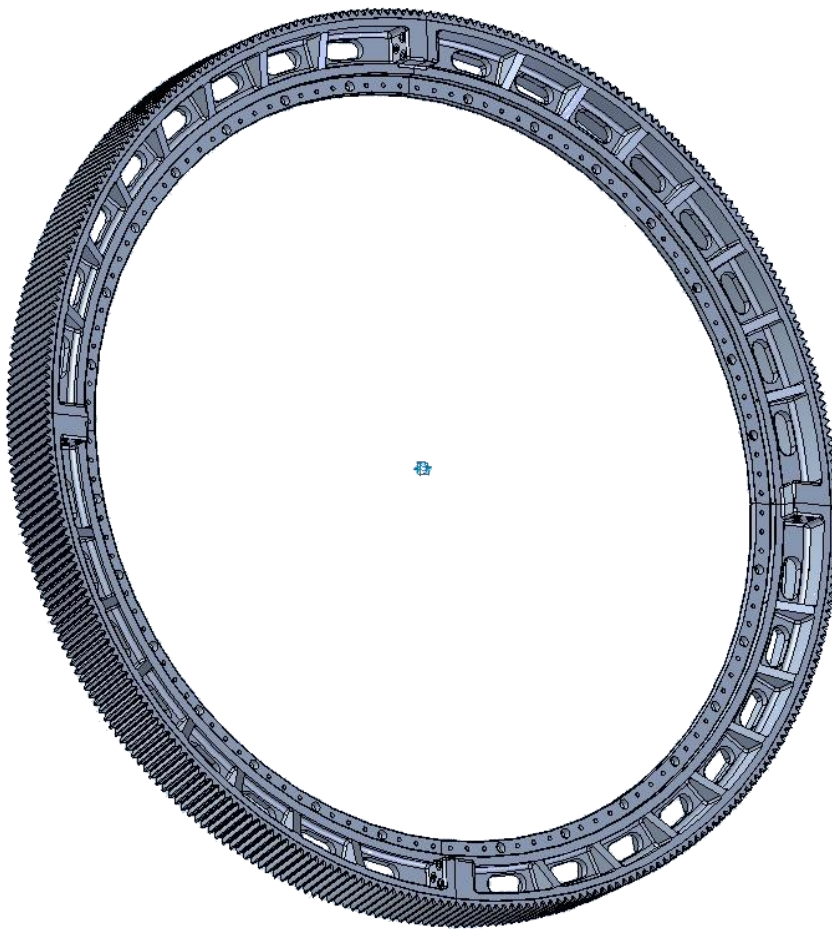


Mill and Kiln Gears



Installation and Maintenance
Manual

Mill and Kiln Gears



Уважаемые партнёры!

Компания **КПД** готова предложить комплектующие к оборудованию самого высокого качества.

Основные наши позиции это:

- **Редукторы и мотор-редукторы David Brown / Benzlers** Швеция – это недоступный ранее на украинском рынке уровень качества, надёжности, уровня технических инноваций и технического совершенства. Представлены редукторы всех компоновок.

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- **Звёздочки для цепей** Sati, Италия

- **Плоские транспортёрные цепи и модульные ленты** Regina

- **Ремни приводные** клиновые, поликлиновые (ручейковые),

вариаторные, круглые, зубчатые специальные, производства компаний **Bando, Япония, Brecoflex, Германия.**

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- **Гидромуфты** и дисковые тормоза Transfluid, Италия.

- **Карданные валы** Elso/Elbe, Германия, широкий диапазон конструкций и размеров, крестовины карданных валов.

- **CTS обгонные муфты** из Италии. Высокое качество изготовления.

Наши специалисты всегда готовы помочь решить проблемы эксплуатации оборудования и предложить надёжные комплектующие.

С уважением,

Павинов Михаил

инженер

ООО «Компания промышленных деталей»

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Mill and Kiln Gears

IMPORTANT

Product Safety Information

General – The following information is important in ensuring safety. It must be brought to the attention of personnel involved in the selection of David Brown Gear Industries(Pty) Limited power transmission equipment, those responsible for the design of the machinery in which it is to be incorporated and those involved in its installation, use and maintenance.

David Brown power transmission equipment will operate safely provided it is selected, installed, used and maintained properly. As with any power transmission equipment **proper precautions** must be taken as indicated in the following paragraphs, to ensure safety.

1. Fire/Explosion
 - a. Oil mists and vapour are generated within gear units. It is therefore dangerous to use naked light in the proximity of gearbox openings, due to the risk of fire or explosion.
 - b. In the event of fire or serious overheating (over 300°C), certain materials (rubber, plastics, etc) may decompose and produce fumes. Care should be taken to avoid exposure to the fumes, and the remains of burned or overheated plastic/ rubber materials should be handled with rubber gloves.
2. Guards- Rotating shafts and couplings must be guarded to eliminate the possibility of physical contact or entanglement of clothing. It should be of rigid construction and firmly secured.
3. Noise- High speed gearboxes and gearbox driven machinery may produce noise levels which are damaging to the hearing with prolonged exposure. Ear defenses should be provided in these circumstances.
4. Lifting- Where provided, only the lifting points or eyebolts should be used for lifting operations (see Maintenance and Installation manuals or general arrangement drawings for lifting positions). Failure to use the lifting points provided may result in personal injury and/ or damage to the product or surrounding equipment. **Keep clear of the raised equipment.**
5. Lubricants and Lubrication
 - a. Prolonged contact with lubricants can be detrimental to the skin. The manufacturer's instruction must be followed when handling lubricants.
 - b. The lubrication status of the equipment must be checked before commissioning. Read and carry out all instruction on the lubricant plate and in the installation and maintenance literature. Heed all warning tags. Failure to do so could result in mechanical damage and in extreme cases risk of injury.
6. Electrical Equipment- Observe hazard warnings on electrical equipment and isolate power before working on the gearbox or associated equipment, in order to prevent the machinery being started.
7. Installation, Maintenance and Storage
 - a. In the event that the equipment is to be held in storage, for a period exceeding six (6) months, prior to installation or commissioning, David Brown Gear Industries (Pty) Limited must be consulted regarding special preservative requirements. Unless otherwise agreed, equipment must be stored in a building protected from extremes of temperature and humidity to prevent deterioration.
 - b. External gearbox components may be supplied with preservative materials applied, in the form of a "waxed" tape overwrap or wax film preservative. Gloves should be worn when removing these materials. The former can be removed manually, the latter using white spirit as a solvent.
 - c. Installation must be performed in accordance with the manufacturer's instructions and be undertaken by suitably qualified personnel.
 - d. Before working on a gearbox or associated equipment, ensure that the load has been removed from the system to eliminate the possibility of any movement of the machinery and isolate power supply. Where necessary, provide mechanical means to ensure the machinery cannot move or rotate. Ensure removal of such devices after work is complete.
 - e. Ensure the proper maintenance of gearboxes in operation. Use only the correct tools and David Brown Gear Industries (Pty) Limited approved spares for repair and maintenance. Consult the Maintenance manual before dismantling or performing maintenance work.
8. Hot Surfaces and Lubricants
 - a. During operation, gear units may become sufficiently hot to cause skin burns. Care must be taken to avoid accidental contact.
 - b. After extended running the lubricant in gear units and lubrication system may reach temperatures sufficient to cause burns. Allow equipment to cool before servicing or performing adjustments.
9. Selection and Design
 - a. Where gear units provide holdback facility, ensure that back-up systems are provided if failure of the holdback device would endanger personnel or result in damage.
 - b. The driving and driven equipment must be correctly selected to ensure that the complete machinery installation will perform satisfactorily, avoiding system critical speeds, system torsional vibration, etc.
 - c. The equipment must not be operated in an environment or at speeds, powers, torques or with any external loads beyond those for which it was designed.
 - d. As improvements in design are being made continually the contents of this catalogue are not to be regarded as binding in detail, and drawings and capacities are subject to alterations without notice.

The above guidance is based on the current state of knowledge and our best assessment of the potential hazards in the operation of the gear units.

Any further information or clarification required may be obtained by telephoning or writing to:

DAVID BROWN GEAR INDUSTRIES (PTY) LIMITED
P.O. BOX 540, BENONI, 1500 GAUTENG
TEL : (011) 748 0000

Mill and Kiln Gears

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Mill and Kiln Gears

INTRODUCTION

David Brown mill and kiln gears are manufactured to the highest standards in design, materials and workmanship. Quality and accuracy are carefully monitored during production and the purpose of this publication is to offer guidance on installation, commissioning and operation so as to ensure reliability in service and also to achieve the full designed gear life.

The importance of adhering to correct procedures cannot be emphasized too highly. Failure to do so may lead to a rapid deterioration in gear condition, with a corresponding reduction in life, and possibly a sudden and total breakdown due to tooth fracture.

This publication deals with mill and kiln gears made in several segments, which are assembled together on site on the driven equipment. A ring gear may be fastened in one of several ways depending on the application, e.g. flange mounting, tangent plate mounting or mounting on stools or chairs or packings of various kinds. Whichever method is employed the basic installation objectives are the same i.e.

1. The ring gear must be assembled with its joints correctly aligned and tightened, and adjusted so that the tooth pitch cylinder runs concentric with the axis of rotation.
2. The pinion or pinions must be set relative to the ring gear so that the backlash is correct under normal operating conditions and the tooth contact marking is satisfactory.
3. Gear teeth must receive an adequate supply of lubricant of the correct type and must be suitably guarded to prevent the ingress of debris and contaminants.
4. It is assumed that foundations, bearings supports and the structure on which the gear is mounted will have been designed so that over the range of operating conditions, satisfactory tooth contact markings will be maintained.

