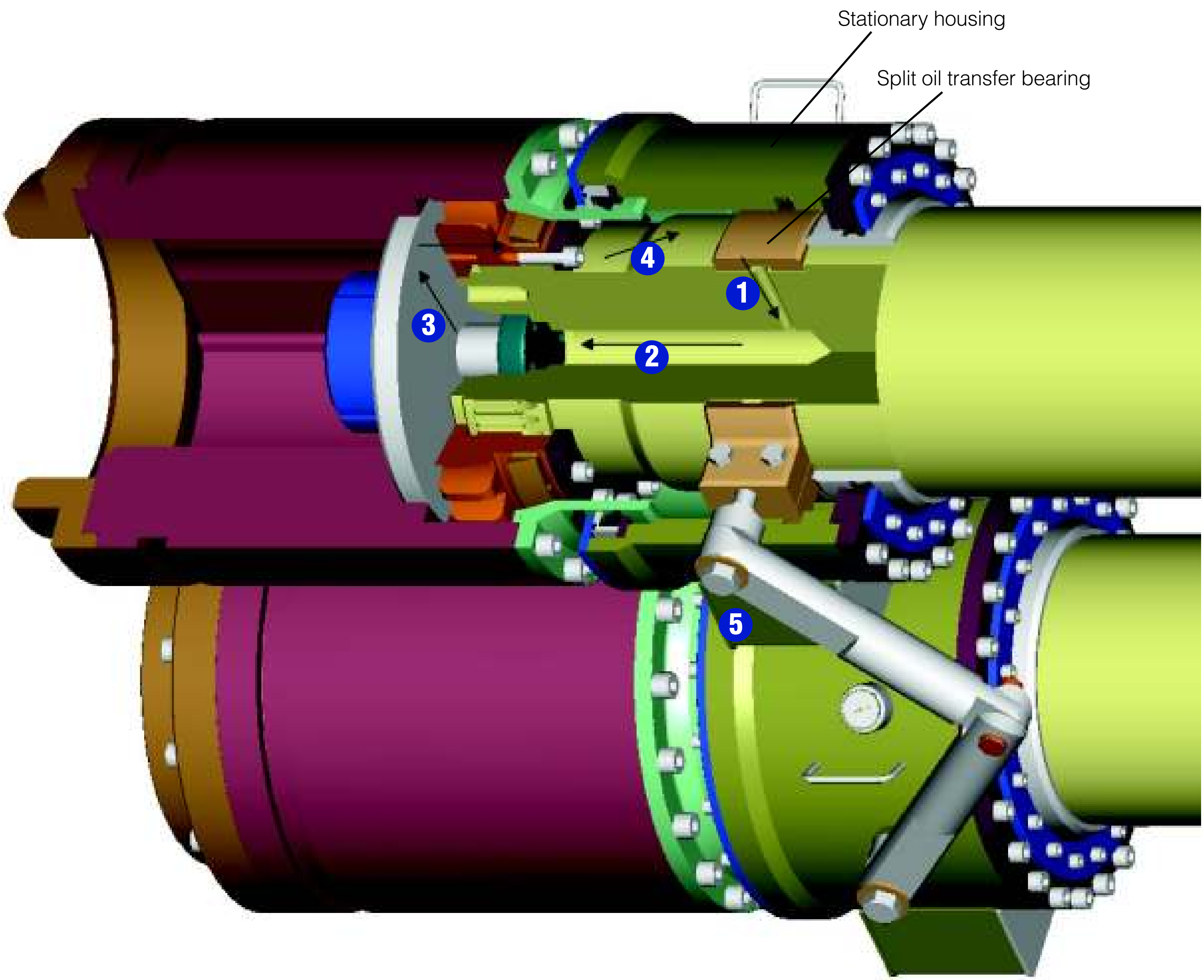
In order to address the inadequacies of grease lubrication, Renold has developed an oil lubricated spindle design for use in all types of mills including Hot Strip Roughing and Finishing applications.

All types of spindles create heat through sliding contact under heavy compressive stress at the tooth flanks of the contacting teeth. Conventional grease lubricated spindles rely on this heat to be emitted from the OD of the spindle. If the heat generation rate exceeds the rate at which the heat can be emitted, then the temperature will rise to unsafe levels. Lubrication breakdown, galling and eventual destruction of the gear mesh will result.



1. Split Oil Transfer Bearing
2. Stationary Housing
3. Rotational Restraint for Non-Rotational Components
4. Oil Return
5. Oil Supply
6. Sump Extension Off Housing
7. Rotating Shaft

Continuous Circulating Oil Lubrication Continued



The Renold Continuous Circulating Oil Lubrication System provides a vehicle to remove this destructive heat. Oil is pumped onto the rotating spindle components through a transfer bearing, where it passes

1. radially inward,
2. through the center of the shaft,
3. radially outward around the end of the shaft, then across the teeth where it picks up the heat that is generated at the gear mesh.
4. It then flows out of the rotating components into the stationary housing,
5. and finally drains back to sump. The oil is then cooled and filtered before being returned to the spindle.

