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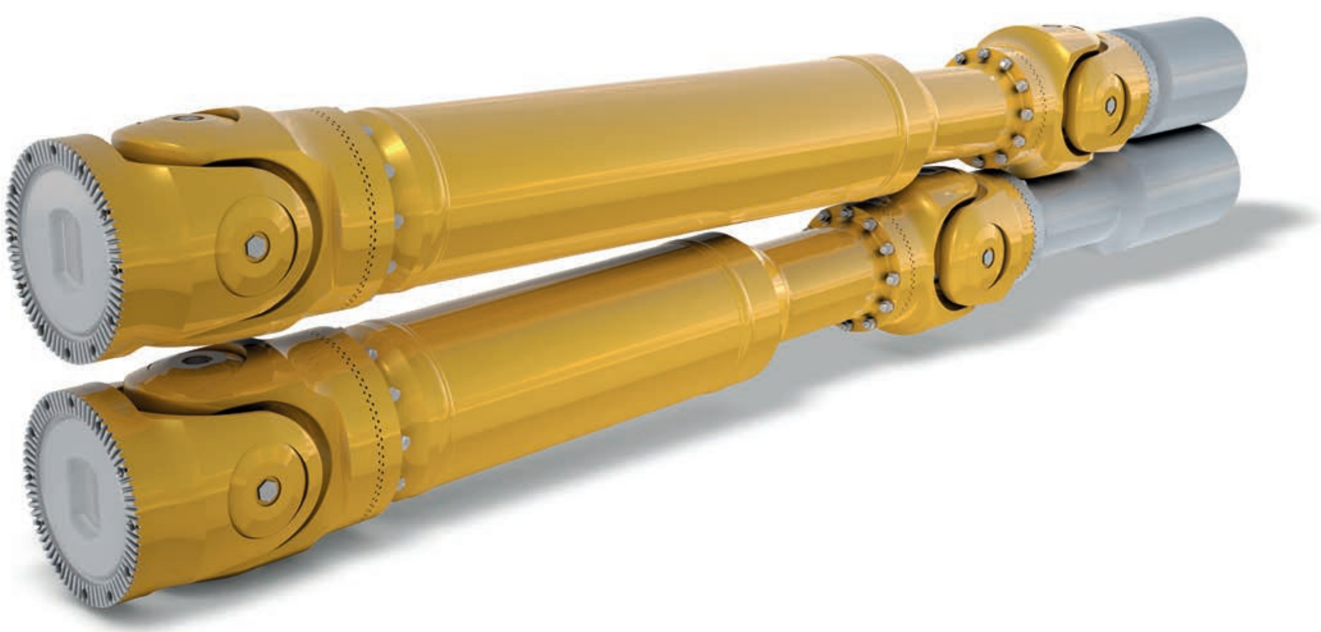
Performance enhanced cardan shaft drives for cold rolling mills



Advantages

+ High torque capacity, even at large deflection angles
+ Low life cycle costs along with reduced sensitivity to vibrations
+ Maximized efficiency through the use of roller bearings
+ Minimal maintenance

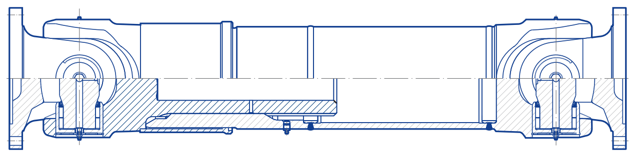
Reliable torque transmission from input to output at the highest torque capacity is the most important characteristics of Voith cardan shafts. However the drive configurations of cold rolling mill stands vary, ranging from reversing single stands on tandem drives to one-way operated five-stand production lines, for these configurations we provide special solutions meeting the highest demands!

The drive shaft diameters typically used range from approximately 350 mm to 550 mm. With these dimensions the welding-yoke and flange driver are typically designed as die forgings in order to minimize expenditure. The base design however severely restricts or can prevent further optimization, which is required in particular applications.

With your needs and requirements in mind: Voith offers the standard version, the R-Series, as well as the specialized CH-Series, which is optimized for the particularly high torque requirements in cold rolling mills.