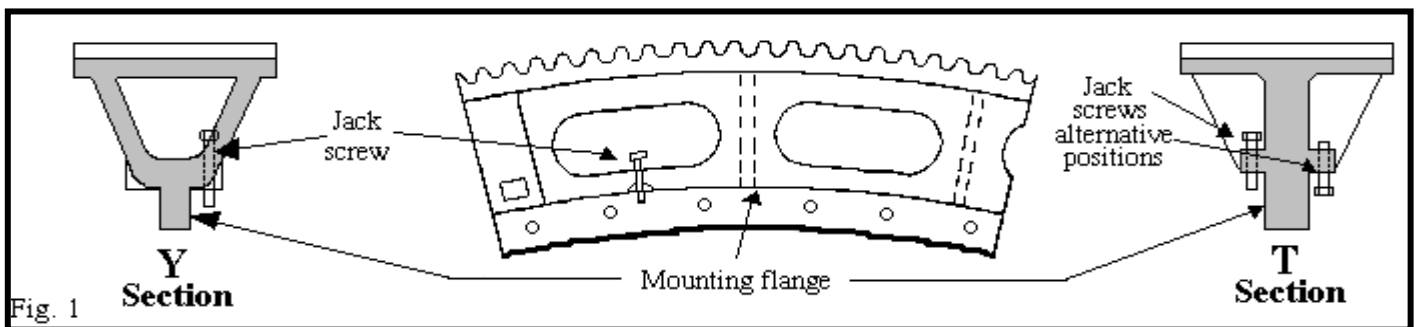
This manual needs to be available for use during installation of the girth gearing supplied. It will need reference to and support from information contained in the Inspection Records supplied to the customer at the time of dispatch of each gear set.

Mill and Kiln Gears

SOME DESIGN ASPECTS

David Brown ring gears are designed with material, shape and type of construction best suited to the individual application. Structural dimensions are based on advanced analytical design techniques and the tooth ratings conform to the procedures agreed with the customer. Mill and kiln gears are usually rated in accordance with the appropriate AGMA standard, although British or DIN standards may also be used.

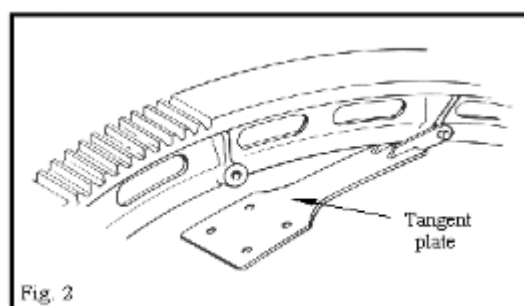
Material quality is carefully monitored during manufacture by ultrasonic, magnetic particle and other methods to ensure freedom from significant defects. Chemical composition and mechanical properties are normally certificated, copies of which are made available to customers.



Ring gears generally have either a 'Y' or 'T' sectional shape, which is usually symmetrical about a radial line through the center of the face width, see Fig. 1. When of symmetrical design the gear may be mounted either way round which, with unidirectional drives, allows the gear to be turned round should the original working tooth flanks become worn or damaged.

The method of mounting depends on the application. Grinding mills usually have a machined flange onto which the gear flange is bolted. To assist in setting the radial position during installation the gear is fitted with jacking screws as shown in Fig. 1.

With kilns and other plant in which significant changes in operating temperatures are experienced, it is desirable to isolate the gear from the effects of thermal expansion. This may be achieved by mounting the gear on tangent plates as shown in Fig. 2.



Drive gears and support path rings commonly used on sugar diffusers are designed with the sectional shape shown in Fig. 3 and are supported on the outside of the diffuser shell on taper wedges.

The joints of ring gears are designed with maximum strength and stability, incorporating clearance bolts for holding the segments together. Location dowels or keys are provided to achieve correct alignment during assembly. Depending on the application and gear proportions, one of two alternative styles of joint design is generally used, see Fig. 4. Joint Type "A", which is used most frequently, has the faces which bolt together machined in a plane parallel with the gear axis. With helical gears,

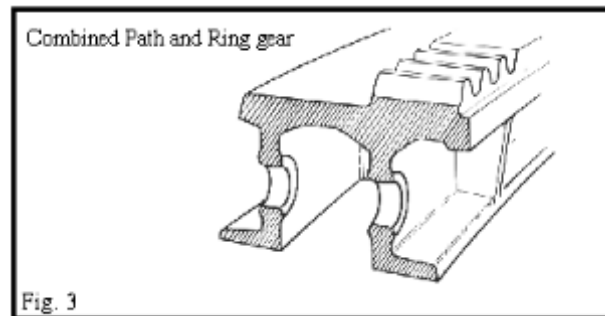
Mill and Kiln Gears

the rim section is inclined at the tooth helix angle. Joint faces on the gear rim below the tooth root are not a close fit and alignment of each joint is effected by an axial dowel.

With joint Type "B", the full joint face is inclined at the tooth helix angle and each joint location is effected by the locating assemblies as shown, where a tapered pin is drawn into a taper bore split sleeve.

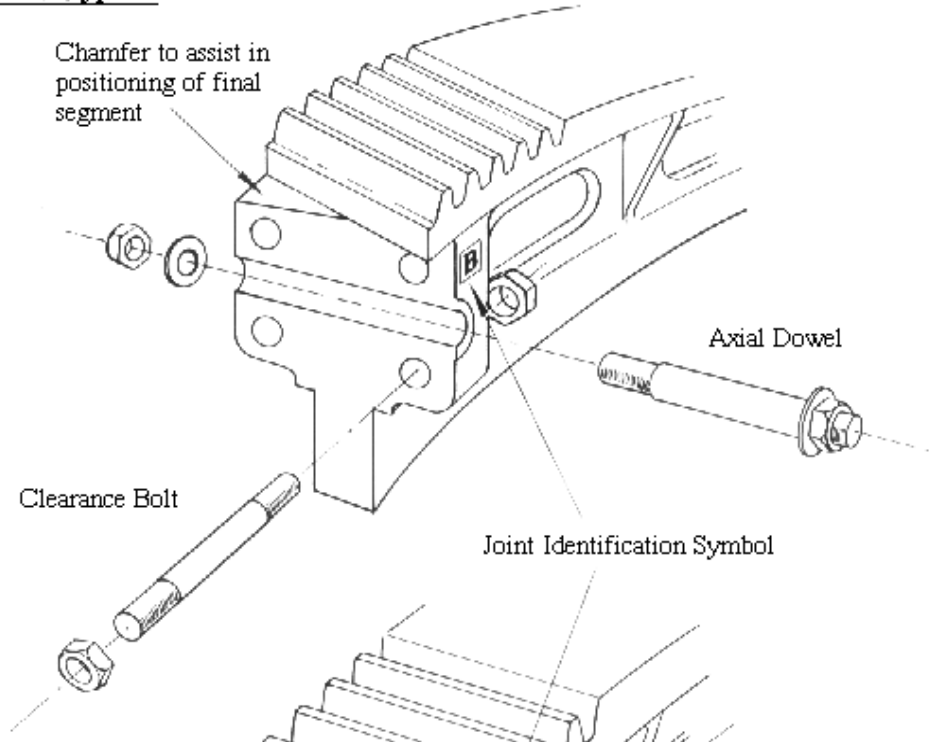
Relief is included at joints in areas remote from the tightening and location bolts.

During manufacture gear segments are stamped to identify the mating joints and the joint location dowels and holes are match-marked.



Equally spaced measuring stations, are stamped around one face of the gear rim. These are reference positions at which runout readings are taken in the factory and on site. Runout measurements should be made on the stamped face.

Joint type A



Joint type B

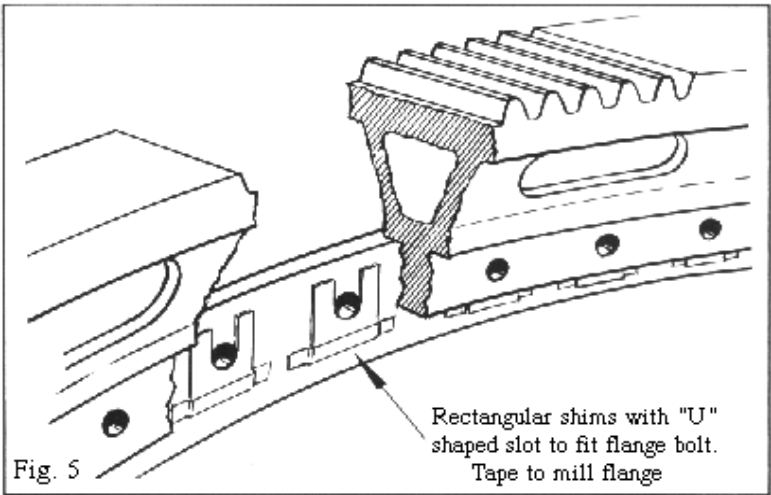
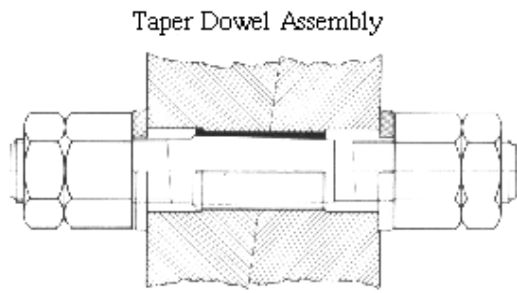
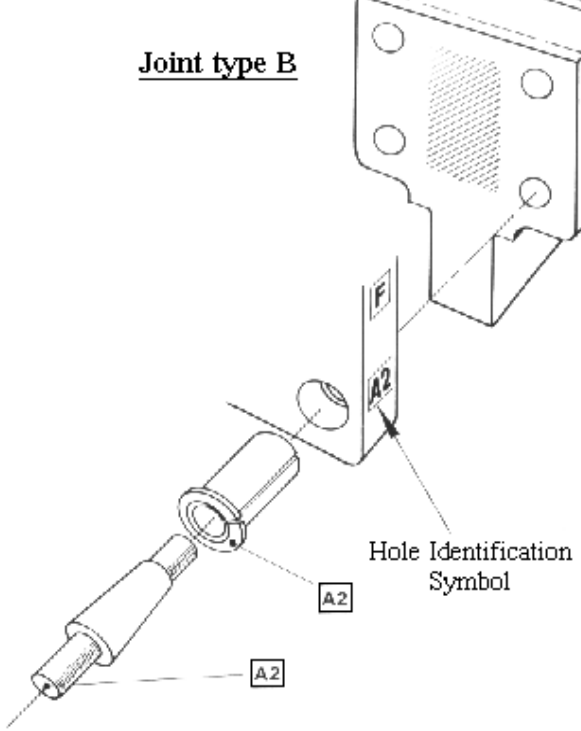