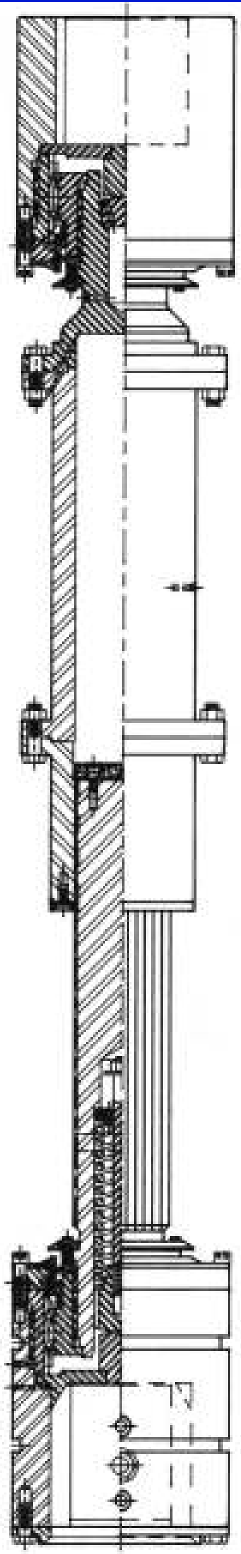
This process also flushes away any wear debris that occurs at the tooth flanks, instead of allowing it to remain at the gear mesh to act as lapping compound, as is the case with grease lubrication.

This Oil Lubrication System has been proven to:

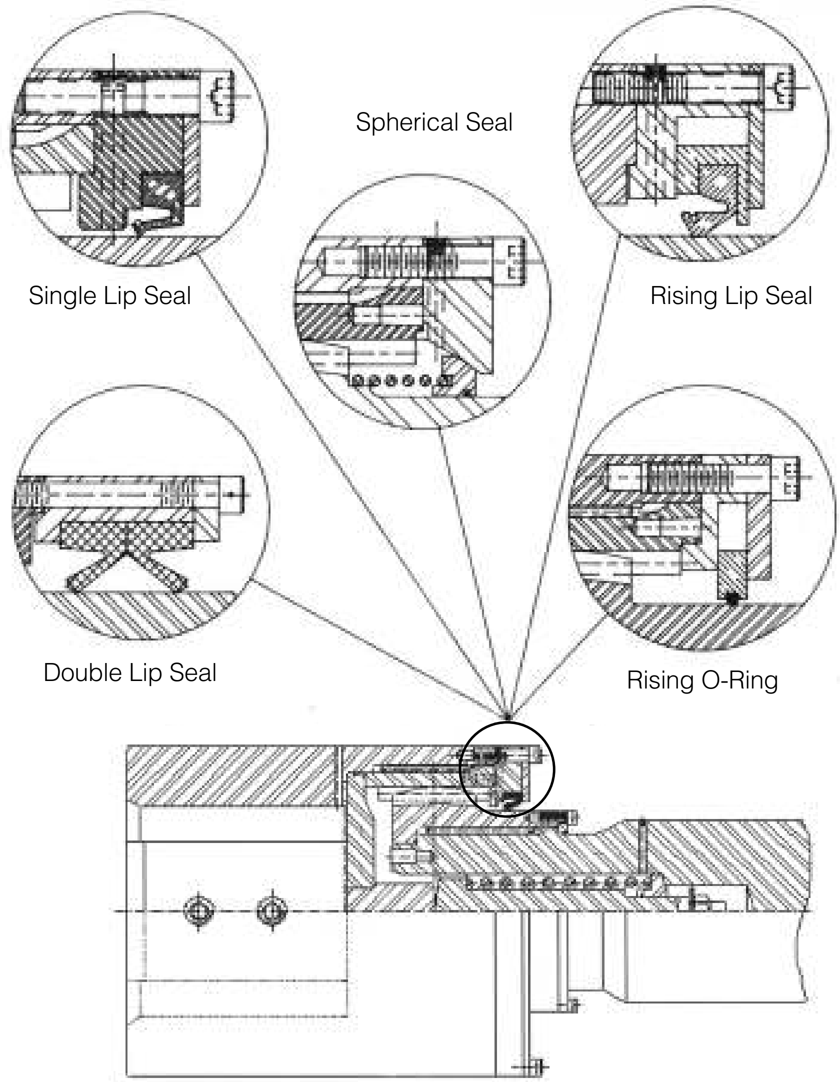
- Dramatically extend wear life of the spindle gearing
- Eliminate the need for weekly greasing
- Improve cleanliness behind the mill
- Reduce contamination of the rolling fluid system
- Reduce operating expense
- Reduce mill downtime