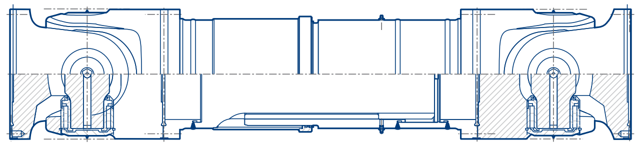
The different cardan shaft ranges available:

Type R cardan shaft (standard version)



- Torque range: 32 kNm to 1 000 kNm
- Flange diameter: 225 mm to 550 mm
- High torque capacity
- Optimized bearing life
- Flange in friction and positive locking design
- Length compensation with an involute profile – SAE profile starting from size 350; available on demand
- Optimized torsional rigidity and deflection resistance in a low-weight design
- Well suited for use in high-speed drive applications
- Optional: Low-maintenance length compensation using plastic-coated (Rilsan®) involute profiles

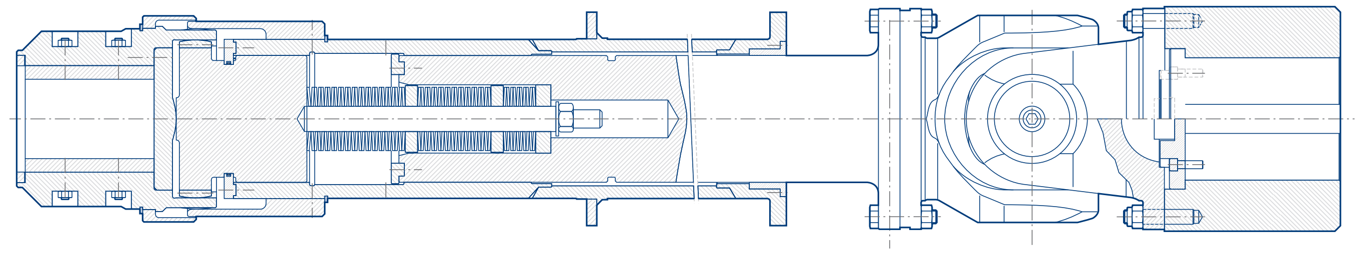
Type-CH cardan shaft (high load design)

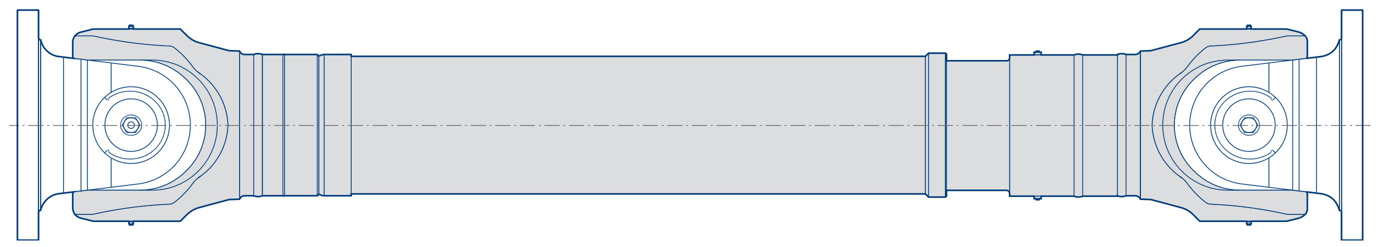


- Torque range: 140 kNm to 20 690 kNm
- Flange diameter: 350 mm to 1 460 mm
- Very high torque capacity
- Optimized bearing life
- One-piece flange yokes (integrated)
- Flange yokes (neck / neckless)
- Flange with Hirth coupling to transmit maximum torque
- Length compensation with SAE profile

Planned according to your requirements –
Voith Universal joint shafts are highly efficient in operation

