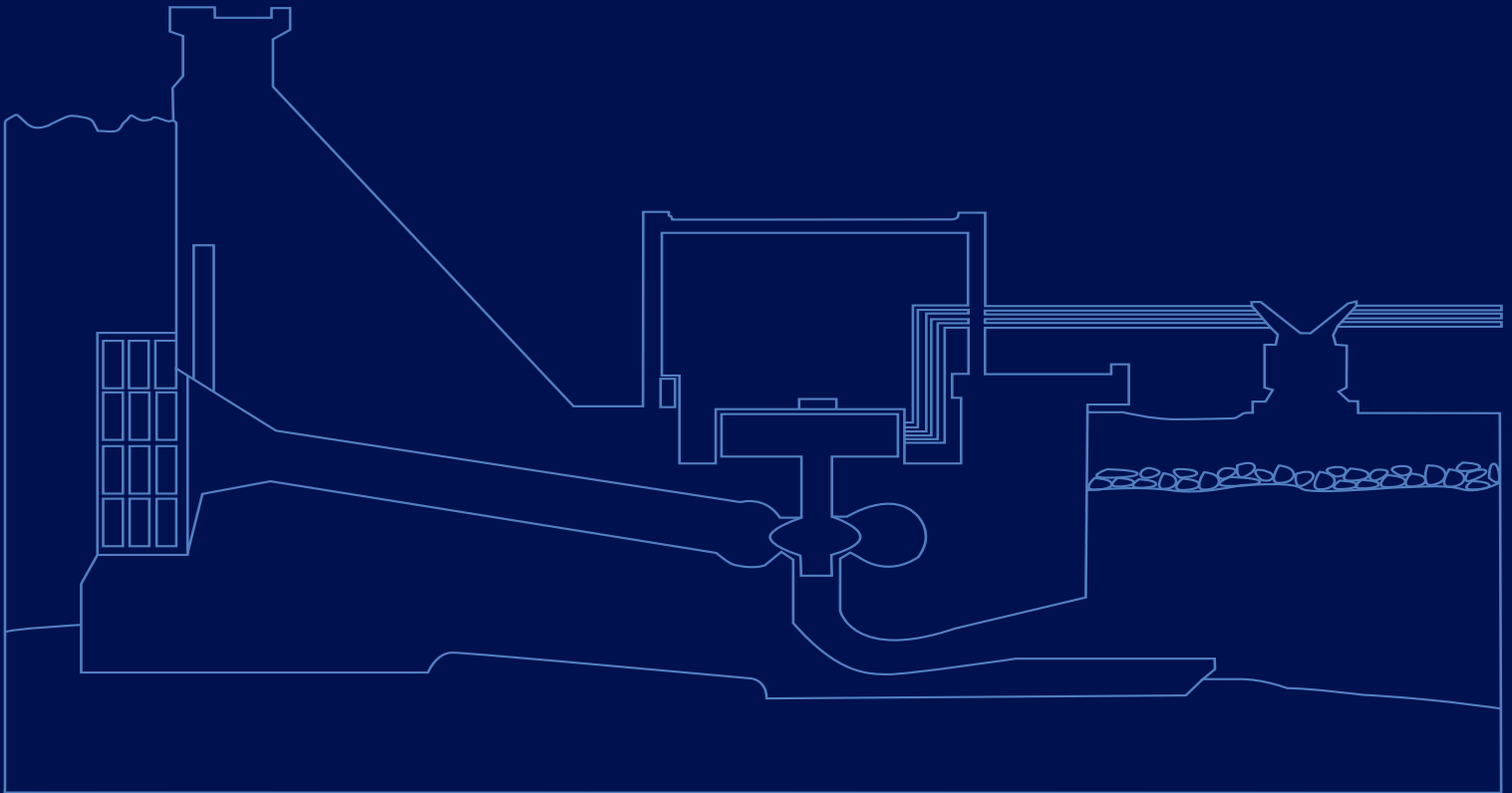


## Power Transmission Solution



# for Water Power

*RENK Speed Increaser with Integral Turbine Bearings*

# Design of Low head Hydro and advantages of a High Speed

Low head sites usually can only be exploited by the use of Kaplan Turbines. They are typically designed with horizontal axis and usually appear in the form of so called