Fig. 4

Fig. 5

INSTALLATION OF FLANGE MOUNTED GEARS

1. If several similar ring gears are on site awaiting installation, identify the correct segments for each set. Note each segment identification and joint match marks, see Fig. 4.
2. Thoroughly clean the protective compound from machined surfaces. Inspect carefully the mounting flange faces, joint faces and edges of bolt holes for signs of bruising, and dress as necessary. Similarly, inspect and dress the mill flange.
3. Measure the runout of the mill flange face onto which the gear is to be mounted, using a method described in pages 9 to 12 inclusive. Take readings at the stations stamped on the mill or, if the mill is not stamped, at the same number of equally spaced stations corresponding to those stamped on the gear. Record the position of the stamped stations relative to a known point on the mill.
4. Compare the mill flange outside diameter (from mill manufacturer) with the gear counter bore diameter (from David Brown inspection records) and calculate the distance that the jack screws should project radially inwards to hold the gear segments at the correct radial position. Set the jack screws accordingly.
5. Decide on erection procedure. Either assemble the ring gear in segments in halves and then erect the halves on the mill or, if this is not practical due to weight, size, headroom, etc., segments will require to be mounted individually on the mill flange. NOTE : With type "A" joint, a chamfer is included on the male portion of the flat face on at least one segment. This will enable the last segment to be inserted easily with all others already in position on the mill flange. Chock the mill position to accept the first gear segment. Refer to the mill manufacturer for a suitable chocking method taking into account the extreme 'out of balance' which will exist with only part of the gear mounted. Segments are preferably mounted at the 12 o'clock position if crane heights permits.
6. Taking care to protect the gear teeth from damage from wire ropes, chains, etc. lift the segment into place and lower onto the jack screws. Adjust the segment position circumferentially to obtain alignment of the mounting flange holes. Fit all the flange bolts and impact tighten alternate bolts at this stage.
7. Un-chock and rotate the mill and re-chock in position prior to mounting the second segment. Lift the segment into place and fasten lightly the flange bolts. Proceed to complete the joint after referring to the section on bolt tightening techniques described on page 8.

a) Type "A" joints

From the stamped marks, identify the location dowel corresponding to the hole, and insert it prior to closing the joint. The segments will then align as they are drawn together by the clearance bolts. Tighten the nuts at each end of the location dowel to attain correct axial positioning of the segments. The joint should be flush to within 0.003 in. (0.075 mm) on the rim face. Fit all clearance bolts and tension as described on page 8. Alternatively it is permissible, if preferred, to impact-tighten only at this stage and to tension fully after the complete ring has been assembled.

b) Type "B" joints

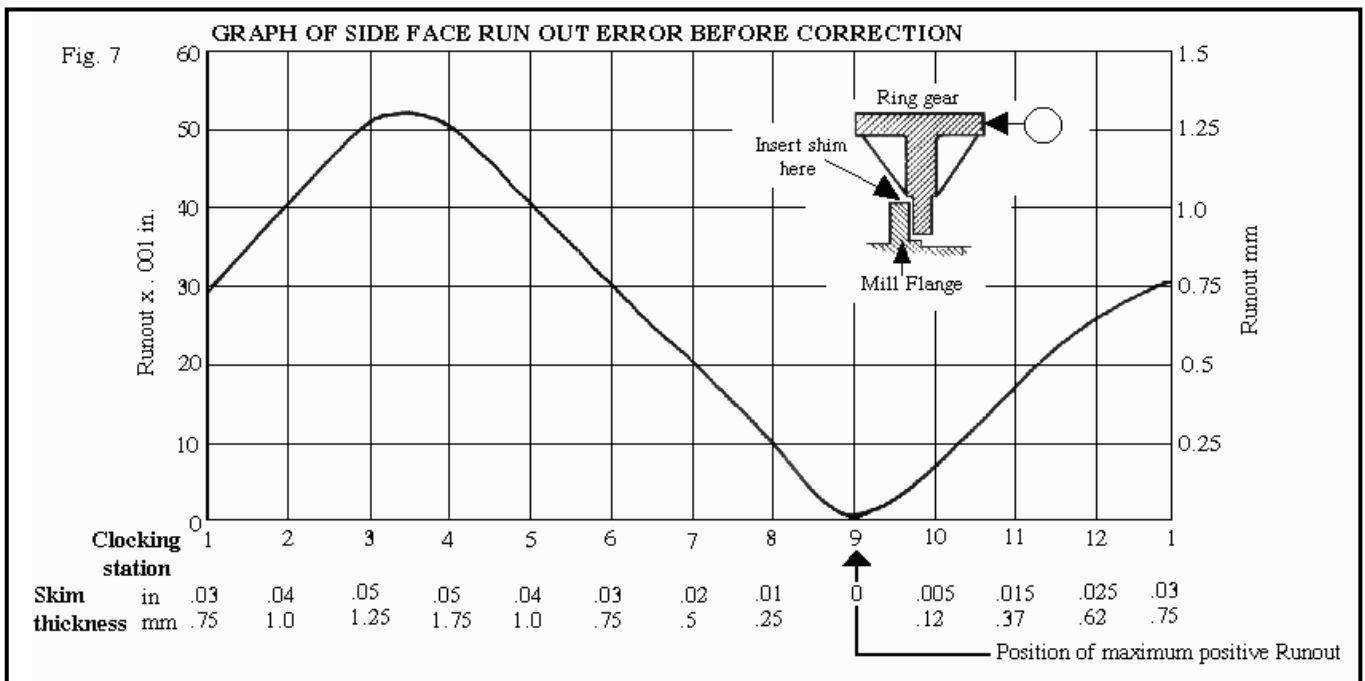
Draw the segments together with the clearance bolts until the faces are touching. Checking that the location holes in each half of the joint are in alignment and if necessary, manipulate the segment positions until they are aligned. From the stamped marks, identify the correct taper sleeve, coat with anti-scuffing paste and insert the sleeve into the hole from the stamped end. Tap into place until it fits against the location shoulder. Insert the taper dowel and drive it firmly into the sleeve. Fit the washer and nut on the small end of each taper dowel and tighten each alternately in stages to achieve correct alignment of the segments. The joint line in the tooth root between segments should not vary by more than 0.0015 in. per foot (0.13 mm per meter) across the face-width. Tighten the location dowels and clearance bolts as described on page 8. Alternatively it is permissible, if preferred, to impact-tighten only at this stage and to fully tension after the complete ring has been assembled.

8. Repeat operations 6 and 7 until all segments are assembled. When mounting the last segment it may be necessary to slacken off the flange bolts on the first and last but one segments fitted and jack out these two segments slightly to enlarge the space and permit the insertion of the final segment. When the last joint is being closed, and the bolts tensioned, it is important to back off the jack screws to permit the joints to close without imposing abnormal stresses on the gear structure.
9. When all joints have been fully tightened the mounting flange bolts must be impact-tightened and the jack screws brought back onto the mill flange periphery in readiness for checking gear runout.
10. Radial and side face runouts should now be assessed as described on pages 9 to 12 inclusive. Radial runout should be checked first and corrected if necessary prior to correcting for side face runout.
11. Radial adjustment of small gears can be effected using jack screws bearing in mind that, in order to jack radially outwards at one position, the jack screws must be backed off elsewhere to permit inward movement. The mounting flange bolts must be loosened in those sectors where movement is required.

Mill and Kiln Gears

Method of mounting	Max. radial runout Total indicator reading	Max. side face runout Total indicator reading
Flange	0.001 in/ft, 0.08 mm/m of gear diameter	0.0006 in/ft, 0.05 mm/m of gear diameter
Tangent plate or other	0.002 in/ft, 0.16 mm/m of gear diameter	0.0015 in/ft, 0.13 mm/m of gear diameter
Differential radial runout across face width of Flange Mounted Gears		0.002 in/ft, 0.16 mm/m of gear face width

Fig. 6



A large gear will be difficult to move against its own weight, and may result in damage to the jack screws. Having examined the radial runout pattern to determine the position of greatest positive runout, the mill should first be rotated so that the mounting flange bolts, positioned at 180° to the greatest positive runout, can be slackened. The mill should then be turned so that the position of greatest positive runout is at the 12 o'clock position, and the jacking screws backed off by the amount of correction required. The remainder of the mounting flange bolts should now be slackened, allowing the ring to settle on to the jack screw under its own weight. The jack screws can be used to move out the gear at the 9 o'clock or 3 o'clock sectors as required. Before rechecking the radial runout, each jacking screw should be brought on to the mill flange and the mounting flange bolts impact tightened. If necessary repeat this procedure until the radial runout is within the permitted tolerances given in Fig. 6

12. If the total side face runout (algebraic difference between the highest and lowest indicator readings) exceeds the figure shown in Fig. 6 it may be corrected by inserting shims between the gear and mill mounting flange. By plotting the runout as shown in Fig. 7 the shim thickness at each stamped station can be deduced relative to the low point. Shim thickness for intermediate positions may be obtained by linear interpolation. A pack of shims shaped as shown in Fig. 5 should be prepared for fitting under each bolt. The shim may span several bolts in sectors where the required thickness is substantially constant. The geometry of the mill and gear in the mounting flange areas will dictate how the shims are best

Mill and Kiln Gears

inserted and, occasionally, the gear may have to be jacked well away from the mill flange. Shim packs should be taped to the mill flange, as shown, to retain the correct position until the gear is bolted up again.

