GEAR SPINDLES

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Gear Tooth Shape & Design

Crowned FLANKS

To maximize the gear spindle performances, the gear tooth design must be optimized, according to the following parameters:
 * Max angle of misalignment (under load)
 * Max angle of misalignment (at roll change)
 * Max operating torque
 * Peak operating torque
 * Type of drive (unidirectional or reversible)

The hub teeth have crowned flanks. This prevents gear tooth endloading, reduces contact stress and increases the contact area.

The amount of flank crown, based on the maximum angle of misalignment (usually at roll change), is optimized to obtain the minimum backlash, using specialized computer programs, verifications by 3-D modeling system and Finite Elements Analysis.

Crowned TIP

The tips of the teeth are crowned with a radius equal to the one of the mating internal gear.

The crowned external tip which is in contact with the root of the internal gear tooth, assures an accurate radial piloting, with concentric sphere/cylinder action.

This enables minimum diametral clearance, which, by centering physically the internal and external gear teeth, assures good dynamic balance characteristics under all loads, speed and misalignment conditions.

Crowned CHAMFER

Faces of the external teeth adjacent to the tips are chamfered by suitable cutting tools to eliminate interference with the internal teeth root fillets.

At the same time this assures the total contact of the gear tooth flanks and freedom to misalign.

Also the internal gear tip is chamfered to avoid dangerous vibrations during teeth movement.
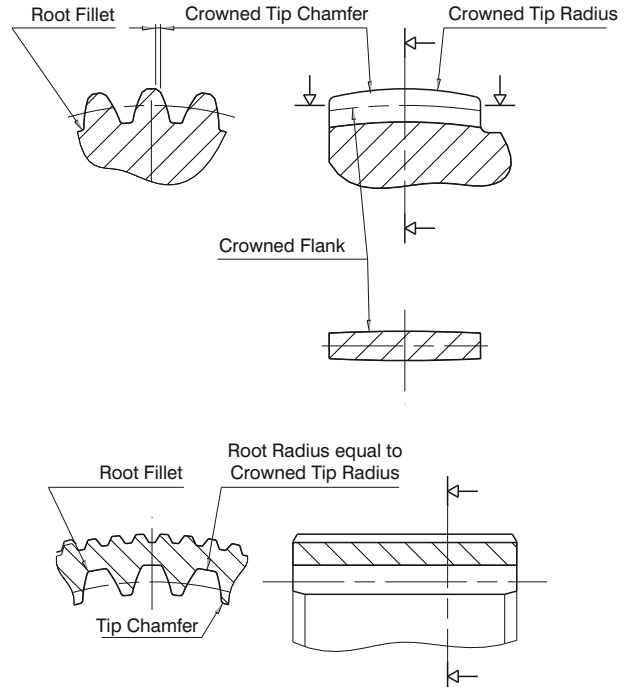
Gear Tooth Materials & Heat Treatments

Any gear spindle coupling component operating for the torque transmission is manufactured from special alloy steel and is heat treated.

The selection of a proper combination of steel and heat treatment, depending on the stressing level and the required operating life, can be:

Type A - X38CrMo V51 * SGNG

Type X38CrMo V51 alloy tool steel core hardened and tempered with final heavy duty nitriding cycle Surface hardness > 1100 [HV]
Gear teeth ground before and after nitriding

Type B - 18NiCrMo5 * CHG

Type 18NiCrMo5 alloy steel case hardened and tempered Surface hardness > 625 [Hv]
Gear teeth ground after case hardening and tempering

Type C - 31CrMo12 * SGN

Type 31CrMo12 alloy steel hardened and tempered and special gas nitriding cycle for high depth Surface hardness > 750 [HV]
On request: gear teeth ground after gas nitriding

Type D - 42CrMo4 * NGN

Type 42CrMo4 alloy steel hardened and tempered and normal gas nitriding cycle for standard depth Surface hardness > 550 [HV]

Material Type	Load & Shock Intensity				Working & No Load Angle				Operating Speed				Operating Temperature			
	L	M	H	V	L	M	H	V	L	M	H	V	L	M	H	V
A			○					○				○				○
B			○				○				○			○			
C		○					○					○				○	
D	○						○				○					○	
	L = Light M = Medium H = Heavy V = Very heavy															