Spindle Designs and Features

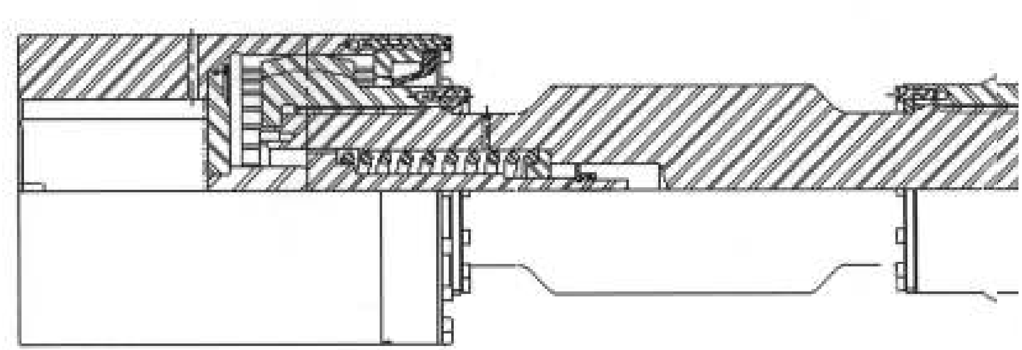
These examples show some of the features of Renold Ajax Spindles that are currently in operation.



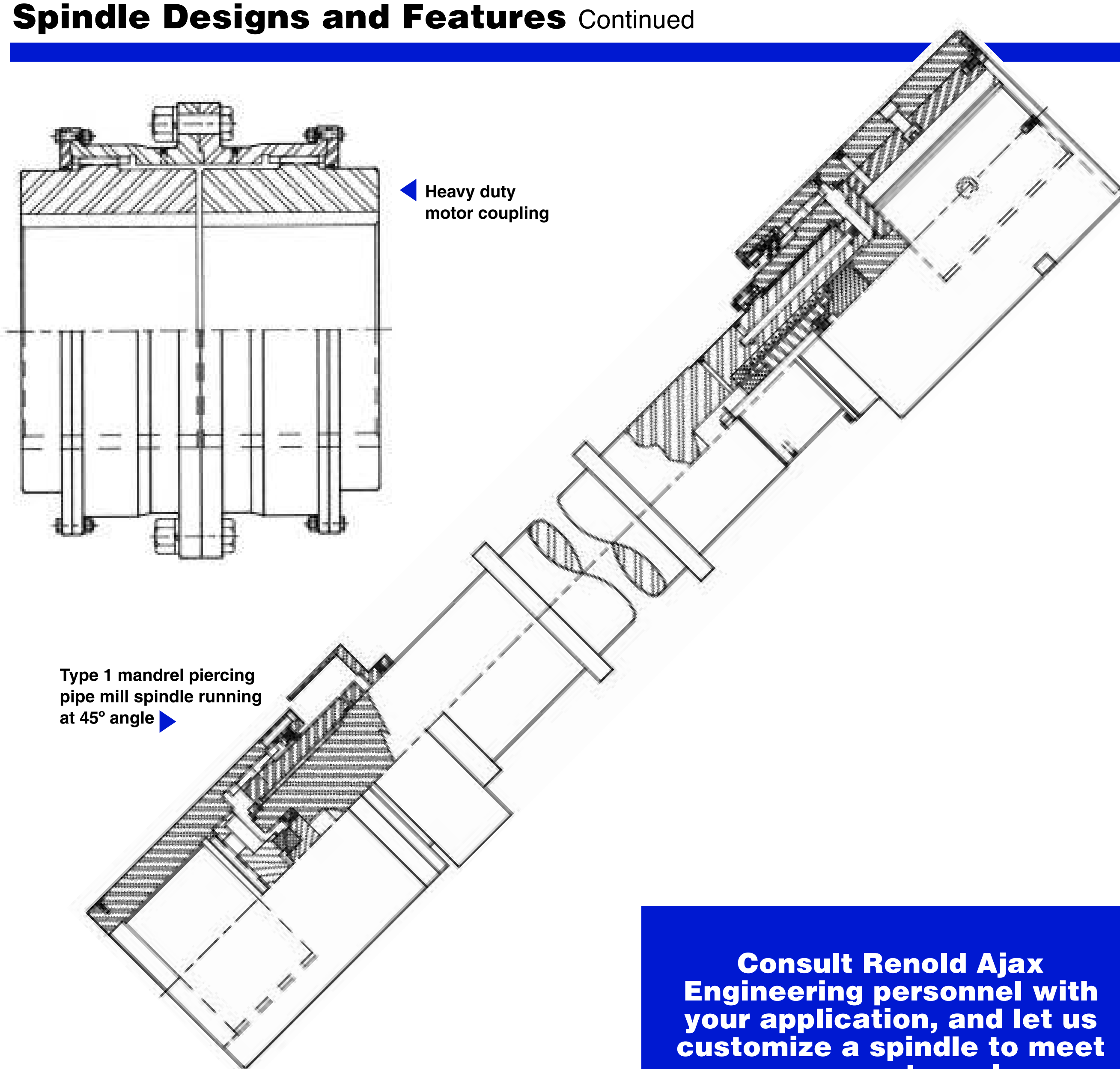
Vertical Type 3 telescopic spindle for top driven bar mill