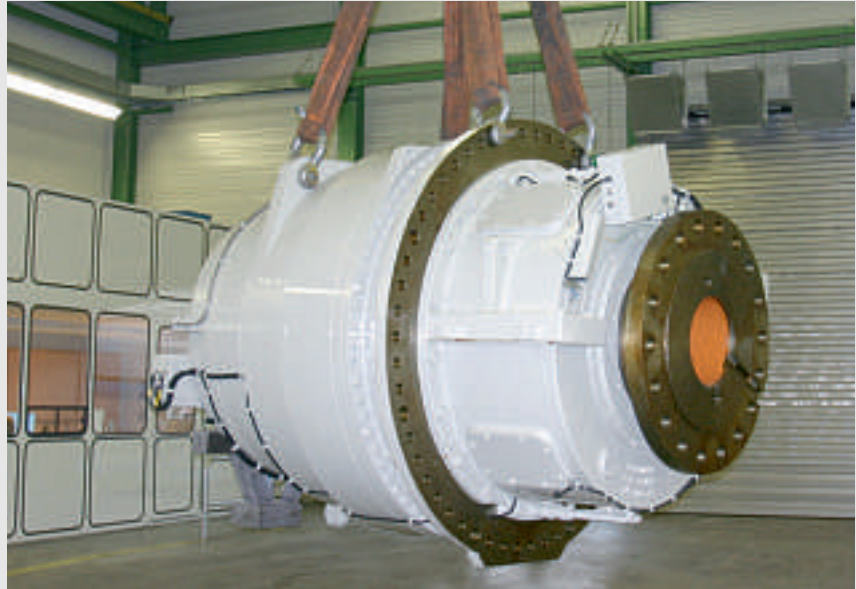
- “Bulb”,
- “Pit” or
- S-Turbines

### All designs have the following features in common:

- Long lifetime.
- Operation at any load from zero to nominal.
- Overspeed operation at 3 times nominal speed.
- Support of radial and axial turbine thrusts.
- Low noise emission.
- Low maintenance i.e. life cycle costs.
- High efficiency (also at part load).

### RENK has answers to satisfy all those challenges:

- Sleeve bearings where ever feasible.
- The floating element of the epicyclic gear is the sun pinion it compensates the machining errors. It is floating at minimum loads.
- The use of sleeve bearings provides high abilities to bear ultimate speeds (no roller acceleration or cage stress).
- The most mature Axial Bearing design made by RENK with ultimate industrial and marine experiences.
- Most sophisticated 3-dimensional tooth lead and profile modifications.
- Maximum disassembly/reassembly in the pit due to spur gearing.

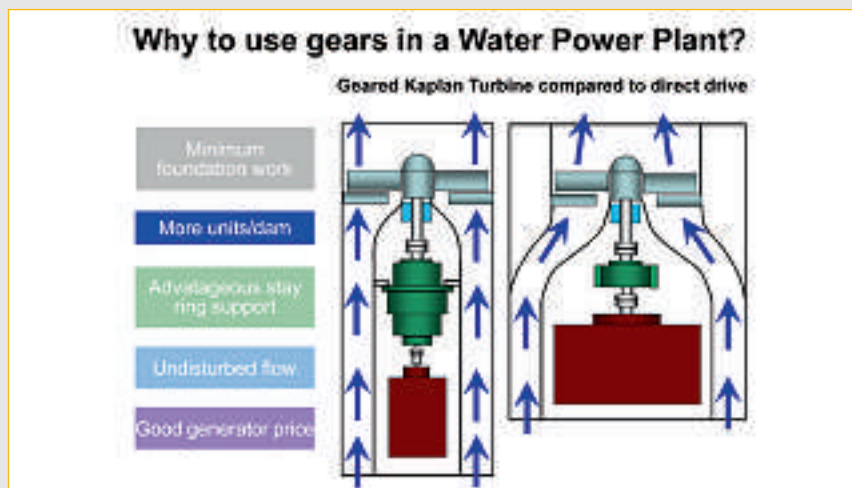


Picture 1:  
Gear units for water power, type PBR 170 SB.