Mill Spindle Size Selection

After a pre-selection made on the basis of the required design and of the available space (min. Roll Diameter), check that the final selection complies with the following conditions.

a) Rated Torque Check

The rated torques, Tk and Tf, shown in Tab. 03, correspond to the torques to be transmitted by the gear elements based on load angle = 1.5° and service factor K1 = 1.

a1) Check the Preliminary Selection by comparing the rating torque revised according to the proper factors with the continuous torque required at the max load angle.

$$Tk \cdot \frac{K2 \text{ (Tab.02)}}{K1 \text{ (Tab.01)}} \geq Td \quad \text{where:} \quad Td = \frac{N \cdot 30}{n \cdot \pi} \quad \text{and :}$$

Tk [kNm] = Fatigue Torque - (Tab. 03)
Td [kNm] = Continuous Torque per spindle
N [kW] = Motor Power per Spindle
n [RPM] = Base Spindle Speed

a2) Besides, check that :

$$Tf \cdot K2 \text{ (Tab.02)} \geq Tmax \quad \text{where:} \quad Tmax = \frac{N \cdot 30 \cdot TAF}{n \cdot \pi \cdot 100} \quad \text{and :}$$

Tf [kNm] = Peak Torque (90% Yield Limit) - (Tab. 03)
Tmax [kNm] = Max Continuous Torque for each spindle
TAF [%] = Torque Amplification Factor

Tab. 01 — Service Factor K1

Steel Mill Type	Factor K1
One Way Cold Mill & Aux Equipment	1.50 ÷ 1.75
Reversing Cold Mill	2.00 ÷ 2.50
One Way Hot Mill	2.25 ÷ 2.75
Reversing Hot Mill	3.00 ÷ 3.50

Tab. 02 — Misalignment Factor K2

Load Angle [deg°]	Factor K2
0.50°	1.40
1.00°	1.20
1.50°	1.00
2.00°	0.80
2.50°	0.65
3.00°	0.55

a3) After selecting the size, check that the minimum Roll Diameter is greater than the M1 Roll Head diameter (Tab. 04) and the M2 Pinion Head diameter is smaller than the Pinion Centers.
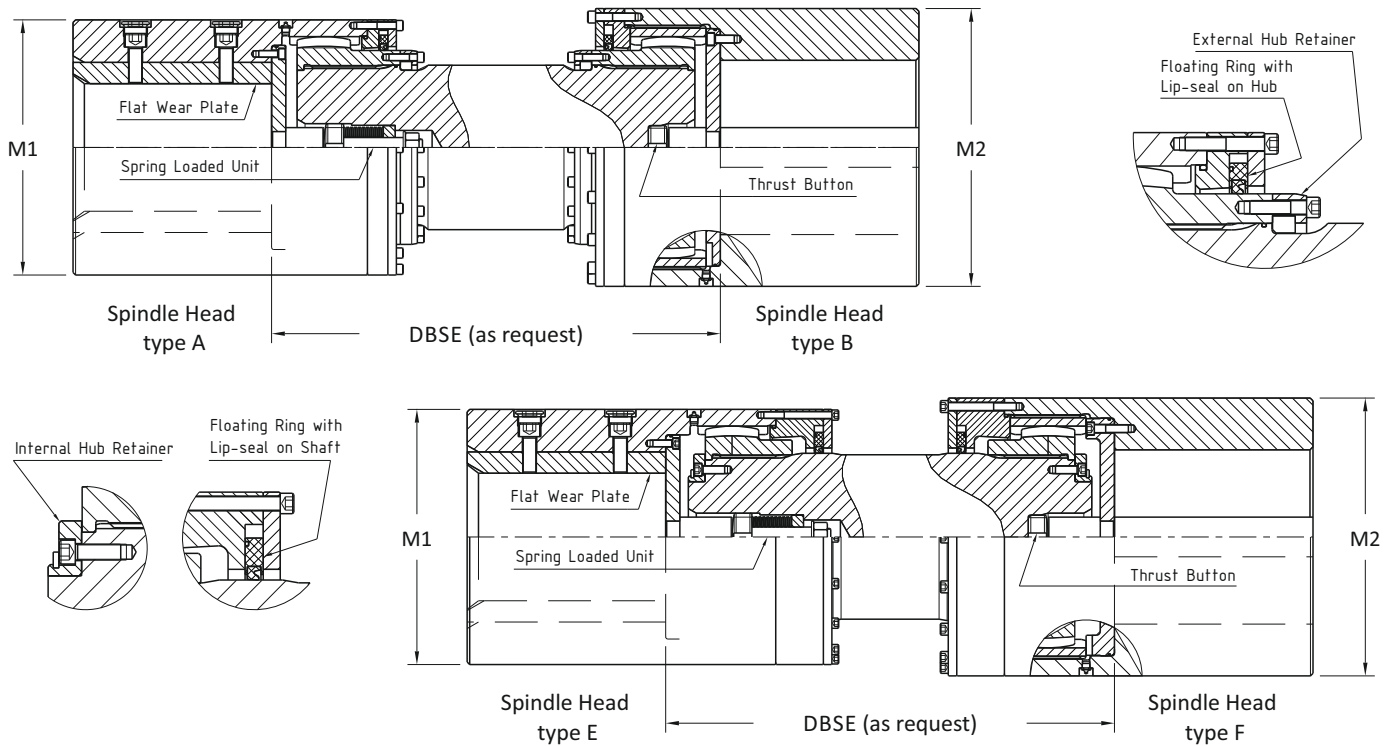
Tab. 03 — Torque Capacity at 1.5 degrees misalignment

