General Gear Assembly and Maintenance Techniques of Renk-Maag Turbogears, specific to the “GB” Series Gearbox

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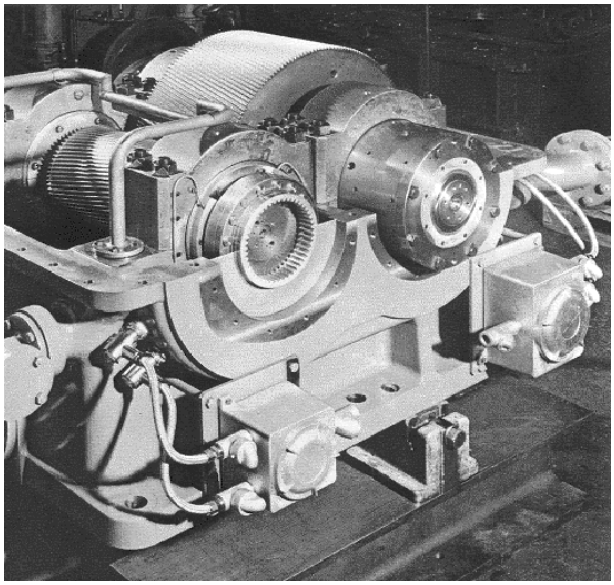
1 Assembly at Renk-Maag

Although the components of a gearbox, as supplied to the assembly shop, are machined to a high degree of precision, a certain amount of fitting and adjustment remains to be done during assembly in order to obtain the product quality essential for the required performance standard of the gear unit.

Based on the example of a typical turbo gear with the two shafts, arranged in a horizontal plane, and mounted in a gear casing split horizontally at the shaft centers, as shown in figure 1, we can describe the major steps of assembly as follows:

Figure 1: Turbo gear type GB



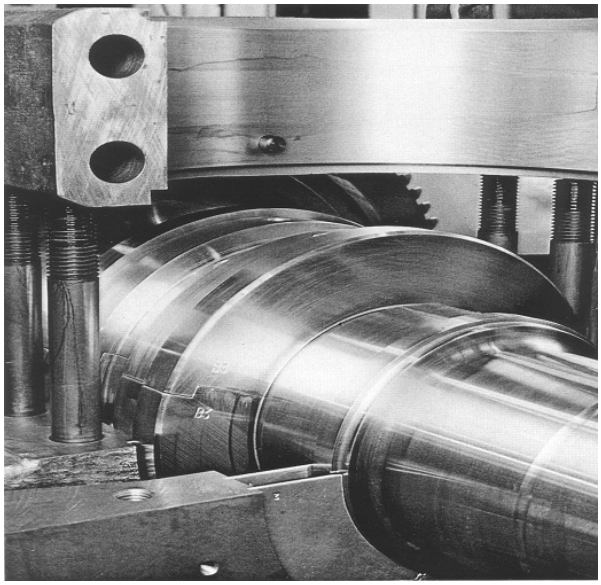
1.1 Gear casing

The bolted casing comes finish-machined, precision-bored from the machine shop. The bottom (mounting) surface and the casing separating surface are re-checked for flatness and parallelism. With the gear casing mounted free of distortion (three-point-support) the two casing bores, which are to seat the bearings, are checked with zero-clearance gauge shafts for parallelism. Using "prussian blue" the bores (bearing seats) are checked against the gauge shafts for roundness, cylindrical shape and alignment of bores. Any remaining deficiencies are corrected by scraping until a perfect solid seating of the bearings is assured.

1.2 Bearings

The two-piece bearings, as shown in *figure 2*, consist of hand-fitted stepped halves. They have been machined with exactly concentric bores to the minimum specified bore diameters.

Figure 2: Bearing, bearing cap, shaft seals



The bearings are seated in the gear casing and the bearing cap is adjusted, if necessary, to obtain a solid zero-clearance seat that results in light pre-tension during operating as the bearings reach higher temperatures than the gear casing.

The bearing bores are then finish-scraped to gauge shafts, of minimum nominal bearing diameters, assuring cylindrical, perfectly lined-up bearings of identical diameter for each shaft. Parallelism of the shaft centers also is controlled within very close tolerances.

The tilting pad thrust bearings are adjusted to the specified axial clearance by grinding the spacer ring.

1.3 Rotors

Correct gear tooth alignment is essential for satisfactory gear performance. At assembly, the gear tooth contact has to conform to a specified no-load contact pattern relevant to the longitudinal tooth correction of the particular gearset.