- No high speed bearing.
- Minimum amount of bearings (BLR design).
- The hydraulic losses can be reduced by the drastically smaller Pit/Bulb-width.
- The amount of units per meter powerhouse can be nearly doubled which reduces the construction costs.

The efficiency of synchronous generators rotating at turbine speed ranges between 96% and 96.5%. Would those generators run at speeds of 750 or 1000 rpm their efficiencies would clearly rise. RENK Water turbine gears will increase the overall efficiency of the system.

In addition to the efficiency advantage there is a clear investment advantage. The costs of the gear and its accessories are clearly over compensated by the savings on the generator.



Turbine Speed (rpm)	Direct Drive Generator Efficiency (%)	Geared Turbine Efficiency * (%)		Profit (kW/MW)
		Gear Efficiency	Generator Efficiency	
50 – 70	96.20	98.40	98.30	5.3
70 – 100	96.30	98.60	98.30	6.2
100 – 150	96.40	99.00	98.30	9.2

Table 1:

Approximate figures for indication only.

Table 2:

Modular components.

### Design Requirements for the Gear Unit and RENK's Response

Water power gear units form an integral part of the turbine. They thus have to be designed in close cooperation with the turbine manufacturer. Especially the gear units low speed shaft requires utmost attention, the features are:

- The axial bearing is to be supported in an adequately stiff structure to allow even distribution of the turbine thrust. This includes an adequate support in the turbine/pit structure – preferably by stay ring (flange) mounting.
- The radial load imposed on the gear preferably is low enough to provide as little as possible bending of the combined shaft. For proper overspeed performance the radial bearing support is as stiff as anyway possible.
- A rear end support of the gear is obligatory for all PBR and BLR arrangements and helpful for PAR designs to provide stable alignment at variable thrust load and facilitate alignment.
- Exclusive use of double articulated, anti sludge type, pressure oil lubricated tooth couplings.
- High speed coupling, integral with the gear unit and generator coupling hub included for short over all length.