		Operation principle	Flexion angle	Torque capacity	Operation clearance	Vibration	Tribology	Efficiency / power dissipation	Lubricant / environment
Gear shaft characteristics	Today, gear couplings are frequently used in cold rolling stands	Torque transmission via a crowned-toothed rim	< 2°	Required in high to very high torque conditions	Increasing play with increasing deflection angle; further play enlargement from abrasion (wear)	Vibration excitation with radial play	Sliding and rolling motion → subject to wear	99.49 % / 41.1 kW*: High power loss (due to CO_2 emissions)	• Conditional sealing with higher lubricant losses • Oil lubrication • Continuous lubricant supply required • Increased lubricant consumption
Advantages of using universal joint shafts		Cardanic torque transmission with journal cross roller bearings	> 10°	Required in low to very high torque conditions	Almost no play due to roller bearing	Minimum excitation to torsional vibration	Rolling friction → wear-free	99.996 % / 0.32 kW*: Low power loss (due to CO_2 emissions)	• Sealed roller bearings, no lubricant loss • Grease lubrication • Long relubrication intervals • Low lubricant consumption





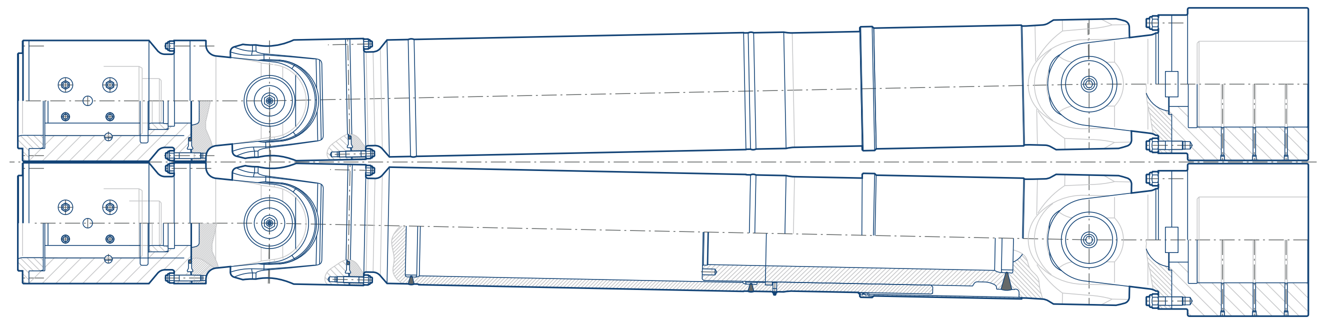
*based on 8000 kW at 2°

Conventional cardan shaft solution

For conventional rolling mill drives, the joints of the upper and lower shafts are arranged directly above one another. The maximum possible roll-side joint diameter is obtained based on the minimum work roll diameter. For highly loaded drives, the work roll diameter and joint diameter are generally the same. The selection of the work roll diameter is subject exclusively to rolling process related parameters. Technical performance dimensions of the drive shaft are normally not considered.

Consequently, the universal joint shaft needs to overcome the torque demands within the given constraints, i.e. limited space and high engine power. In some cases, this can lead to a lower than desired service life, especially on the roll-side joints. The joint dimensions on the engine side, are often reinforced beforehand due to the bigger existing center distance.

Representation of a conventional cardan shaft assembly



Advantages and disadvantages of the conventional design

Advantages

+ Identical components on upper and lower parts
+ Simple and efficient spare parts storage
+ Minimum deflection angle for both shafts, thus maximum possible service life of the cardan shaft bearings
+ Small distance between roll neck and roller-side joint, thus low forces on the connecting hub (wobbler) connection
+ Axial displaceability of the work rolls possible when using shafts with length compensation