13. When both radial and axial runouts are correct the flange bolts must be fully torque-tightened and the jack screws backed off from the mill flange.

Setting the pinion

14. The pinion base plates will be installed according to the mill manufacturer's recommendations to achieve correct level and position.
15. Thoroughly clean the seating faces of the base plate and plummer blocks and remove bruises and burrs as necessary. Set the pinion, complete with bearings and plummer blocks, in position on the base plate so that the face width is in line with that of the ring gear and move the pinion hard into engagement with the gear teeth. Using feeler gauges, measure the clearance between one pinion tooth and the two gear flanks it engages at both ends of the face width. From the four readings deduce the amount one bearing must be raised relative to the other to equalize the clearances at each end of the same flank.
16. Withdraw both plummer blocks away from the gear by the same distance until the backlash is approximately correct. Refer to page 13 and 14.
Insert a shim pack under each plummer block of at least 0.05 in (1.25mm) total thickness, together with an additional shim under one plummer block to make the vertical adjustment deduced above. These shims will permit the plummer blocks to be lowered, if necessary, at a later stage to make alignment adjustments. Tighten the plummer block holding down bolts.
17. Finally, proceed to align the pinion as described on pages 15 and 16.

INSTALLATION OF TANGENT PLATE MOUNTED GEARS

1. Tangent plates and the kiln shell will normally be drilled with matching clearance holes to facilitate assembly. Tangent plates must be attached to the gear segments prior to mounting.
2. Note the segment identification and joint match marks. Thoroughly clean the protective compound from machined surfaces. Inspect joint faces and edges of bolt holes with care for signs of bruising, and dress as necessary.
3. Take care, when slinging, to protect the teeth from damage from wire ropes or chains etc. Lift the first segment into place and bolt the tangent plate to the shell.
4. Rotate the shell ready to accept the second segment and chock in position. Refer to the kiln manufacturer for a suitable chocking method taking into account the out of balance which exists with only a section of the gear mounted.
5. Lift the second segment into place and fit loosely the tangent plate shell bolts and proceed as follows to complete the alternative types of joint. Refer to page 8 for bolt tightening techniques.
 - a) **TYPE "A" JOINTS**

From the stamped marks, identify the location dowel corresponding to the hole, and insert it prior to closing the joint. The segments will then align as they are drawn together by the clearance bolts. Tighten the nuts at each end of the location dowel to attain correct axial positioning of the segments. The joint should be flush to within 0.003 inches (0.075 mm) on the rim face. Fit all clearance bolts and tension as described on page 9. Alternatively it is possible, if preferred, to impact-tighten only at this stage and to tension fully after the complete ring has been assembled.
 - b) **TYPE "B" JOINTS**

Draw the segments together with the clearance bolts until the faces are touching. Check that the location holes in each half of the joint are in alignment and, if necessary, manipulate the segment positions until they are aligned. From the stamped marks, identify the correct taper dowel assembly for each hole. Smear the dowel and split sleeve with anti-scuffing paste and insert the sleeve into the hole from the stamped end. Tap into place until it fits against the location shoulder. Insert the taper dowel and drive it firmly into the sleeve. Fit the washer and nut on the small end of each taper dowel and tighten each alternately in stages to achieve correct alignment of the segments. The joint line in the tooth root between segments should not vary by more than 0.0015 inches per foot (0.13 mm per meter) across the face width. Tighten the location dowels and clearance bolts as described on page 8. Alternatively it is permissible, if preferred, to impact-tighten only at this stage and to tension fully after the complete rig has been assembled.

When the joint has been completed, tighten the bolts holding the tangent plates to the kiln.
6. Proceed to mount the remaining segments to complete the ring gears.
7. To facilitate locating the ring gear true on the kiln, tack weld two brackets to the kiln shell at four equally spaced positions around the kiln, see Fig. 8. The jack screws are positioned to seat on two of the turned side faces of the gear rim.
8. With the jacking screws set away from the rim face, check the side face runout using the two-clock method described in pages 10 to 13 inclusive. In addition, internal micrometer readings should be taken between the rim face and a datum point on each bracket.
9. Having deduced the required corrective axial movement of the rim from the runout pattern, use a crane or jacks to support the weight of the gear. Slacken the tangent plate bolts and back-off the jacking screws.
10. Remove the crane or supporting jacks and re-check the internal micrometer readings to confirm that the adjustment made is correct. Re-check the axial runout using the two-clock method. If necessary repeat the adjustment procedure until the runout is within the permitted value shown in Fig. 6.

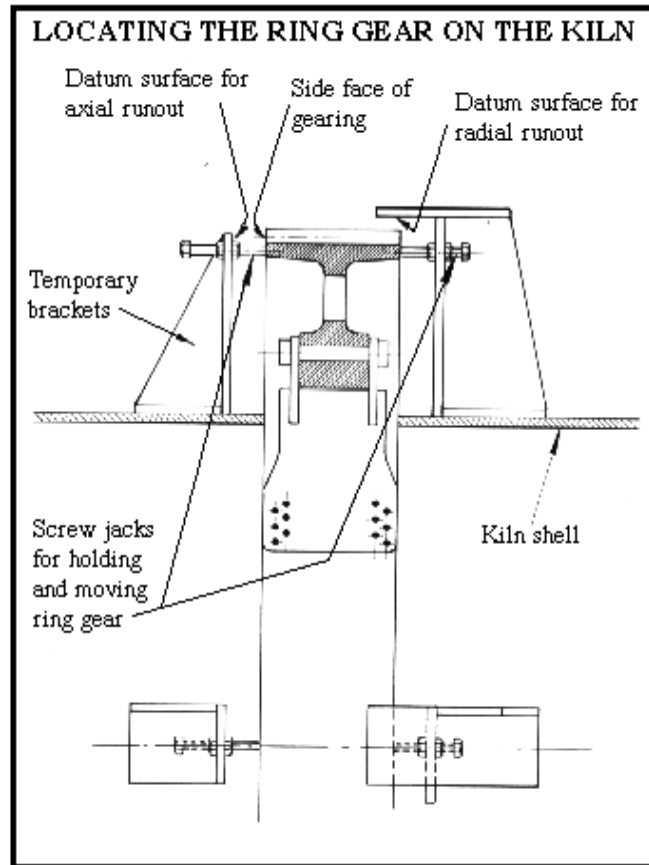


Fig 8

11. When the side face runout is correct set the jacking screws within 0.002 inches (0.05 mm) of each side face. Measure the radial distance between the tooth tips and the overhanging datum surface on each bracket. Rotate the kiln and record the radial runout with a dial indicator on the tooth tips as described on pages 9 to 12 inclusive.
12. Rotate the kiln so that the greatest positive runout is at the 12 o'clock position. Taking the weight of the gear with a crane or jacks, slacken the tangent plate bolts and using the micrometer readings as a reference, lower the ring by the appropriate amount. Re-tighten the tangent plate bolts and remove the crane or supporting jacks.
13. Re-check the radial runout and compare with the permitted tolerance shown in Fig.6. Repeat the adjustment procedure as necessary.
14. When the radial adjustments are complete back-off the jack screws from the rim and re-check both the radial and side face runouts. When both are satisfactory the pinion should be positioned and aligned as described on pages 15 and 16.
15. When satisfactory contact markings have been obtained the tangent plates should be secured finally to the kiln, in accordance with the kiln manufacturer's instructions.

Setting the Pinion

16. The pinion base plates will be installed according to the mill manufacturer's recommendations to achieve correct level and position.
17. Thoroughly clean the seating faces of the base plate and plummer blocks and remove bruises and burrs as necessary. Set the pinion, complete with bearings and plummer blocks, in position on the base plate so that the face width is in line with that of the ring gear and move the pinion hard into engagement with the gear teeth. Using feeler gauges, measure the clearance between one pinion tooth and the two gear flanks it engages at both ends of the face width. From the four readings deduce the amount one bearing must be raised relative to the other to equalize the clearances at each end of the same flank.
18. Withdraw both plummer blocks away from the gear by the same distance until the backlash is approximately correct. Refer to page 13 and 14. Insert a shim pack under each plummer block of at least 0.05 inches (1.25 mm) total thickness, together with an additional shim, under one plummer block to make the vertical adjustment deduced above. These shims will permit the plummer blocks to be lowered, if necessary, at a later stage to make alignment adjustments. Tighten the plummer block holding down bolts.
19. Finally, proceed to align the pinion as described on pages 15 and 16.

BOLT TIGHTENING PROCEDURE

A ring gear must be mounted on the driven equipment so that the pitch cylinder of its teeth is true to the axis of rotation. This is assessed by measuring the radial runout and side face runout of the gear rim. Dial gauges used for runout measurement must be fitted with a large mushroom button.

It is important to ensure that all adjustments on the mill which are likely to cause distortion of the gear mounting flange or alignment of the gear teeth have been completed before final runout and alignment checks are made.