The no-load tooth contact is checked, with the gears mounted in the bearings, by applying "prussian blue" to a few tooth flanks of the gearwheel, which are then rotated through the mesh to transfer the bluing to the pinion teeth as a contact print. This pattern is recorded on a sheet of paper using scotch tape to transfer it from the pinion tooth flank (*see figures 3 to 7*).

Figure 3: Application of "Prussian blue" to gear teeth

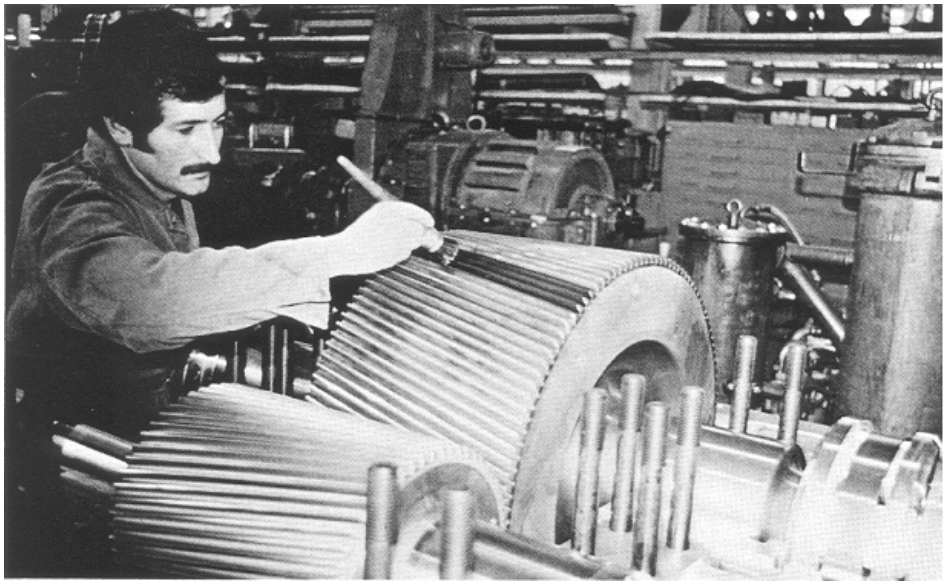


Figure 4: Rotating the blue teeth through the mesh

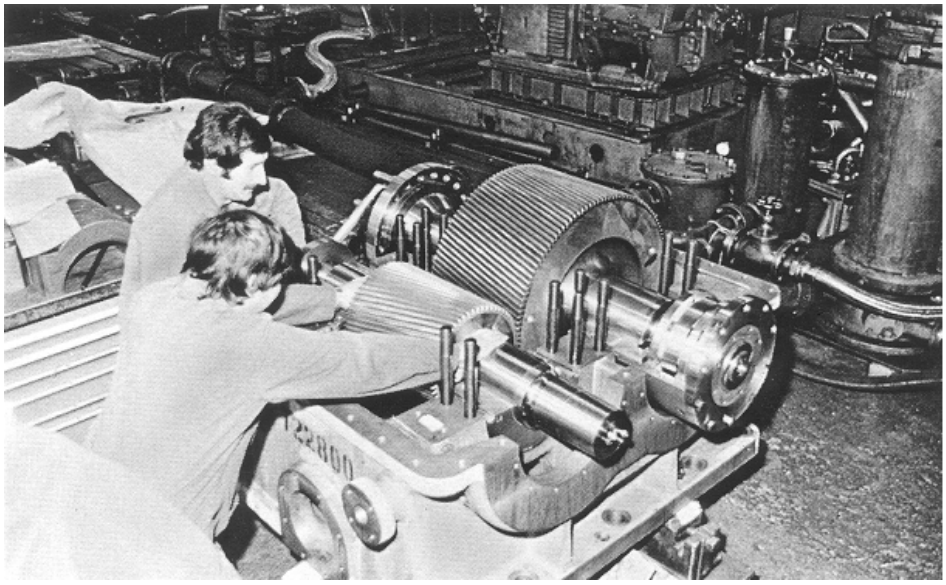


Figure 5: No-load tooth contact pattern (bluing) on pinion teeth

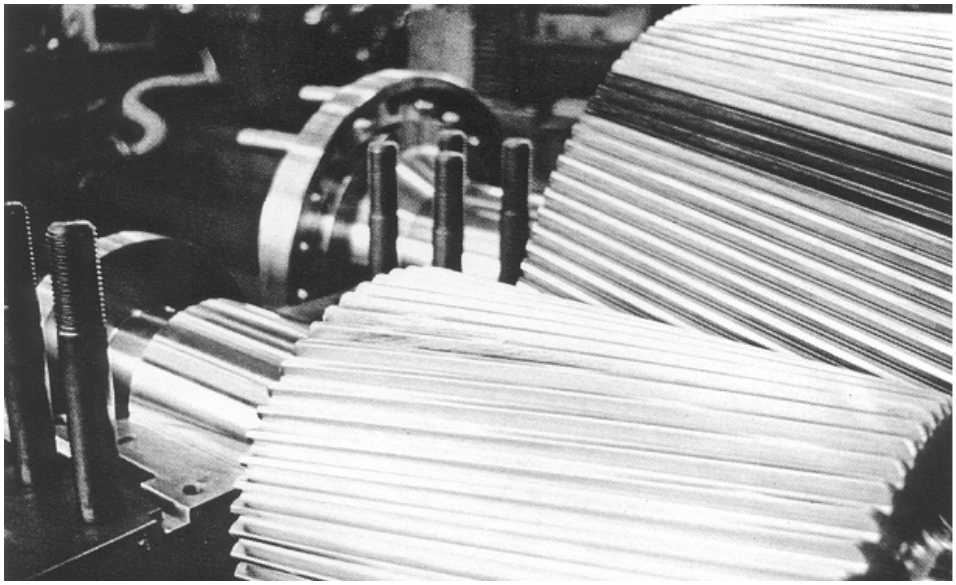


Figure 6: Recording the no-load pattern by using scotch tape