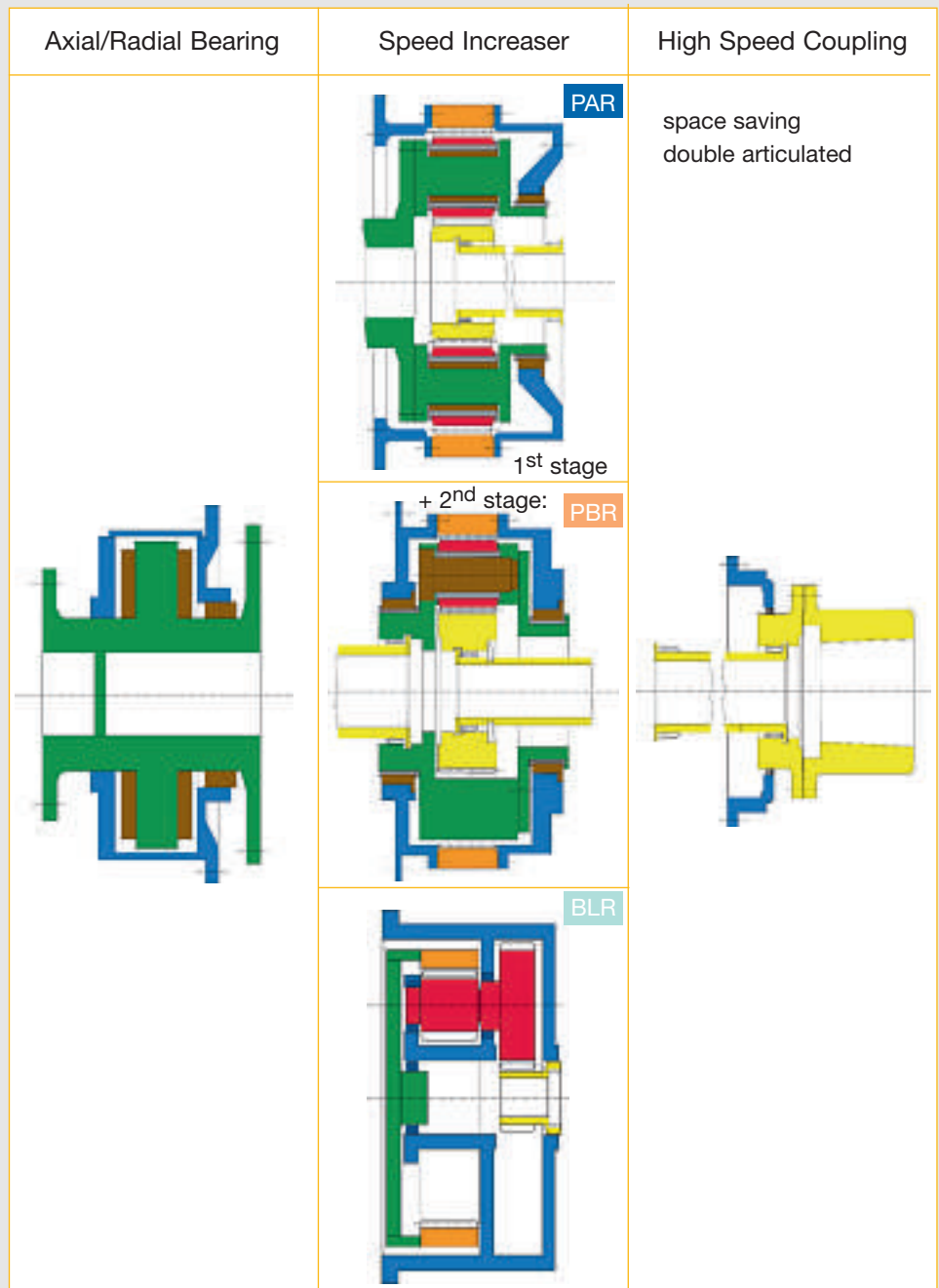
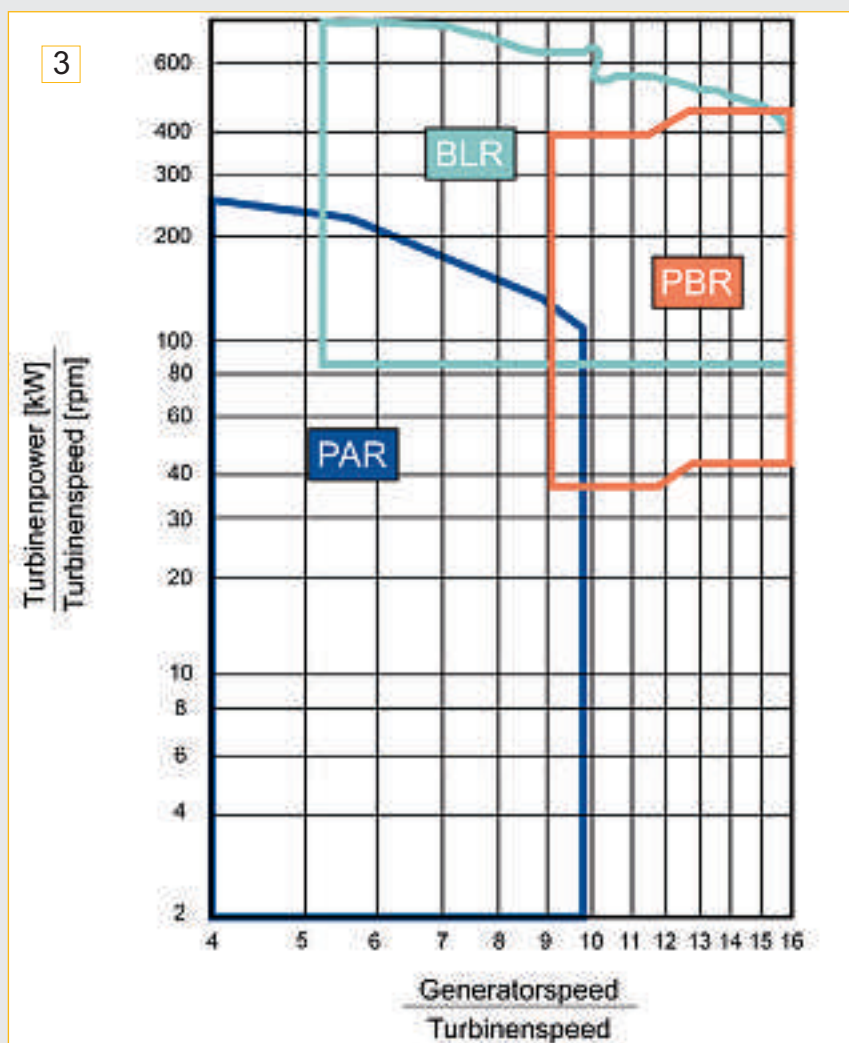