1. RADIAL RUNOUT

Dial gauges are set up to read off the tooth tips or off clocking bands, where appropriate at each end of the gear face width, as shown in Fig. 9. The initial deflection shown on the dial gauge should be as small as possible, consistent with covering the full range of runout. As the gear is rotated slowly, readings are taken at each stamped station, care being taken to read the peak deflection on the dial gauge as it passes over the tooth tip. To confirm consistency the readings must be repeated for at least two revolutions of the gear. If the total indicator reading is greater than the appropriate value shown in Fig. 6, the gear position must be adjusted as described in the sections dealing with the Installation of flange and tangent plate gears.

In addition to showing concentricity, the difference between readings at the same station will indicate rim twist. This should be within the value shown in Fig. 6. These readings are complementary to those for side face runout.

2. SIDE FACE RUNOUT

To assist erection David Brown Gear Industries (Pty) Limited girth gears are manufactured with clocking bands on the outer diameters and side faces of the gear. These clocking bands are machined true to the gear tooth geometry. The measuring methods described in this section relate to runout on any of the faces on the equipment which are required to run in a plane perpendicular to the axis of rotation, e.g. gear rim side face, mill mounting flange, mill thrust faces, etc.

- a. A single dial indicator, positioned at "A" as shown in Fig. 9, not only indicates departures from a true plane but also responds to axial movements of the mill in its bearings. The most reliable method of measuring mill float is to fix a beam across the mill trunnion face and to set a dial indicator "F" on a small ground patch positioned on the axis of rotation. The true runout of the rim face is then "A-F" if the dial indicators read in the same direction as shown, or "A + F" if they read in opposite directions ("A" on opposite rim face). Since mill trunnion bearings usually ovalate slightly, one end of the beam must be allowed some freedom of movement to prevent buckling, resulting in false readings. This can be achieved by slotting the hole and holding the beam against the trunnion face with a spring loaded screw.
- b. A widely used method of assessing face runout is to take simultaneous readings on two dial indicators, one positioned at "A" and the other diametrically opposite at "B" with indicators zeroed at the first station, at other stations the runout is taken as being "A-B"/2.
This method has serious limitations by failing to detect certain runout patterns which are not uncommon, particularly with mills assembled from an even number of segments. This method is therefore not recommended.
- c. If it is not practical to fix a beam across the trunnion face the mill float can be assessed using the two-indicator method, described earlier, on the mill thrust face or on the trunnion face. This should be reasonably true and the mill float "E" is given by " $(C+D)/2$ ".
The gear face runout will then be "A+E" or "A-E", depending on the relative directions of movement of the dial indicators.

If the mill is rotated by tugger winches and wire ropes around the shell, these can influence the attitude adopted by the mill in its bearings and affect the repeatability of the side face runout readings. If this occurs the tugger ropes should be slackened off when the readings are taken.

Fig. 10 can be copied to assist in logging data and plotting radial runout.

Fig. 11 can be copied for logging side face runout obtained by the alternative methods. Fig. 7 shows how the runout is plotted to deduce shim thicknesses.

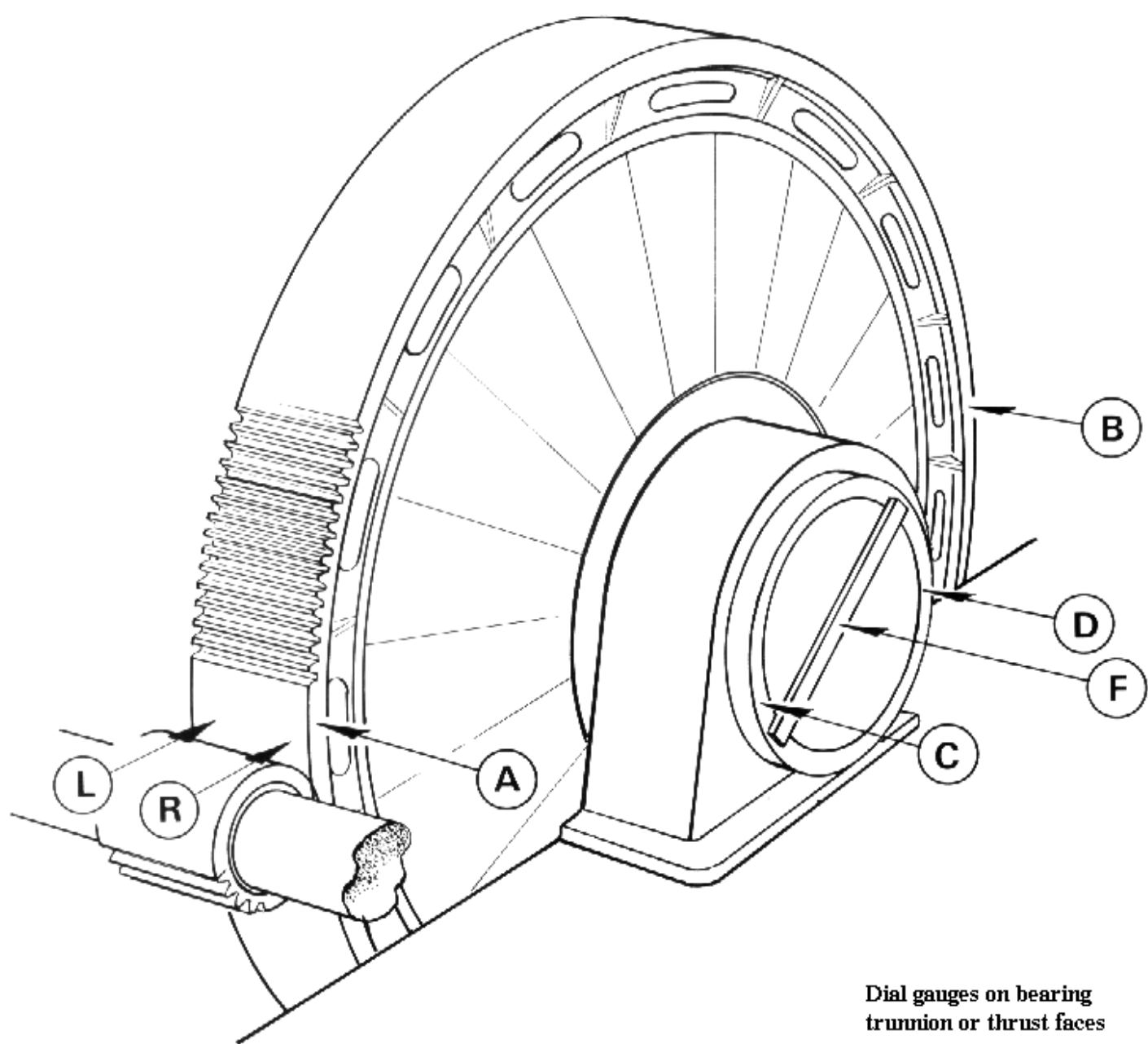


Fig. 9

Mill and Kiln Gears

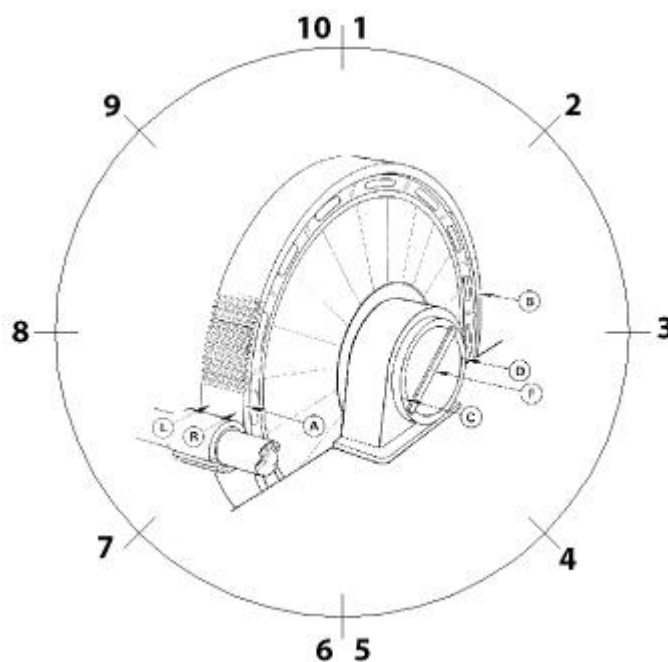
DB Order No.	
Client Order No.	
Drawing No.	
Segment 1 Cast No.	
Segment 2 Cast No.	

Inspector _____

Date _____

Report Number _____

NOTE : $F \approx \frac{C - D}{2}$



STATION	RADIAL RUN-OUT			AXIAL RUN-OUT			BACKLASH
	DIAL L	DIAL R	L - R	DIAL A	DIAL F	A - F	
1J							
2							
3							
4							
5J							
6J							-----
7							
8							
9							
10J							-----
RUN-OUT				-----	-----		-----
DIFFERENCE 1J - 10J				-----	-----		-----
DIFFERENCE 5J - 6J				-----	-----		-----

ALLOWABLE RUN-OUT			ALLOWABLE TWIST 0,16 mm/m FACE
POSITION	RADIAL	AXIAL	
BETWEEN JOINTS			
JOINTS	0.1	0.1	

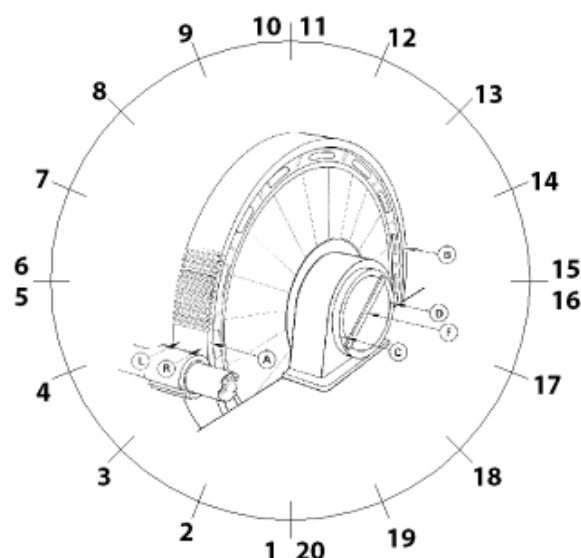
Fig 10

Mill and Kiln Gears

DB Order No.	
Client Order No.	
Drawing No.	
Segment 1 Cast No.	
Segment 2 Cast No.	
Segment 3 Cast No.	
Segment 4 Cast No.	