Disadvantages

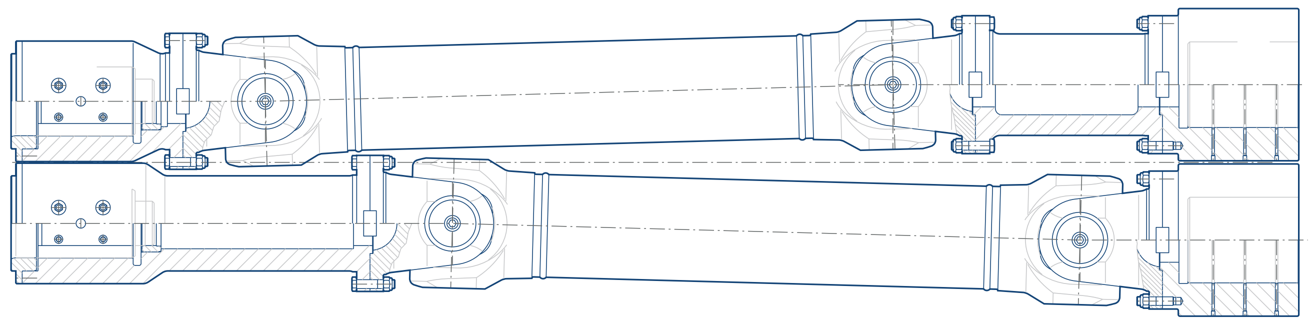
– Due to the often very high rolling torques, the bearing life of the roll-side joints can be shorter than desired
– Motor and roller-side joints are not the same size and have different lifetimes. As a result, different journal cross assemblies (cross and bearings) are required, which increases the number of spare parts

Enhanced performance achieved with a staggered arrangement

Offset designs are well-known and were established to increase the joint-diameter, winning the required space by use of an intermediate shaft with a slim shaft diameter at the opposite drive side. With the standard R-Series only smaller diameter growth differences of approximately 13 % are possible. The decisive factor here is the aforementioned limited geometric optimization range with the use of a conventional die for the welding yoke and flange yoke.

The following figure below illustrates the minimum roll diameter of 385 mm combined with an R-joint, which by the axial offset compared to a conventional arrangement already has a significantly larger joint diameter of 429 mm. Taking into account that the torque in relation to the joint diameter is increased exponential under the power of three, this equates to an approximately 40 % higher torque capacity.

Staggered arrangement of the drive shafts



Advantages and disadvantages of the staggered arrangement

Advantages

+ Identical drive shafts on the upper and lower shaft
+ High torque capacity of the roller side with at least the same torque capacity compared to gear spindles
+ Significant increase in bearing life (> factor 2) of the cardan shaft bearings
+ Motor and roller-side joints are identical and have the same long service life – normal replacement possibilities
+ Identical journal cross assemblies and thus lower spare parts expenditure

Disadvantages

– The upper and lower shafts have different roll end sleeves. Furthermore, a compensation adapter is needed at the harmonic
– The longer lever between the workroll and the joint on the bottom shaft result in higher forces at the connection point. For longer and thus heavier shafts a hydraulic roller bearing weight support, a so called spindle support, is recommended to compensate for additional forces. At the same time this is also helpful to relieve the support forces onto the workroll
– The shortened cardan shafts result in a slightly larger joint deflection angle. As a result, the bearings undergo longer rolling distances, which reduces their service life slightly

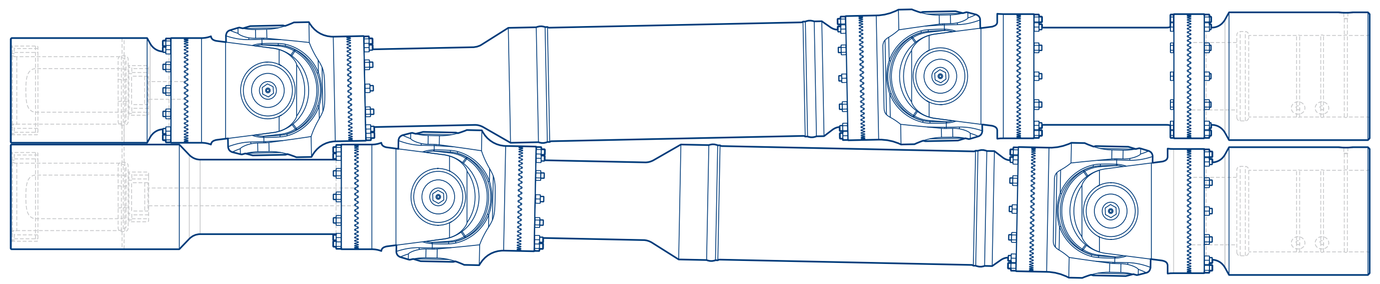
Optimized offset design with special Voith joints

The performance and design potential of the flange drivers in the CH-Series result in further performance-enhancing possibilities for the powertrain. Especially when compared to the standard R-series universal joint shaft range. The optimized offset design makes it possible to realize a joint and work roll diameter difference of up to 30 %, which corresponds to a jump of about two series sizes. The torque capacity is doubled and the bearing life of the joint bearings is increased almost tenfold.