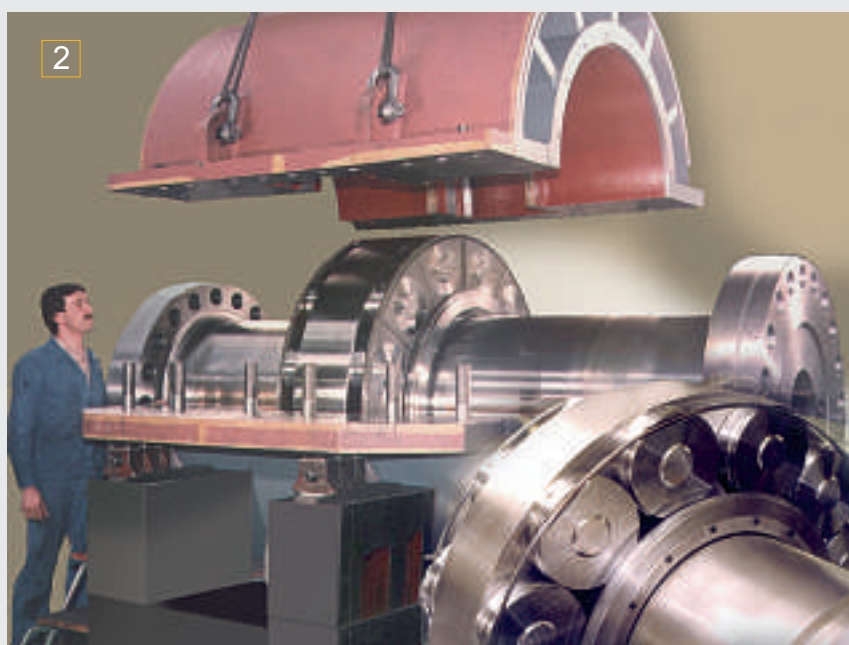