Various Seal Options available on Renold Ajax Spindles



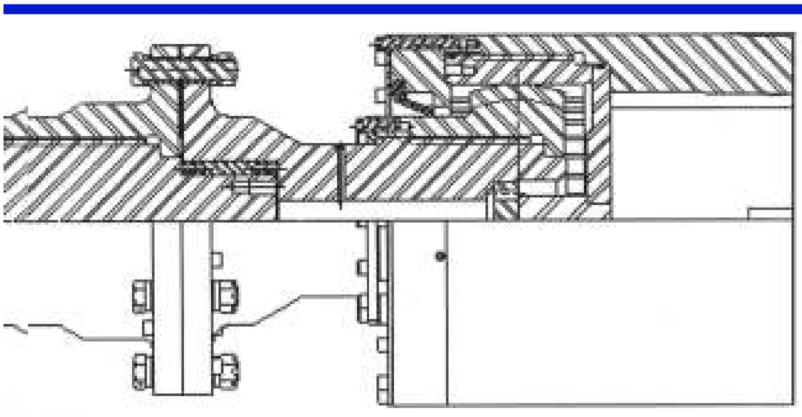
Spindle Designs and Features Continued



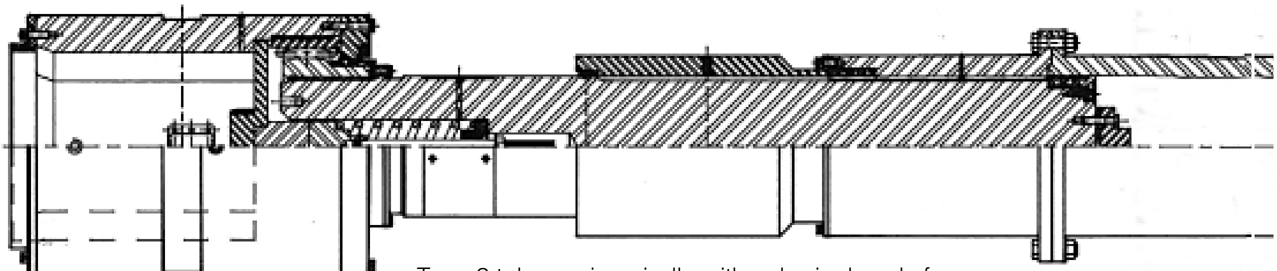
◀ **Heavy duty motor coupling**

Type 1 mandrel piercing pipe mill spindle running at 45° angle ▶

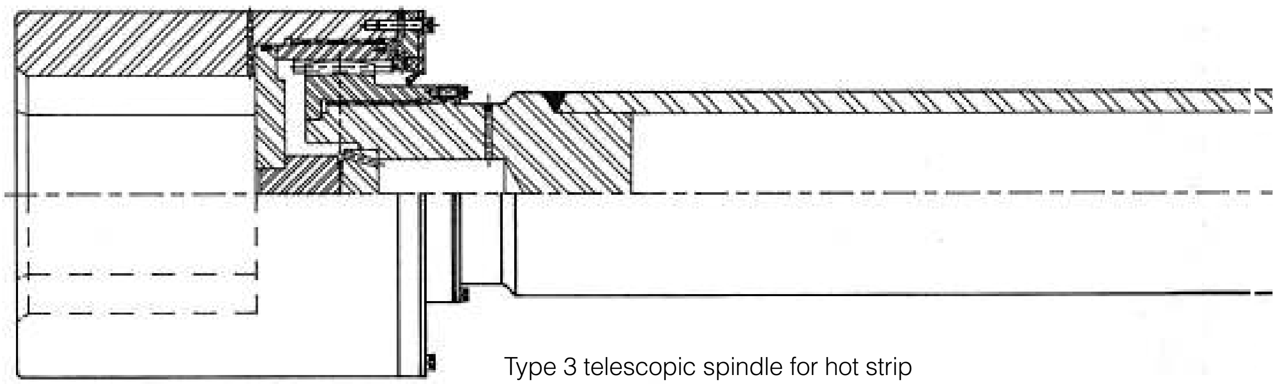
Consult Renold Ajax Engineering personnel with your application, and let us customize a spindle to meet your exact needs.