At the same time, the joints can be replaced individually thanks to the modularity of the flange connection.

To keep the bearing diversity of the components low and thus ensure optimal availability, the journal cross assemblies of the CH-/R-Series are kept the same. These joints have been tried and tested in tens of thousands of proven installations.

Offset arrangement of the cardan shafts



Advantages of an optimized offset design

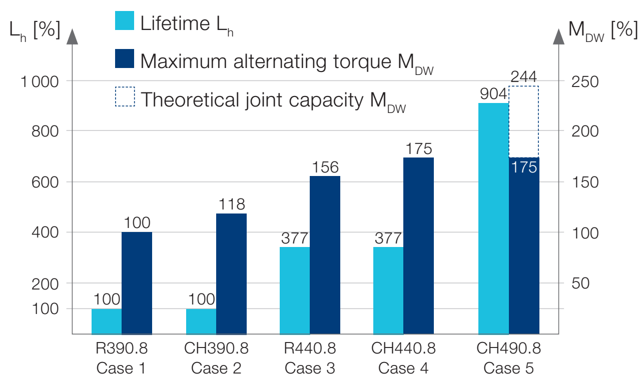
Advantages

+ Drive shafts are identical on the upper and lower shaft
+ Higher torque capacity of the roller side. Additionally even higher torque capacity compared to gear spindles
+ Significant increase in bearing life (> factor 9) of the cardan shaft bearings
+ Identical journal cross assemblies and thus lower spare parts expenditure

The case study shows a variety of possibilities and the potential for improvement.

As an example, thereafter the roll-side joint is considered at a minimum work roll diameter of 385 mm.

Case study



It can be observed that the component strength increases, with the size and type selected. A drastic increase in the bearing life and, ultimately, the service time ensues. Compared to a standard arrangement, a simple offset arrangement improves the lifetime by a factor of 3. When using an optimized offset design, the lifetime can be increased by a factor of 9.

With these high torques and small flange connection diameters, hirth toothing is indispensable. The numerous teeth distribute the torque evenly around the circumference. Furthermore, this results in a backlash free connection.

Cardan shaft specifications

Case	Propeller shaft assembly	Torques	Dimensions	Remarks
1	Standard arrangement R 390.8	M_{dw} 160 kNm (100 %) M_z 325 kNm CxR 67.1 kNm	Swing dia. 380 mm	Both variants necessary for telescopic shafts
2	Standard arrangement CH 390.8	M_{dw} 190 kNm (118 %) M_z 325 kNm CxR 67.1 kNm (L_h 100 %)	Swing dia. 380 mm	
3	Offset R 440.8	M_{dw} 250 kNm (156 %) M_z 500 kNm CxR 100 kNm (L_h 377 %)	Swing dia. 429 mm Flange Q429, not H385 Smaller W-tube, not the R-tube	Due to higher torque capacity of a CH flange yoke the offset performance can be increased.
4	Offset CH 440.8	M_{dw} 280 kNm (175 %) M_z 500 kNm CxR 100 kNm	Swing dia. 429 mm Double flange Flange Q429 or H385 Smaller W tube, not R tube	Refer to the production drawing flange yoke from R and CH and forging blank contour (page 12).
5	Offset CH 490.8	M_{dw} 280 kNm M_z 500 kNm CxR 130 kNm (L_h 904 %)	Swing dia. 490 mm Double flange Flange Q429 or H385 Special mid-section	The reduced torque capacity is due to connecting flange limitations.

For the analysis and development of an improved drive concept, we will request further information:
- Heights and distances from the gearbox to the working rolls
- Connection of the wobbler to the working roll and connecting flange to the gear pin
- Current drive shaft and the actual service life
- Motor data, gearbox data, rolling data (speed, TAF, operating hours per annum)
- What possible improvements could be made?

Project selection

The values provided below are intended to give a rough idea and a basis for orientation purposes. Starting with a given roller diameter, the corresponding CH joint with the corresponding M_{dw} values can then be selected; intermediate values being possible. Please be aware that a design assessment must however be carried out in all instances.