Inspector _____

Date _____

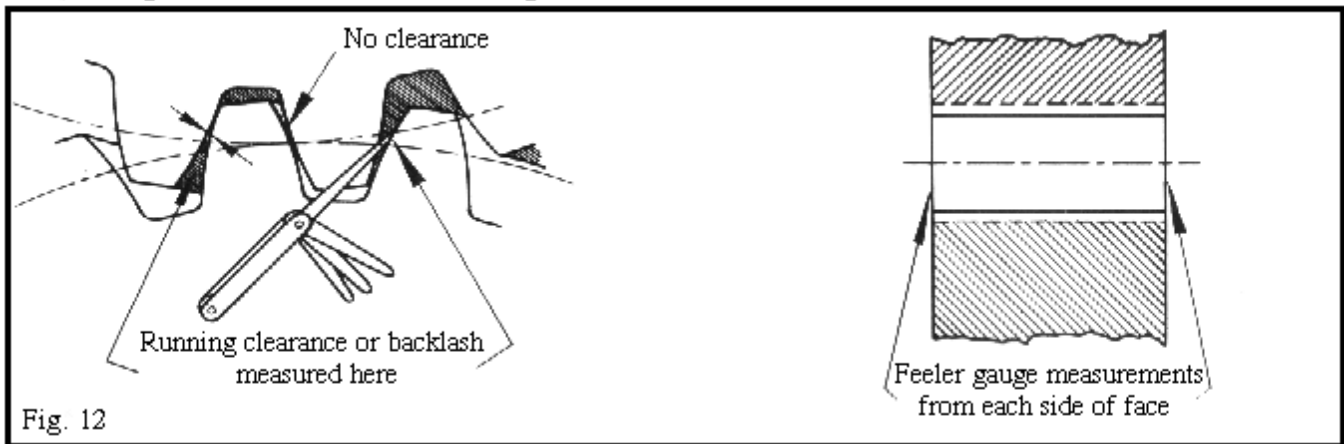


STATION	RADIAL RUN-OUT			AXIAL RUN-OUT			BACKLASH
	DIAL L	DIAL R	L - R	DIAL A	DIAL F	A - F	
1J							
2							
3							
4							
5J							
6J							----
7							
8							
9							
10J							
11J							----
12							
13							
14							
15J							----
16J							
17							
18							
19							
20J							----
RUN-OUT				----	----		----
DIFFERENCE 1J - 20J				----	----		----
DIFFERENCE 5J - 6J				----	----		----
DIFFERENCE 10J - 11J				----	----		----
DIFFERENCE 15J - 16J				----	----		----
ALLOWABLE RUN-OUT						ALLOWABLE TWIST 0,16 mm/m FACE	
POSITION	RADIAL			AXIAL			
BETWEEN JOINTS							
JOINTS	0.1			0.1			

Fig 11

BACKLASH

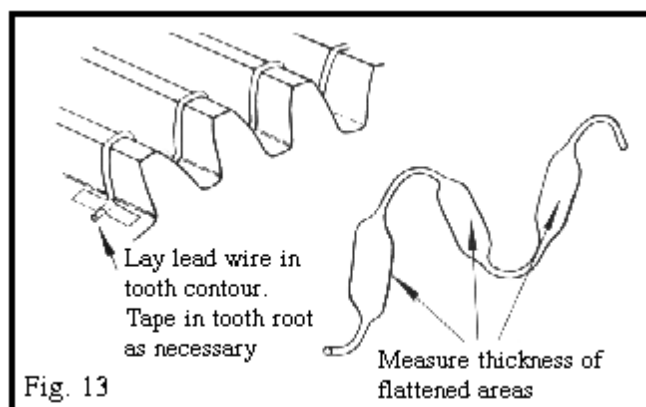
Checking Backlash with Feeler Gauges



For optimum meshing action and maximum life, the gear and pinion must operate with the correct backlash. Backlash can be measured in several ways.

- The preferred method is to use feeler gauges as shown in Fig. 12. The pinion is rotated until the teeth are in contact with the gear teeth on one drive flank. Backlash is then determined by inserting feeler gauges between the trailing flanks of the teeth as shown. Measurements should be made at each end of the face width and should be similar for correctly aligned gears (see also "Feeler gauge measurement" on page 15).
- Soft lead wires may be passed through the mesh as the gears are rotated at inching speed. The leads are laid as shown in Fig. 13, near to each end of the face width of either the gear or the pinion. After passing through the mesh the flattened portions of the wire, at the points where contact has been made at the tooth pitch line are measured with a micrometer. Backlash is the sum of wire thicknesses on opposite flanks of the same tooth.

Note : Generally end relief will be present for a distance of $1/20^{\text{th}}$ of the face width from each end of the teeth. To avoid misleading results, feeler gauges should be inserted to a distance greater than this and lead wires must be positioned inboard of the position at which end relief starts.



- In some installations the close proximity of gear guards or pinion bearings housings will restrict access to the teeth end faces and prevent feelers being inserted. Under these circumstances backlash may be assessed by setting a dial gauge on a pinion tooth and rocking the pinion backwards and forwards to make contact on both flanks. The amount of backlash present is the total indicator reading.

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Fig. 14 gives the correct working backlashes for a range of tooth pitches. It is emphasized that the conditions which prevail when the gears are being installed will differ from those under normal working conditions and the following allowances must be taken into account in the setting of backlashes.

1) Thermal expansion

Gears will operate at temperatures higher than ambient due to heat generated at the tooth mesh and heat generated within the process equipment on which the gear is mounted. Reinforced concrete foundations, which are usually used to support mill / kiln bearings and pinion bearings, and which therefore control the gear center distance, are usually at a lower temperature than the gears. It is common practice to assume that the full gear expansion must be allowed for by additional setting backlash. Figs. 15 and 16 show backlash allowances for a range of temperature rises, gear center distance and tooth pressure angle. Additional backlash may be necessary to compensate for wear in kiln roller support installations.

2) Structural deflection

This may be significant when the center line of the pinion is below that of the gear, and if the gear support structure deflects when fully loaded. This will be known by the mill / kiln manufacturer. If the gear axis deflection and the relative position of gear and pinion axes are specified, David Brown Gear Industries (Pty) Limited will be pleased to advise on the appropriate backlash allowance.

3) Effect of radial runout

The specified backlash must always be attained at the position where the maximum positive radial runout of the ring gear is adjacent to the pinion being set.

Design backlash during normal operation

Circular Pitch (in.)	Diametral Pitch	Metric Module	Operating Backlash	
			in.	mm.
6.28	½	50	.038-.050	.97-1.27
4.188	¾	35	.034-.044	.86-1.12
3.1416	1	25	.032-.042	.81-1.07
2.513	1¼	20	.028-.036	.71-.91
2.094	1½	18	.024-.031	.61-.79
1.574	2	12	.022-.029	.56-.74
1.257	2½	10	.019-.025	.48-.64

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Additional backlash allowance for expansion at operation temperatures at 20° pressure angle

Temperature rise °F °C		Centre Distance															
		50 in		70 in		90 in		110 in		130 in		150 in		200 in		250 in	
		1270 mm		1780 mm		2285 mm		2795 mm		3300 mm		3810 mm		5080 mm		6350 mm	
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
10	6	.002	.05	.003	.08	.004	.10	.005	.13	.006	.15	.007	.18	.008	.20	.011	.28
20	11	.004	.10	.006	.15	.008	.20	.010	.25	.012	.28	.013	.33	.017	.43	.022	.56
30	17	.007	.18	.009	.23	.012	.28	.015	.38	.017	.43	.020	.51	.026	.66	.033	.84
40	22	.009	.23	.013	.33	.016	.41	.020	.51	.023	.58	.027	.69	.034	.86	.044	1.12
50	28	.011	.28	.016	.41	.020	.51	.025	.64	.029	.74	.034	.86	.043	1.09	.055	1.40
60	33	.013	.33	.019	.48	.024	.61	.030	.77	.035	.89	.040	1.02	.052	1.32	.066	1.68
70	39	.016	.41	.022	.56	.028	.71	.034	.86	.041	1.04	.047	1.19	.061	1.55	.077	1.98
80	44	.018	.46	.025	.64	.032	.81	.039	.99	.047	1.19	.054	1.37	.069	1.75	.088	2.24
90	50	.020	.51	.028	.71	.036	.91	.044	1.12	.052	1.32	.060	1.52	.078	1.98	.099	2.52
100	56	.022	.56	.031	.79	.040	1.02	.049	1.25	.058	1.47	.067	1.70	.087	2.21	.110	2.79

Fig. 15

Additional backlash allowance for expansion at operation temperatures at 25° pressure angle