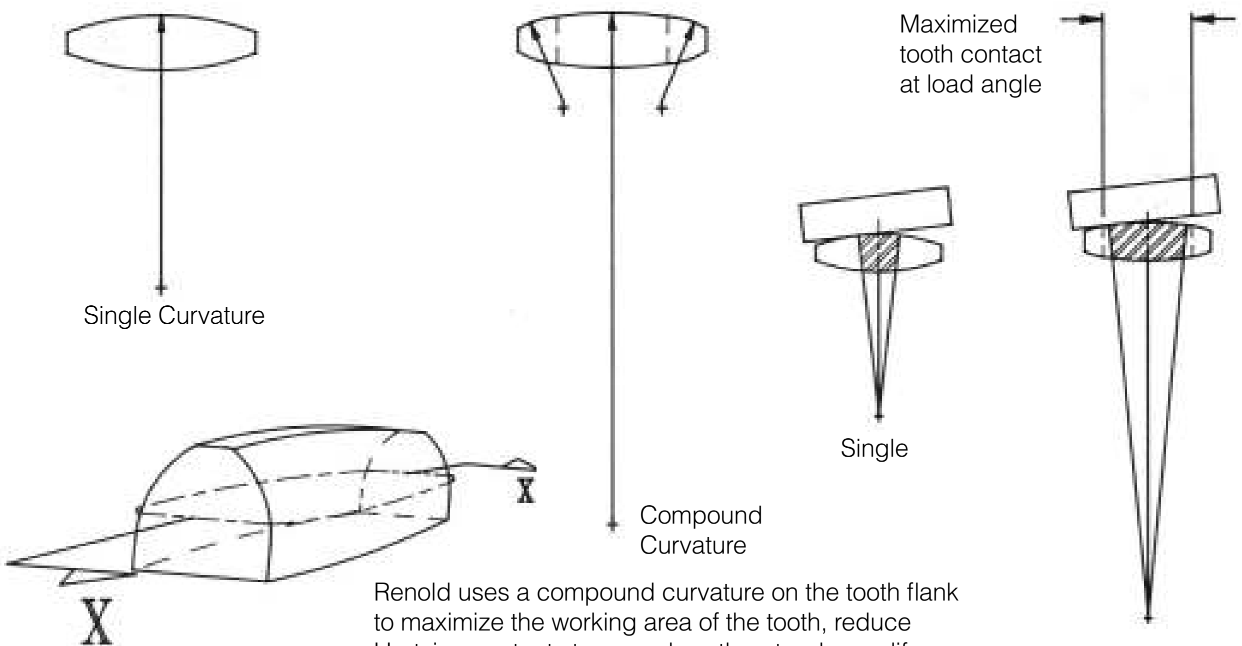
Type 3 hot strip reversing rougher spindle with overload release arrangement



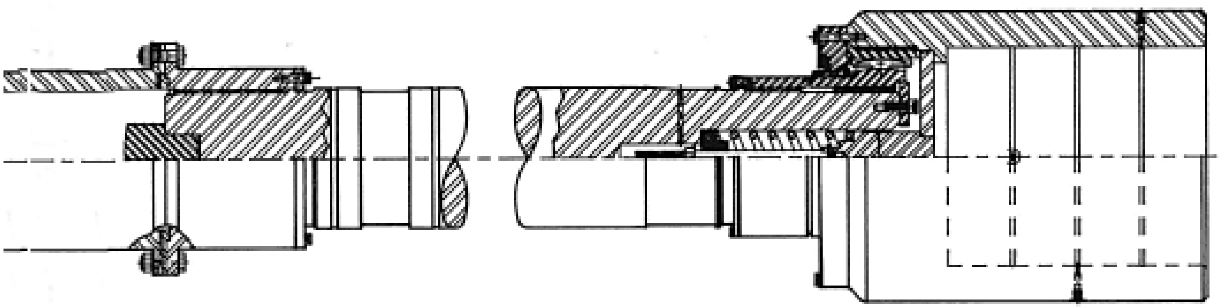
Type 3 telescopic spindle with spherical seals for single stand reversing (Steckel) mill with roll shifting