Selection of the cardan shaft size

Minimum working roll diameter [mm]	CH-Series	min. CH flange yoke neck neck diameter [mm]
275	350.8	272
310	390.8	305
360	440.8	355
400	490.8	395
455	550.8	450

Our broader portfolio offering includes:
- Project consultation services
- Maintenance, service advice and planning
- Complete solutions from a single source
  - from spindle supports, spindle head clamps through to special connection flanges
  - new, low-wear connection hub technology → FlexPad

For any project, upgrade or modernization project, our wealth of experience and knowledge will assist you in bringing about the most functional and cost effective operation.

Contact us at:

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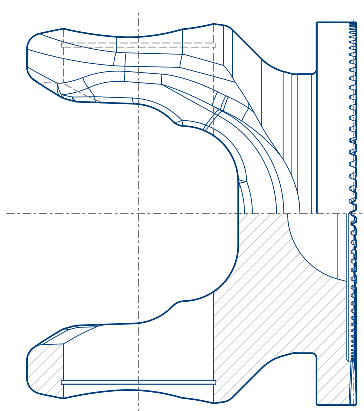
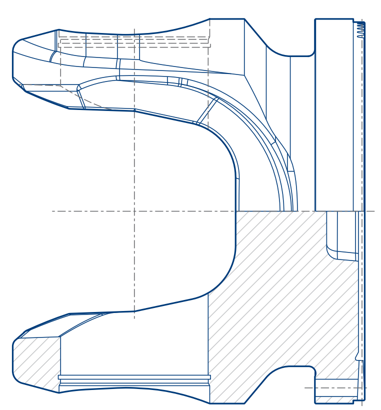
Or your local Voith representative for more information.

Appendix

Flange yokes

The standard R-Series and the more sophisticated CH-Series have two different types of flange yokes for the rota sizes of 350, 390, 440, 490 and 550 mm. Both flange drivers are die forged, yet they have differences detailed below:

Differences in flange yokes

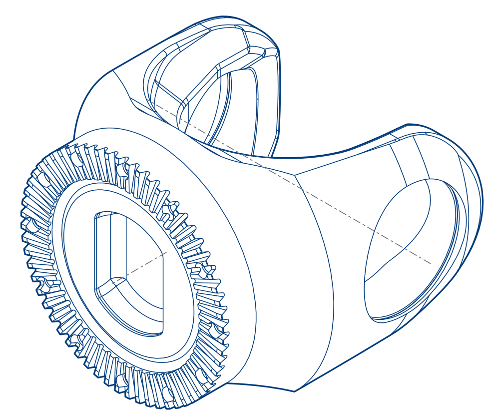
	R-Series	CH-Series
Deflection angle	Maximum 15° deflection angle	Maximum 10° deflection angle
Material	42CrMo4	High strength quenched and tempered material with about 20% higher performance
Special features	Friction-, face-key-, hirth serration-flange	Only with Hirth serration
Suitability for welding	Suitable	Not suitable
Technical drawing		

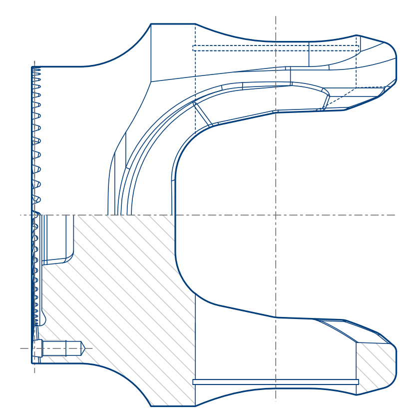
Due to the given geometry of the forging blanks of the flange yoke design, the R-Series has insufficient material space to machine to neckless design and accomodate the flange bolting threads.

The CH-Series offset flange yoke

When utilizing the CH-Series there is sufficient space for the flange bolting and hirth toothing. This is a result of the massive base material requirements for achieving the highest torques.

The transition from the yoke to the hirth serration is gentle, avoiding local stress spikes, despite the large difference in diameter (395 mm to 305 mm).





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