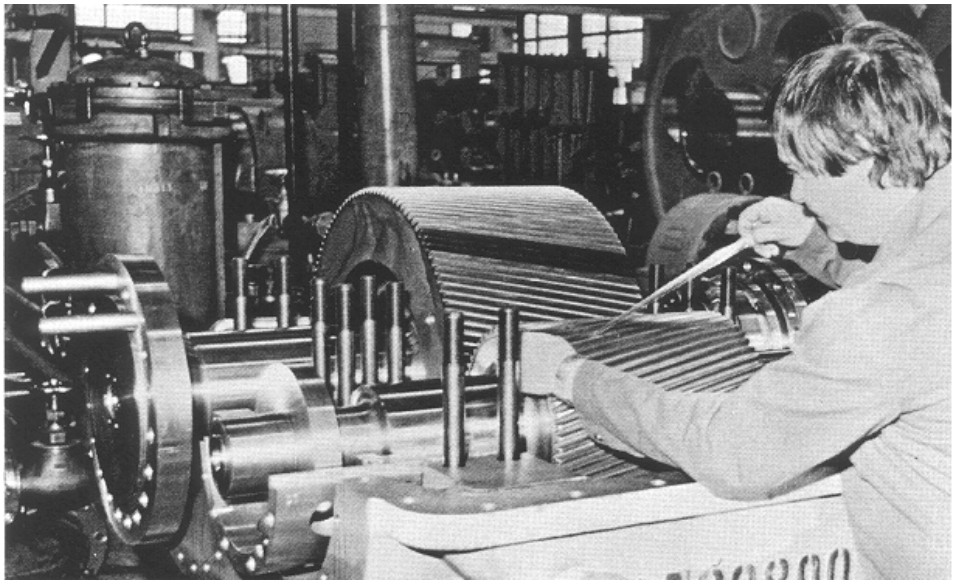
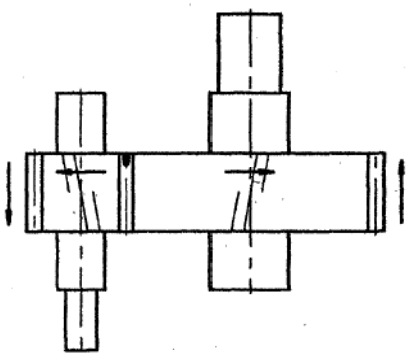


Figure 7: Record of no-load pattern Opposite: Instruction on assembly drawing.



Instruction for mounting

Tooth Contact pattern of non-working flanks at ambient temperature to be symmetrical to centre of facewidth. Check of tooth bearing pattern of working flanks at no load and ambient temperature as shown in figure.

The correct no-load tooth contact, during assembly, ensures an appropriate full load contact. In order to facilitate later checking of the full-load tooth contact some teeth of pinion and gear wheel are coated after shop testing by a thin even layer of red lacquer which wears off within a short operating time showing clearly the load contact of the gear teeth.