Temperature rise °F °C		Centre Distance															
		50 in		70 in		90 in		110 in		130 in		150 in		200 in		250 in	
		1270 mm		1780 mm		2285 mm		2795 mm		3300 mm		3810 mm		5080 mm		6350 mm	
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
10	6	.003	.08	.004	.10	.005	.13	.006	.15	.007	.18	.008	.20	.009	.23	.012	.31
20	11	.005	.13	.007	.18	.009	.23	.011	.28	.013	.33	.015	.38	.020	.51	.025	.64
30	17	.008	.20	.011	.28	.014	.36	.017	.43	.020	.51	.023	.58	.030	.76	.038	.97
40	22	.010	.25	.014	.36	.018	.46	.023	.58	.027	.69	.031	.79	.040	1.02	.051	1.30
50	28	.013	.33	.018	.46	.023	.58	.028	.71	.033	.84	.038	.97	.050	1.27	.063	1.60
60	33	.015	.38	.021	.53	.028	.71	.034	.86	.040	1.02	.046	1.17	.060	1.52	.076	1.93
70	39	.018	.46	.025	.64	.032	.81	.039	.99	.047	1.19	.054	1.37	.070	1.78	.089	2.26
80	44	.020	.51	.029	.74	.037	.94	.045	1.14	.053	1.35	.061	1.55	.080	2.03	.102	2.50
90	50	.023	.58	.032	.81	.041	1.04	.051	1.30	.060	1.52	.069	1.75	.090	2.29	.115	2.92
100	56	.026	.66	.036	.91	.046	1.17	.056	1.42	.067	1.70	.077	1.96	.100	2.54	.128	3.25

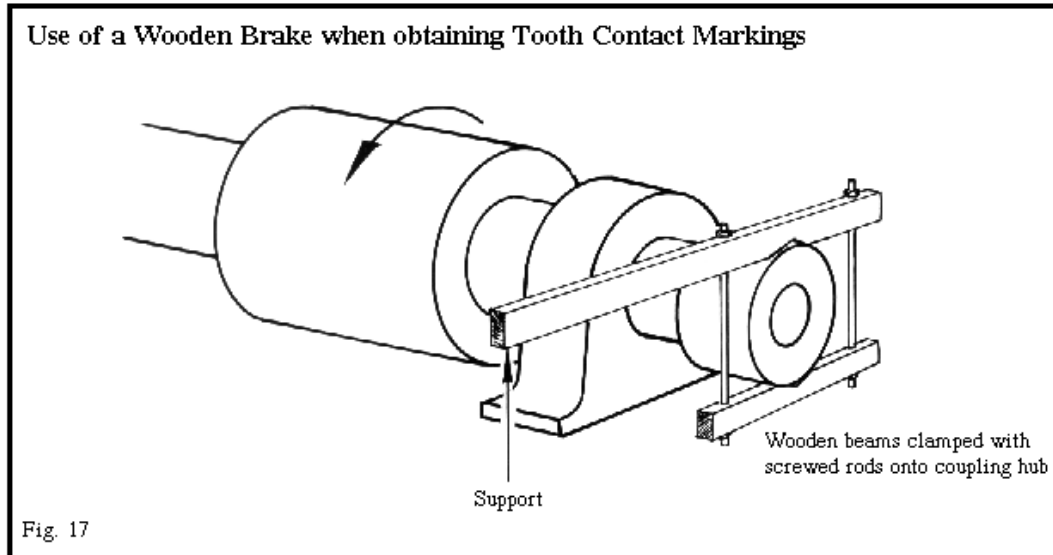
The final criterion of correct alignment is the contact marking which is obtained on the teeth under load. As a preliminary check during installation or, as an approximate re-check during service, alignment may be assessed using feeler gauges or lead wires.

1. FEELER GAUGE MEASUREMENT

With gear and pinion teeth held in contact on the drive flanks, it should not be possible to insert a feeler gauge between the contacting flanks at either end of the teeth. See Fig. 12. Generally end relief will have been applied for a distance of 1/20th of the face width from each end of the teeth. To avoid misleading results feeler gauges should be inserted to a distance from the face which is greater than this. With helical gears, pinion and gear teeth will be in a different phase of engagement at each end face. If contact is near the pitch line at one end and near the pinion or gear tip at the other the tip relief designed into the tooth shape can give misleading readings. Reliable results are obtained by inching round so that readings are taken at the same place of engagement on the same pair of teeth at each end of the face.

2. LEAD WIRE MEASUREMENT

Lead wires are used as described on page 13, the wires being placed near to the tooth ends, taking into account end relief. The thickness of the flattened portions of wire on the driving flanks should be the same at each end of the teeth for correct alignment. This method is particularly useful for approximate alignment checks on gears in service when it is impractical to remove guards or clean down the gears to permit contact markings to be checked.



3. CHECKING CONTACT MARKING

The contact marking is observed by covering the pinion teeth with a thin coating of suitable marking medium so that when the gears are rotated together the medium is transferred onto the gear teeth. The marking medium is usually an oil base dye such as "Micrometer" blue in the United Kingdom or Prussian blue in North America. It can be thinned as necessary with light oil to permit easy and uniform application by brush. The pinion should be driven using the inching drive and the marking medium on the teeth replenished frequently so that a marking is obtained on all the ring gear teeth. The first pass through the mesh should be of one revolution of the ring gear only, in one direction, followed by closed examination of the marking. If satisfactory, rotation should continue for at least two full revolutions of the gear to produce a well defined marking. With bi-directional drives the procedure must be repeated for the opposite direction of rotation.

When the ring gear is driven by two pinions it is customary for the incher to drive through one only. The non-driving pinion contact is checked by applying the marking medium to its teeth and rotating the gear with the inching drive, as before. As marking compound is picked up by the driving pinion teeth, it must be wiped off to prevent it from re-transferring onto the gear teeth and creating a misleading impression. To intensify the marking and obtain a more positive or identifiable result, a reaction torque may be applied to the driven pinion using a wooden brake as shown in Fig. 17. If a speed reducing gearbox is installed the brake will be more effective if applied to the gear box input shaft.

ALIGNMENT OF PINIONS

ALIGNMENT CRITERIA

Correct alignment is indicated by a contact marking centrally disposed on the gear teeth. In general the initial no-load contact should be evident over 80% of face width and 40% of the tooth depth. Pinions with end relief will not show contact near the teeth ends. It is important to note that a completely uniform marking will rarely be achieved since even minor imperfections of geometry and surface finish will influence the marking under no-load conditions, causing some degree of patchiness.

It is usually satisfactory to optimize the contact patterns under no-load conditions during installation. Due to the deflection characteristics of the mill or kiln, it may be necessary to make some allowance in the initial markings. Guidance should be requested from the mill or kiln manufacturer. Confirmation that the alignments are correct should be obtained as early as possible after the installation has reached full load by strobe light inspections and examination of the bedding-in marks on the tooth surfaces.

If the rim side face runout is within the specified tolerance the contact marking should be reasonably constant around the gear but, when some wandering is evident, the best average marking must be achieved. If a minor bias exists toward one side it is better to have the heavier contact towards the end of the face width remote from the driven end of the pinion. As load is applied the marking will tend to spread towards the driven end.

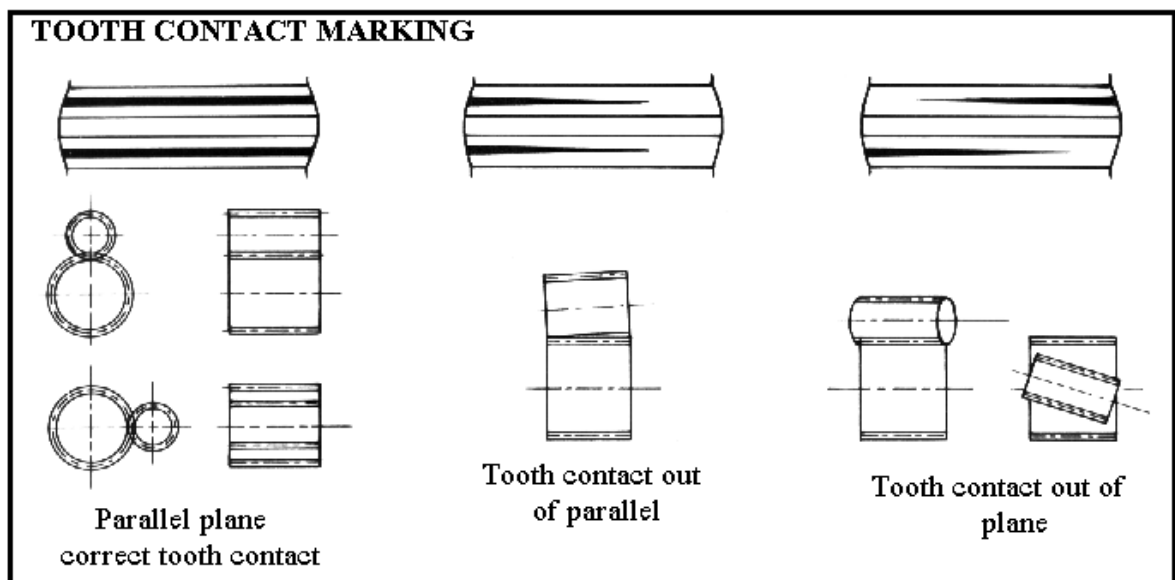


Fig 18

Contact markings will clearly indicate the state of alignment of each pinion, typical patterns being shown in Fig. 18. Alignment is adjusted by moving the pinion plummer blocks horizontally, towards or away from the ring gear, and / or vertically by inserting or removing shims. With bi-directional drives the contact markings must be optimized on both driving flanks and compound movements will be necessary. For uni-directional operation the marking need only be optimized on one flank and final minor adjustments made by shimming. However, a reasonable contact is still desirable on the non-driving flanks to avoid high load concentrations which may occur during occasional overdrive conditions, such as when the mill oscillates after run down.

When the contact marking is satisfactory, contact tapes should be taken on both flanks of one ring gear tooth at each stamped station with the gear meshing with each pinion in turn. Contact tapes are obtained by carefully pressing transparent adhesive tape onto the full length of the tooth and smoothing down to pick up the marking medium on the adhesive. Tape is then peeled off the tooth and transferred to white paper. With large pitch teeth it may be necessary to

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use several overlapping strips of tape to cover the full tooth depth. The composite tape can be peeled off in one piece. On each record be sure to identify the tooth number, the flank, the tooth tip and the tooth end identity.