Table 3:  
Available designs, torques and ratios.

- PAR** - single stage planetary design
- PBR** - double stage planetary design
- BLR** - step epicyclic design



Picture 2:  
RENK's bearing modules have proven their reliability not only in water power, but also in marine or cement applications up to 2000 tons of axial thrust.



### The Axial and Radial Bearing Unit

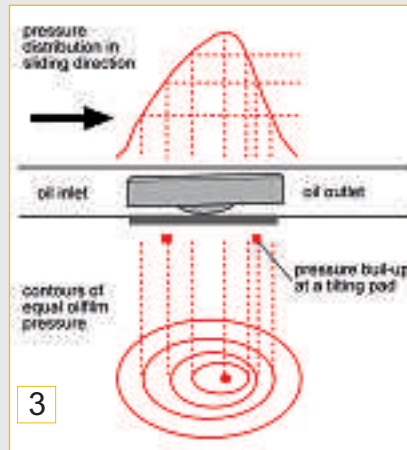
The axial thrust of the turbine is safely borne in a RENK RS-type axial bearing. RS bearings, made in RENK's Hannover factory are providing unique features which should be obligatory for any Hydro Turbine:

- The pads can tilt to built up an oil-wedge (picture 3), and equilibrate any deflection of the shaft thrust collar by being able to tilt in any direction due to their ball support. The pads deflect their support proportional to their load. This means that highly loaded pads unload themselves similar to a self-aligning system as the flexibility of the support is one order of magnitude higher than the oil film.

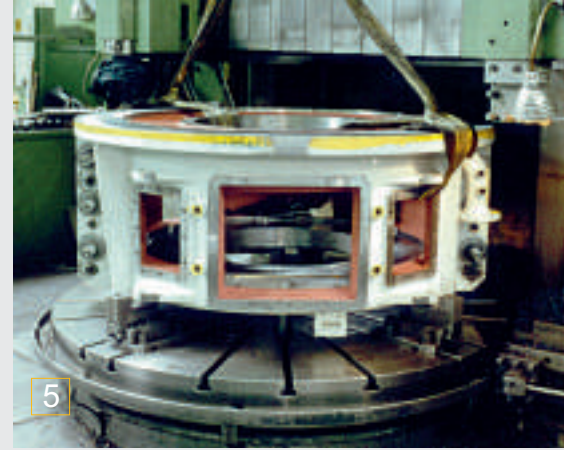
Picture 3:

Pressure distribution and function of the spherical pad support of the RENK-RS bearing pads.

- The pads are cooled better than conventional pads as the access of cold oil supplied out of the rotating shaft is better (picture 4).
- The specially designed oil supply to the Thrust Bearing provides a flooded design with maintenance free seals and efficient cooling – flooding is monitored.
- The pads can be inspected and/or replaced one by one using an included special tool.



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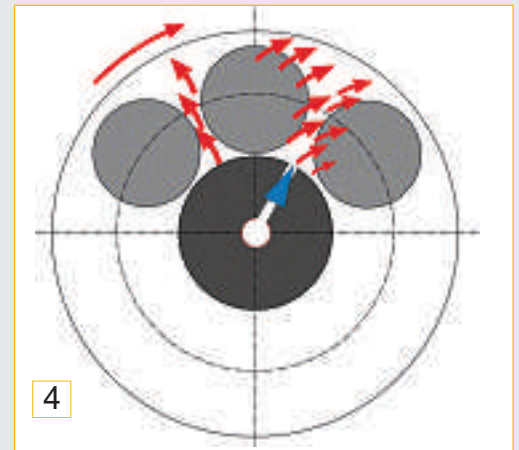


Picture 5:

Axial-Radial bearing module casing during machining (pad replacement opening in the middle).

Picture 4:

Advantageous cooling of the round pad axial bearing unit.



4

### Single Stage or Double Stage? RENK solves the question

Many Hydro applications require a ratio which is high for a single stage and low for a double stage gear. The combined Planetary and Parallel Shaft gear is just a compromise. Encouraged by the success of this System in the Wind Industry RENK now provides the optimum solution for the "in between ratios": The "Step Epicyclic Concept" type BLR. It's features are (also see table 2):

- Lowest possible noise, as annulus is not part of the casing and all gearing is ground.
- Best possible and easiest possible in pit disassembly and/or reassembly.