Also measured and recorded are bearing clearance and gear tooth backlash. With all parts having been manufactured to specification, both are automatically within the correct range.

1.4 Shaft Seals

The horizontally split shaft labyrinths, made of either brass or aluminum, are individually seated in the casing grooves for easy exchangeability and are checked for correct running clearance.

1.5 Conservation

After the shop test run, the gearbox is completely dismantled and thoroughly cleaned. During final assembly, all machined surfaces of the gear parts are coated with a product for corrosion protection for shipment and storage. The bearing surfaces are coated with non-drying conservation oil to allow the easy turning of the shafts during later alignment. All internal screws and bolts are now secured since the gearbox does not have to be dismantled for cleaning before start-up. The anti-corrosion coating will dissolve completely during flushing of the system without harmful effect on the lube oil. The bolted gear case flanges are sealed with a non-hardening sealant.

2 Installation in the Field

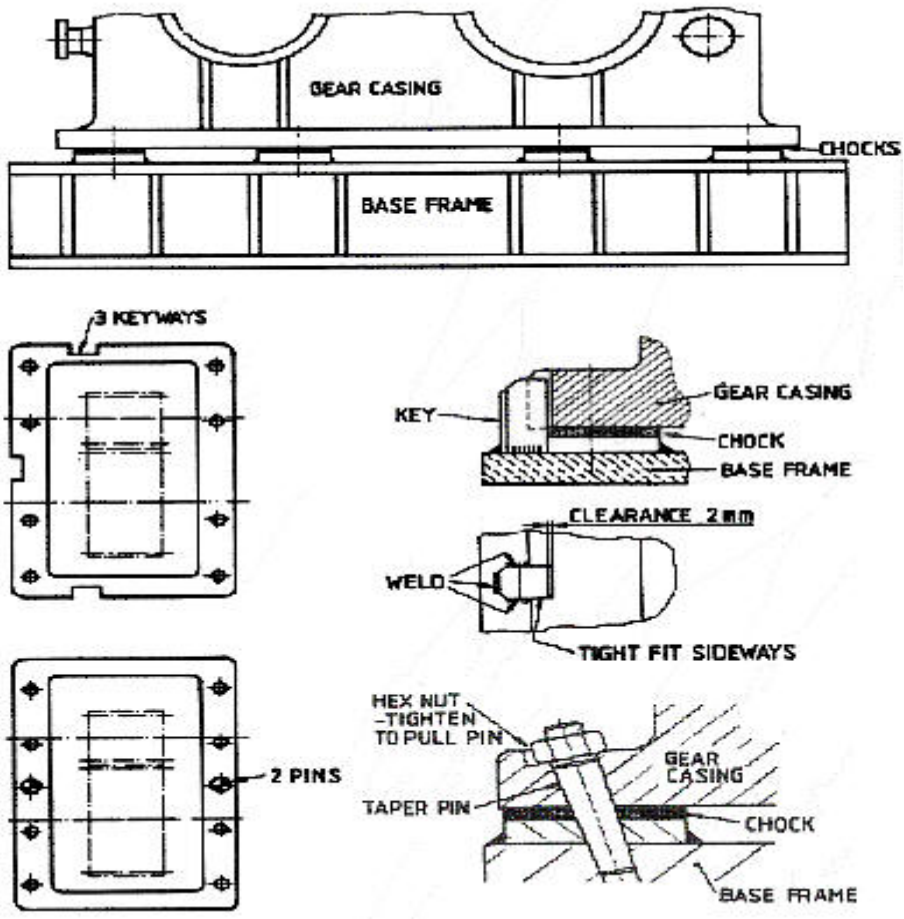
The main objective in gear erection, besides correct shaft alignment with the coupled machines, is to assure a solid undistorted mounting of the gearbox as the most important precondition of a satisfactory gear performance.

2.1 Erection on the Base Frame

The gearbox is mounted on the base support pads with appropriate footing chocks or shims of equal thickness (see figure 8). After rough alignment the correct seating of the gearbox on the base is checked carefully. No gap (so-called "soft-foot") is allowed at any footing with tie-down bolts either loose or tightened.

Final shaft alignment should conform with drive train specifications as accurately as can be achieved, since good alignment is essential to the satisfactory operating behavior of the train.

Figure 8: Gear Foundation/Base Frame



2.2 Tooth Contact Check

The no-load gear tooth contact, established during shop assembly, has to be rechecked during erection; the first time after seating the rough aligned gearbox and the last time after final alignment. The check is done through the inspection port or with the upper gear casing removed. The gearbox must always be uncoupled and bolted down solidly.