1. Prior to assembling the gear guards, the ring gear, pinions and guards should be thoroughly cleaned. The working area should be inspected closely to ensure that all debris, tools and tackle have been removed from the rotating components.
2. In preparation for starting up, the gear teeth must be completely covered with lubricant by inching round with the sprays operating continuously. During this time the correct operation of the spray system can be confirmed.
3. After initial start up the gears should be operated at partial load for a time to permit the tooth surfaces to achieve initial bedding. As a general guide, operation at 50% load for approximately 48 hours will be satisfactory, building up to full load over a further 24 hours. During this time the lubricant supply should be generous ensuring that the film of lubricant is replenished frequently. The application of very light loads is not recommended as contact on driving teeth flanks may be intermittent, the gears may run noisily and little benefit will be achieved.
4. Modern lubricants normally require the use of a "running in" lubricant for a short period prior to this introduction of the service lubricant. David Brown Gear Industries (Pty) Limited warns users that uncontrolled use of such lubricant can result in permanent surface damage to the gear teeth. David Brown Gear Industries (Pty) Limited can in most instances offer specific advice on the lubricant being used.

NOTE

The choice of lubricant to be used is normally the responsibility of the end user and the lubricant supplier. Whilst David Brown Gear Industries (Pty) Limited are happy to offer advice, where possible, we cannot accept responsibility for the lubricant performance or accept liability for any damage caused by inadequate lubrication.

5. Stroboscopic inspection of the gear mesh whilst in motion will be helpful. When heavy black residual lubricants are used useful observations can be made. Areas of the teeth which are not in contact will have a shiny black appearance. In contacting areas the colour will vary from dark brown to bright metallic "silver" depending on film thickness and intensity of loading. Very bright local areas may indicate high spot contacts and are worthy of examination with the gears stationary. Misalignment is indicated by a tapering contact area.
With single pinion drives visual examination of the ring gear teeth will show the consistency of marking around the gear whereas the pinion will tend to show the average of the multiple contacts it makes with different ring gear teeth. With dual pinion drives the observations are more difficult to interpret. The ring gear teeth will show the average of its multiple gear teeth contacts but some indication of its general alignment status will be evident.
With the gear teeth frozen by the strobe light, globules of lubricant are generally visible at the tooth tips. If the sprays are operating correctly these will be uniformly spread across the full tooth length. Non-uniform distribution may indicate that the nozzle spray pattern or discharge quantity is incorrect and should be checked.

START UP PROCEDURE

Gears must be operated correctly to achieve their full life, i.e. the designed loading must not be exceeded, good alignment must be maintained and tooth surfaces must be adequately lubricated at all times. Advice on lubrication for each application will be supplied by David Brown Gear Industries (Pty) Limited on request.

The following points should be noted in establishing a service inspection routine.

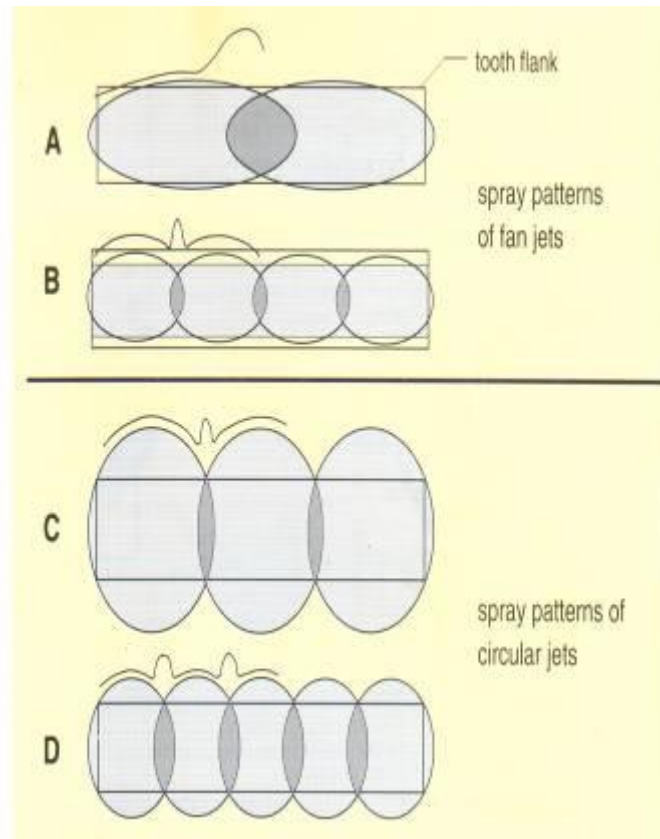
1. Check daily with a strobe light to confirm that the lubrication spray coverage is satisfactory. If in doubt stop the drive and investigate.
2. Act immediately if a lubricant failure warning occurs. Stop the drive until the fault is rectified.
3. Check periodically for lubricant accumulating and setting hard in tooth roots. Over long periods these accumulations may eliminate foot clearances and create high radial loads on the gear teeth, causing distress to the pinion bearings. This may be a particular problem if dust gains access to the gear guard and mixes with the lubricant, becoming compacted in the tooth roots. The hard residue in tooth roots should be cleaned out as necessary.
4. Care must be taken to prevent debris and contaminants from entering the gear guard. Replace seals as necessary. Brush dust and debris from around the inspection hatches before opening. Ensure the discarded lubricant does not build up underneath the pinion. Clean the grease catchment containment regularly.
5. A routine for checking the level of lubricant in the supply container should be established and rigorously maintained. Care must be taken to prevent contaminants from entering the lubrication system as the containers are changed.
6. Operation with inadequate or contaminated lubricant may result in tooth surface damage by scuffing or abrasive wear. If this occurs the gears should be stopped at once and then cleaned down for examination and remedial action. Small local areas of scuffing may be smoothed down with a file or stone to remove the high spots. If major parts of the tooth surfaces are damaged, then more extensive correction action may be necessary to restore a satisfactory area of contact.
7. Using the strobe light, observe periodically the contact marking to confirm alignment. See pages 16. It is possible for alignment to deteriorate due to settling of foundations, bolts becoming loose, high shock loads, etc. Investigate alignment changes and correct as necessary.
8. During the initial period of running some minor pitting may occur on pinion or ring gear teeth. This is a normal behavior pattern of tooth bedding and will usually stabilize without detriment to the gear performance or life. Since it is a fatigue phenomenon, its development will be dependent on operating speed. For the same reason the rate of development will be different on pinions to that on ring gears. If the pitting is biased towards one end of the teeth it may be indicative of misalignment which should be investigated.
9. During routine inspections, changes in noise or vibration characteristics should be noted. Noise surges, or beats at ring gear rotational frequency, may indicate that the radial or side face runout has increased. Excessive side face runout may show up as a wandering contact during the strobe light checks. Particular attention must be paid if "knocking" occurs at ring gear segment joints as they pass the pinion, as this may indicate that the joint has opened. Gears mounted on hot process equipment may be prone to this problem due to thermal expansion of the support structure. Open joints will cause high dynamic loads on adjacent teeth and may lead to serious damage. The tightness of the joint bolts should be checked and the mill manufacturers consulted to ensure that all necessary precautions have been taken to minimize thermal loads on the gear. If the gear has operated for some time with the joint open lubricant will probably have penetrated the joint gap and hardened. It will then be impossible for the joint to close without cleaning the faces which may necessitate that gear segments being wholly removed or, at best, partially removed to permit cleaning of the joint faces.

LUBRICATION

An effective film of the correct type of lubricant must be maintained on the tooth surfaces if the full life of the gears is to be achieved.

The lubricant must be applied so that the full gear face width is completely covered. The number of nozzles, distance from the gear and spray shape must therefore be chosen and adjusted to ensure an overlap between the areas covered by each nozzle.

The lubrication system should be fitted with sensors to detect blockage of individual nozzles. Nozzle blockage will result in parts of the teeth receiving an inadequate lubricant supply, creating a high risk of tooth failure.



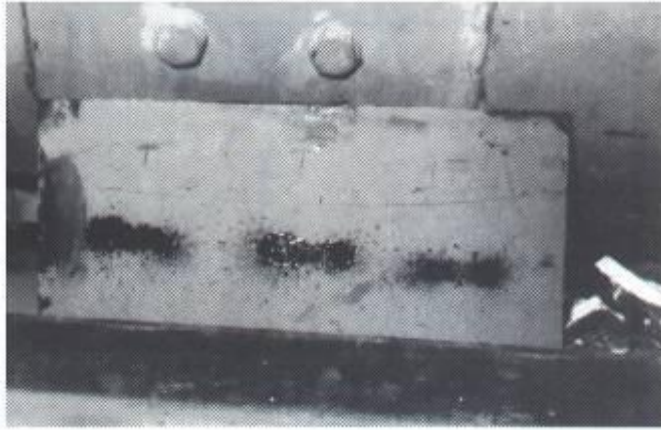
Spray patterns depending on the number of nozzles and the spray geometry.

Note

The pattern achieved should indicate if any adjustment is required. For good coverage the distribution of the lubricant should overlap between spray stations.

Mill and Kiln Gears

The spraying time and interval between sprays will depend on the application in particular, the rotational speed and the specific lubricant being used. These parameters should be confirmed with the lubricant supplier, since they can vary considerably dependant upon the type of lubricant. Some adjustment of the cycle time may be permissible, based on careful observation of the lubricant performance. The lubrication system should be fitted with a second timer which automatically stops the drive if the sprays fail to operate. It is recommended that this timer be set to no more than 50% above the spray cycle time.



Unacceptable spray pattern



Damaged caused by unacceptable spray pattern

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