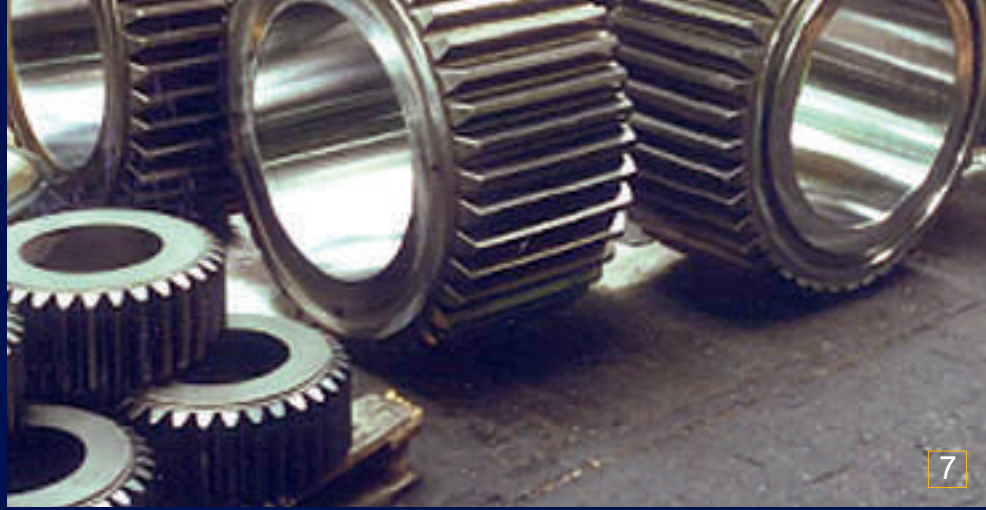
- All gearings (including annulus) are case hardened and ground to at least quality 5, ISO 6336.
- Least possible number of meshes and bearings at maximised ratio.
- Shortest possible design at slightly more casing diameter.
- Planet gears loaded fluctuating and not alternately which increases the safety.
- Planet bearings are at stand still can be surveilled in e.g. bearing temperature with only little expenses.

Picture 6:

Post inspection reassembly of the original rotors of a BLR gear after more than 130.000 operating hours.



Picture 7:  
1st and 2nd stage planets in process.



7

Apart from customary approaches like single or double stage RENK can provide a solution with many unparalleled advantages supported by the experience of an ever increasing number of drives.

No matter which solution is selected, the following features are in common with all RENK hydro turbine gears:

- The floating element of the planetary drive is the sun pinion. It will compensate any manufacturing

tolerance of the system. It is linked to the generator by a double articulated tooth coupling and floats at minimum loads.

- The geared parts are made from specially selected steels providing lower sulphur and phosphorous contents (i.e. more cleanliness) than required by the industrial standards.
- Externally geared parts are ground to quality 4, ISO 6336.

- Internally geared parts can be case hardened and/or ground to quality 5 ISO 6336 in house if so useful to achieve the best technical solution. BLR annulus are always hardened and ground!
- The sleeve bearings are designed and manufactured with the know how of RENK, being a world leading manufacturer of sleeve bearings.

### Lube oil supply

Obviously the lube oil is an element as important for the gears good performance as the gear elements themselves. RENK has therefore developed a lube oil philosophy leading to extremely dependable and uncomplicated lube oil systems:

- Today a 10 µm fine filtration in the main stream providing for trouble free operation even if maintainance is as bad as found in picture 8.
- The use of multibles of small oil pumps provides clearly more availability than the usual use of just a main and a spare pump.
- Pump and filter are a unit. Maintenance can be done by simple disconnection of the pump, no valve, no danger of unauthorized change valve use.

- Even if not maintained the fine filter will do his work and the mesh filter will be active until gear oil inlet pressure drops to ultimate.
- Independent emergency oil pump running on secured DC including control system is available.



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Picture 8:  
Bad lube oil maintenance however 23 years of troublefree operation in water power.

Picture 9:  
The Oil Systems are engineered for maximum availability. They feature two spare pumps, one for AC and one for DC, emergency power.

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