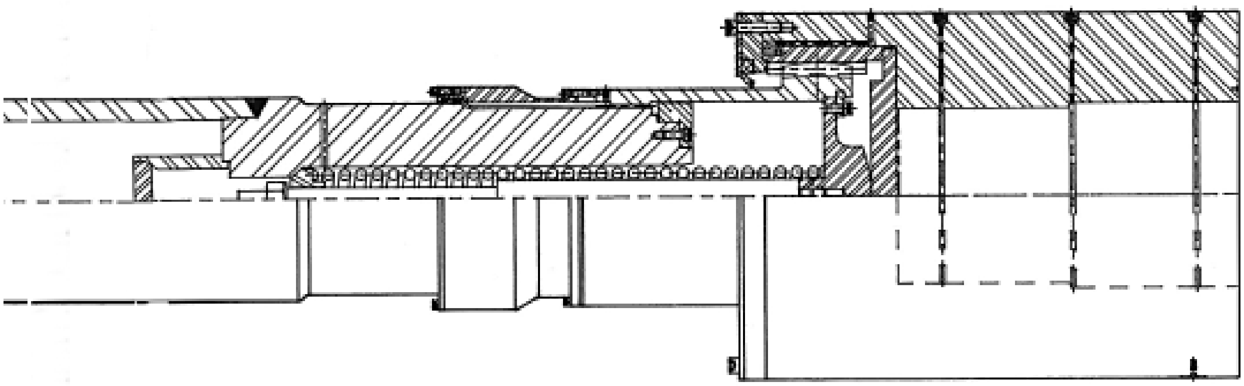


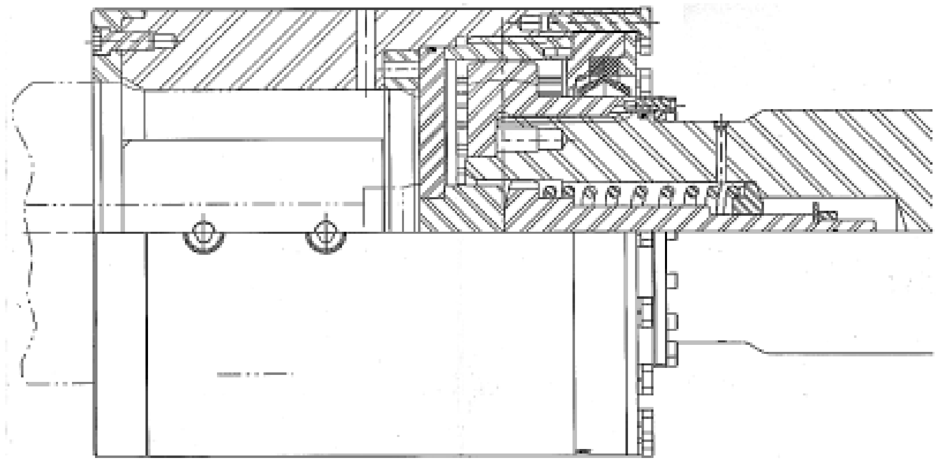
Type 3 telescopic spindle for hot strip finishing stands with roll shifting



Renold uses a compound curvature on the tooth flank to maximize the working area of the tooth, reduce Hertzian contact stress and vastly extend wear life.







Renold also uses a piloting system to reduce the action in the roll end bore without interfering with the roll change process. This system helps to reduce bore wear, reduce vibration and chatter, and improve product quality from the mill.

Materials and Heat Treatment

In selecting gear spindle material, mill operating conditions, desired spindle service life and cost must be taken into consideration.

Early gear spindles were made of medium carbon steel (AISI 1045), normalized and induction hardened for surface wear. This material and heat treatment is still used today, but the search for better performance and wear life has lead manufacturers to use a variety of other materials and treatments.

Contour Hardened Alloy Steel provides a medium-depth case with tolerable distortion but quality assurance is difficult without destructive testing. To prevent cracking due to thermal stresses, a tempering operation is required. Also, instantaneous heat generation at the gear mesh can reach 700° F. The lower tempering temperature of 450° F can lead to soft spots and rapid wear.

Carburizing provides a deep, hard case for greater wear life, but the distortion caused by carburizing can upset tooth spacing and reduce the number of load carrying teeth. Correcting distortion by lapping or grinding decreases the case depth. As with induction hardening 4140, carburizing's low tempering temperature of 350° F to 400° F can lead to soft spots and rapid wear.

Nitrided Alloy Steel was developed by the U.S. Navy for critical applications. Nitriding provides a refined core, hard case, high temperature operation (800° - 900°F) and minimum distortion. Under poor lubrication conditions, the shallow case associated with nitriding limits wear life.

Nitralloy N is a precipitation-hardening material combining the qualities of nitrided steel with an exceptionally strong core and case developed during the final heat treat operation, for performance that exceeds commonly used materials.

Comparative Rating and Service Life Factor

AISI Steel	Heat Treatment	Hardness		Tempering Temp (F°)	Service
		Core (BHN)	Case (Rc EQ)		
AISI 1045	Normalize and induction harden temper	190	52	450° F	Light to medium duty
AISI 4140	Quench temper contour induction harden	300	55	450° F	Medium duty
AISI 4140	Quench and temper nitride	300	50	1050° F	Medium duty
AISI 8620	Carburize quench and temper	280	58	350° F	Medium duty
AISI 4320/4327	Carburize quench and temper	300	58	350° F	Medium to heavy duty
Nitralloy 135/135M	Quench and temper nitride	300	55	1100° F	Medium to heavy duty
AISI 4150	Quench and temper nitride	330	55	1100° F	Medium to heavy duty
AISI 9310/3310	Carburize quench and temper	330	58	400° F	Heavy duty
Nitralloy N	Quench and temper nitride	380	60	1200° F	Heavy duty

Lubrication

Lubrication is Essential

If you are getting short life from your gear spindles, the first thing to check is your lubricant. Proper lubrication is essential to minimize heat generation and assist in heat dissipation when operating in a misaligned condition. Application experience shows that gear spindles almost always fail from overheating. Most commercial lubricants are developed for high-volume applications such as bearings and do not possess sufficient performance characteristics for gear spindle drive applications. Gear spindles require specially compounded lubricants formulated with highly refined base oils that have naturally high viscosity indexes, excellent extreme pressure qualities, water resistance and adhesiveness. To select an appropriate lubricant, check the technical data specifications for the following:

1. The grease should be compounded with a minimum soap base made of select high-quality thickeners, such as aluminum complex for best performance.
2. The grease should, at a minimum, include additives for extreme pressure, rust prevention, adhesiveness, high load carrying capability, boundary lubrication and water resistance.
3. Base oils should possess natural viscosity indexes above 90. The viscosity of the base oils should be no less than 80 SUS and 100^{o} C. The minimum flash point of the base oil should be 475^{o} F. Products containing synthetic base oils should be of the Polyalphaolefin (PAO) synthetic base oil family.
4. The grease should have good low temperature pumping characteristics and should require no more than 1,500 psi applied pressure @ 0^{o}F on the Lincoln ventometer test. The grease should not require heating.
5. Molybdenum disulfide, graphite, PTFE and antimony are excellent additives for extreme pressure and boundary lubrication but will separate out at high rpm. For driven roll speeds over 1,500 rpm, a lubricant void of solids should be used with the exception of Molybdenum Dibutyldithiocarbamate. This is a synthetic form of Molybdenum that is solubilized and will not separate or centrifuge out of lubricants.