On the assembly drawing of every gear unit is also a sketch showing the correct no-load tooth contact pattern. If necessary the correct pattern has to be obtained by stepped shimming between gearbox and base, whereby the solid seating of the gearbox on the base frame must be maintained. Using scotch tape to transfer the blue pattern from the pinion tooth, a permanent record of the final contact check is obtained, and is filed with other erection protocols for future reference. Finally the gearbox is secured against horizontal dislocation on the base by installing the keys or pins at the gear base, and the couplings are installed.

Maintenance

The functional reliability of a gearbox is best maintained by continuous monitoring of the operating conditions in conjunction with regular inspections by competent service engineers.

3.1 Inspections

Gear inspections are to be incorporated into the regular maintenance program of the whole drive train.

Minor Inspections

To be carried out at commissioning, after overhauls and thereafter once a year, these visual inspections are to focus especially on the following items:

- Condition of gear tooth flanks
- Gear tooth load contact pattern

At full load the tooth contact should extend uniformly across the entire face width of the tooth flanks. The red lacquer, with which some of the teeth are coated after shop testing or after overhauls, shows the load pattern clearly.

- Correct lube oil supply to the gear meshes.

For these inspections only the inspection cover on the upper gear case has to be opened, no further disassembly is required.

Major Inspections

To be carried out during major overhaul shutdowns of the drive train, or during unscheduled shutdowns.

In addition to checking tooth load pattern very carefully (see minor inspections) the bearings and seals are also checked and, in case of wear, the bearing clearance has to be measured. For these inspections the gearbox has to be opened and partially disassembled. If inspection time is limited, e.g. during unplanned shutdowns, the bearings and seals can also be removed without uncoupling or removing the gear shafts.

3.2 Replacement of Parts

Bearings, seals or gears which show wear or deterioration of the working surfaces have to be replaced if they cannot be refurbished to specification during the overhaul time.

Bearings

The two bearings of the shaft should preferably be replaced together since a difference in bearing diameters will change the shaft alignment under load and with it the all-important gear tooth contact.

Spare bearings are delivered with the bore finish-scraped to be installed. They have been marked with an arrow in the sense of rotation. At installation they are to be marked with numbers identical to those of the replaced bearings (see figures 9 and 10). The seating of the bearings in the gear casing has to be rechecked for tight seating, as the outside diameters of the bearings vary within tolerances.

After every change of bearings the no-load tooth contact has to rechecked, as does the tooth contact at full load after restarting the drive train. The bearing clearance should be checked by measuring bore and journal, and the resulting clearance recorded for future reference.

Figure 9: Journal bearing – lower half

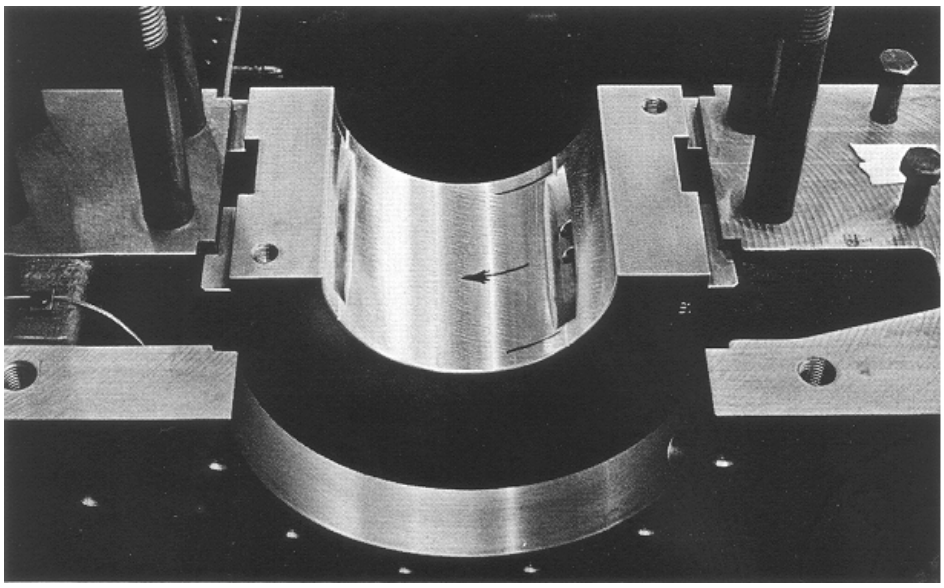
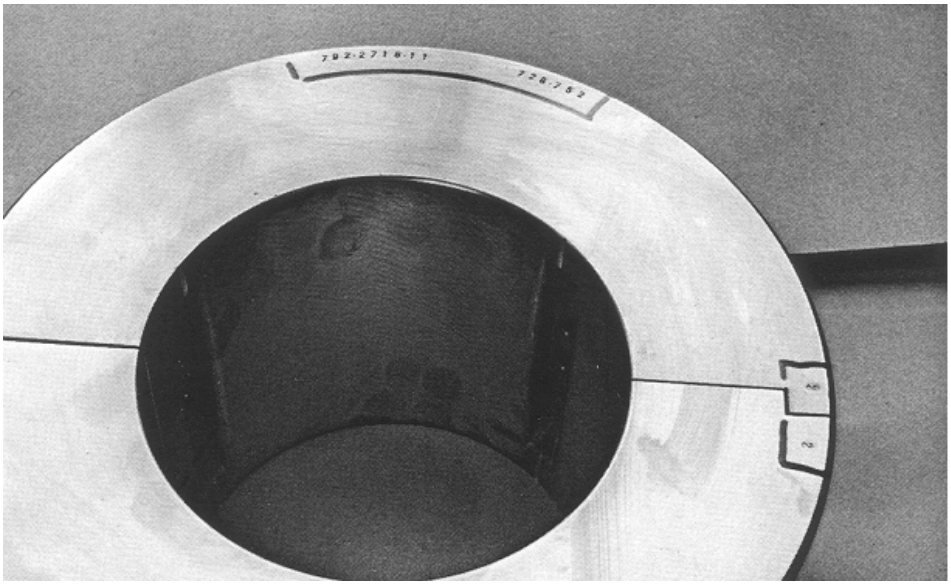


Figure 10: Identification markings on journal bearing



Seals

Labyrinth rings have to be fitted individually into gear casing and checked for correct clearance. The two halves of each labyrinth are marked for correct installation.

Gears

Rotating parts are always replaced as a set. The same procedure for installation and checking, as is used during shop assembly, has to be followed, including the tooth contact check after full load operation.

Replacement of gear parts should be carried out exclusively by competent, trained personnel, preferably by MAAG specialists.

3.3 Service Experience

Given satisfactory operating conditions one may expect practically unlimited service life for all working parts of a MAAG gearbox. The gear tooth flanks and white metal bearings do not noticeably wear if subjected to design conditions of loading and lubrication.

Reliability of gear performance is determined above all by the following factors:

- Rigidity of foundation
- Competence of erection work
- Alignment of drive train

- Dynamic behavior of drive train components
- Lubrication and monitoring system
- Lube oil quality and purity

Deterioration of gearbox operating behavior, such as is signaled by increased noise, vibrations or temperatures, does not necessarily originate from within the gearbox but may be drive train induced. However, it should be investigated promptly to prevent or limit possible damage.

Case hardened gears are generally not affected by high vibrations or temporary overloading. However, the gear teeth may score from a localized breakdown of lubrication, caused by load concentration, when the full load tooth contact extends over less than the full-face width.

Shafts and bearings may be damaged by impurities or process chemicals in the lube oil. Sometimes electric currents can also damage the gear tooth flanks.

Labyrinth ring wear is only to be expected as a result of excessive bearing clearance.

As damage to gears or bearings is often not detected in the early stages by the monitoring systems, the regular gear inspections remain an important part of preventive maintenance.

The danger of corrosion by condensation during prolonged shut downs should not be overlooked. Corroded bearing journals have to be reground to a smaller diameter, which would require non-standard bearings to be supplied; while corrosion which penetrates the gear tooth surface often means replacement of the whole gearset.

3 Foundation

The base frame, on which the gearbox is to be mounted, must be of rigid construction able to absorb the considerable vertical and horizontal reaction forces of the gearbox without distortion.

The base frame design should provide individual footing surfaces at each anchor bolt of the gearbox (*see figure 8*). These footings are to be machined accurately in a single plane.

Between the base footings and gearbox mounting surface solid chocks or shims should be provided to allow for alignment adjustments in height.

The base frame also has to be designed to allow installation of the keys or taper pins that have to be installed, to prevent any horizontal movement of the gearbox on the base, due to internal and external thrust forces.

Oil reservoirs as an integral part of gear foundations may have an ad- verse effect on shaft alignment and tooth contact due to thermal growth.