If the lubricant you are using does not appear on the spindle manufacturer's recommended list, refer to the previous information for minimum grease performance specifications, or call Renold Ajax. RENOLD AJAX recommends use of the following types of lubricants:

High Speed – above 1,500 RPM

AMOCO ....Coupling Grease
ANDEROL ....Anderol 786
MOBIL .... Mobilgrease XTC
SCHAEFFER.................248R Moly Syngard 2000 EP2
SHELL .... Alvania Grease CG
TEXACO ....Coupling Grease 1912

Medium Speed – between 800 and 1,500 RPM

AMOCO ....Coupling Grease
MOBIL .... Mobilgrease XTC
MOBIL .... Mobilux EP111
SCHAEFFER.................279R Spindle Compound
SHELL .... Alvania Grease CG
TEXACO ....Coupling Grease 1912

Low Speed–Below 800 RPM

AMOCO ....Coupling Grease
MOBIL .... Mobilux EP111
SCHAEFFER.................279R Spindle Compound
SCHAEFFER.................200SR Silver Streak
SHELL .... Alvania Grease CG
TEXACO ....Coupling Grease 1912

Frequency

Gear spindles should be lubricated once a week. Be sure to lubricate both ends of the spindle. When installing or reinstalling the spindle, be sure to also hand-pack the teeth with grease prior to greasing by normal methods to ensure the teeth will not run dry for the first few minutes of operation until the lubricant works its way to the gear mesh. More frequent lubrication may be necessary if excessive rolling fluid or contaminants are present, or if excessive heat generation or ambient temperatures are a problem, If operating temperatures of outer spindle casing exceed 130^{o} F / 55^{o} C, check the following:

- Lube level
- Disengagement of spindle carriers
- Misalignment
- Operating torque

Method

When possible, add lubricant until fresh lubricant appears at the discharge. This purge method keeps lubricant properties at their best and contaminants to a minimum. Also try to grease with the rolls installed. When the rolls are installed, the lubricant cavities in the gear mesh are the same size as in normal operation. With the rolls removed, the lubricant can push the adaptors away from the shaft to the maximum extension position and more lubricant can fit in the cavity than will remain once the rolls are installed. When the rolls are subsequently reinstalled and the adaptors are moved into the normal operating position, the excess grease will be forced out, usually inverting the seal lip in the process.

Preliminary Spindle Coupling Selection Guide

To guide the designer and user in preliminary selection of mill spindle couplings, the following approach is recommended. Final selection is best handled by Renold application engineers.

How to Select

- Compute normal torque.
- Select proper service factor.
- Determine load / no load misalignment factor from Graph A. (The no load angle is critical – hold to minimum.)
- Calculate design torque.
- From Graph B or C, determine spindle diameter.
- Cross check size with nominal bore and envelope limitations.
- Send preliminary selection and required data to Renold for final evaluation and selection.

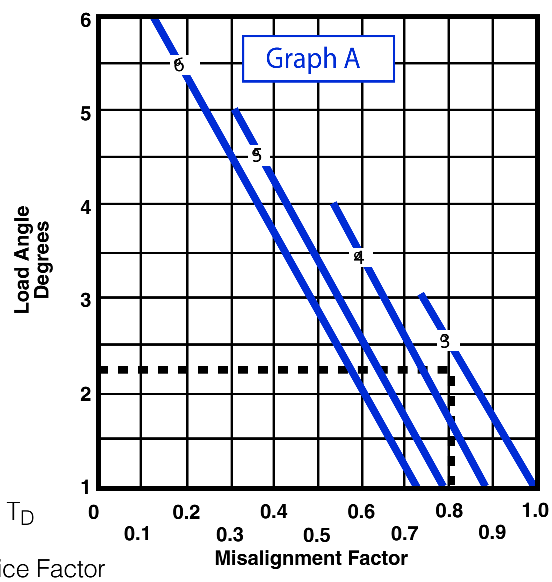
Service Factors

Cold Mills:

One way	=	1.5
Reversing	=	1.75

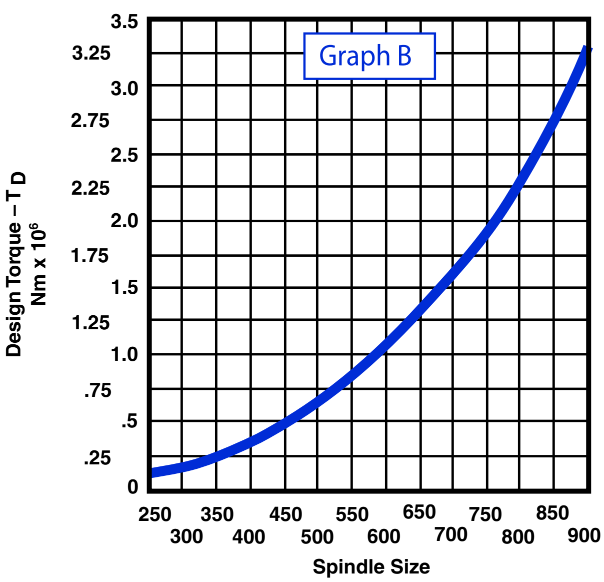
Hot Mills:

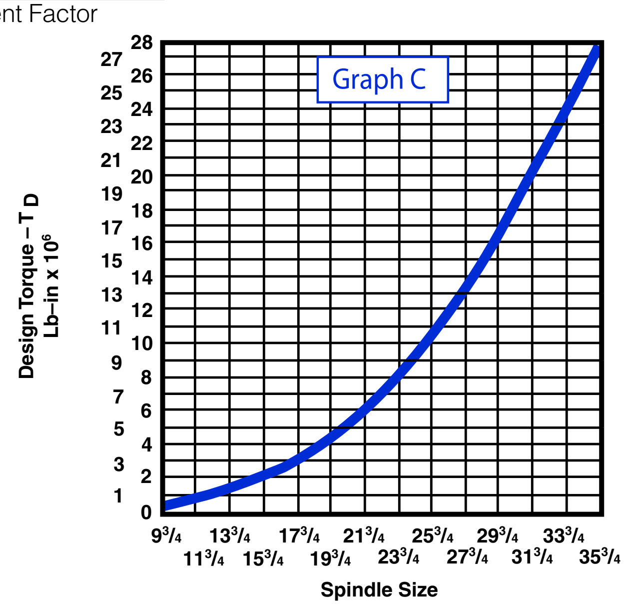
One way	=	2.0
Reversing	=	2.75



To calculate design torque, T_D

$$T_D = \frac{\text{Normal Torque x Service Factor}}{\text{Misalignment Factor}}$$





NOTE: This preliminary selection guide is based on test and experience to operate within the capabilities of the lubricant. Occasionally, applications beyond the scope of this guide may occur. Special alloy materials are used in these applications. Consult Renold Spindle Engineering Department.

Preliminary Spindle Coupling Selection Guide Continued

Name ____________________

Company ____________________

Phone ____________________ Fax ____________________

e-mail ____________________ Date ____________________

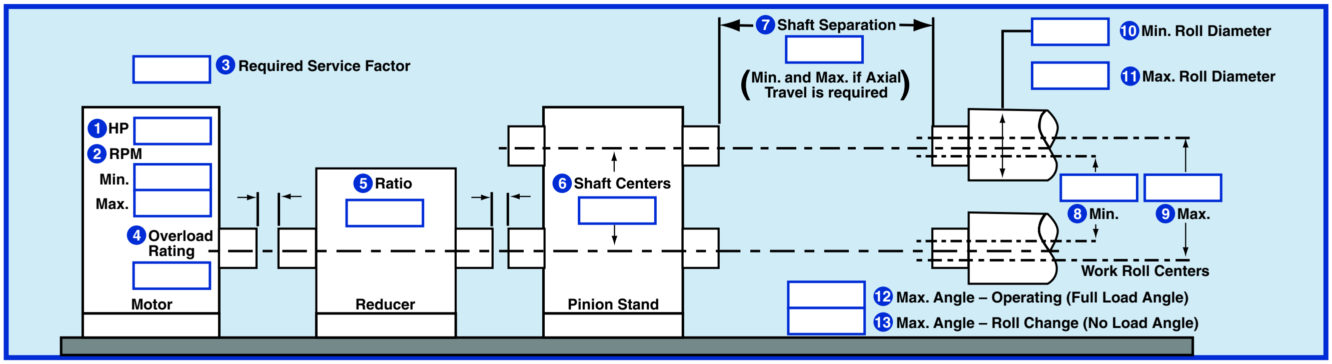
Inquiry Number ____________________

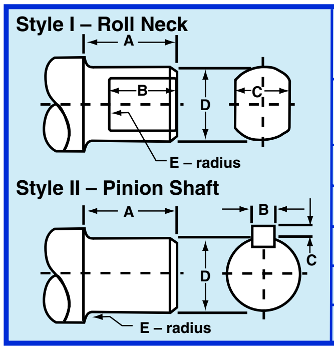
Mill Type ____________________

Number of Stands ____________________

Number of Required Assemblies ____________________

Please provide the following information in the boxes provided:





14 Bore Requirements

Style	Pinion Shaft		Roll Nech	
A	Engagement Length		Engagement Length	
B	Key Width		Flat Length	
C	Key Depth		Across Flats	
D	Shaft Dia.		Neck Dia.	
E	Radius		Radius	

Please note any other mill characteristics such as:

- Method of Roll Change
- Drive Orientation (Vertical or Horizontal, etc.)
- Operating Environment
- Unidirectional or Reversing Drive
- Restrictions on Diameter
- Any Other Pertinent Information

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