Size	Material - type A X38CrMo V51 * SGNG Base Torque Tk [kNm]	Peak Torque Tf [kNm]	Material - type B 18NiCrMo5 * CHG Base Torque Tk [kNm]	Peak Torque Tf [kNm]	Material - type C 31CrMo12 * SGN Base Torque Tk [kNm]	Peak Torque Tf [kNm]	Material - type D 42CrMo4 * NGN Base Torque Tk [kNm]	Peak Torque Tf [kNm]
22	369	922	226	565	143	357	100	250
23	429	1072	267	667	171	962	120	300
24	488	1220	290	725	186	465	130	325
25	534	1335	316	790	201	502	139	347
27	674	1685	417	1042	262	655	184	460
28	775	1937	462	1155	295	737	205	512
29	846	2115	502	1255	320	800	222	555
31	915	2287	543	1357	345	862	239	597
32	1206	3015	751	1877	474	1185	335	837
34	1380	3450	826	2065	529	1322	369	922
36	1516	3790	897	2242	572	1430	396	990
37	1638	4095	970	2425	618	1545	428	1070
40	2285	5712	1402	3505	885	2212	617	1542
42	2620	6550	1633	4082	1030	2575	730	1825
44	3010	7525	1792	4480	1145	2862	794	1985
46	3280	8200	1945	4862	1239	3097	860	2150
48	4030	10075	2505	6262	1576	3940	1113	2782
51	4610	11525	2755	6887	1764	4410	1225	3062
53	5060	12650	2995	7487	1905	4762	1320	3300
56	5470	13675	3240	8100	2060	5150	1425	3562
59	6770	16925	4010	10025	2555	6387	1770	4425
62	7320	18300	4335	10837	2760	6900	1912	4780
64	7920	19800	4680	11700	2970	7425	2048	5120
67	8550	21375	5035	12587	3180	7950	2185	5462
70	10980	27450	6480	16200	4110	10275	2835	7087
74	11840	29600	6990	17475	4425	11062	3050	7625
77	12770	31925	7520	18800	4745	11862	3260	8150
80	13690	34225	8070	20175	5085	12712	3490	8725

Spindle Assembly AB

Spindle Assembly EF

Flat Wear Plate

Spring Loaded Unit

M1

Thrust Button

M2

Spindle Head type A

DBSE (as request)

Spindle Head type B

External Hub Retainer

Floating Ring with Lip-seal on Hub

Internal Hub Retainer

Floating Ring with Lip-seal on Shaft

Flat Wear Plate

Spring Loaded Unit

M1

Thrust Button

M2

Spindle Head type E

DBSE (as request)

Spindle Head type F

Tab. 04

SPINDLE HEAD TYPES A - B - E - F

Size	Dimensions [mm]					
			Roll Sleeve			Pinion Sleeve
	M1	M2	d1 max	d2 max	f max	d3 max
22	270	285	170	200	127	190
23	285	300	180	210	135	200
24	295	315	190	220	142	210
25	310	330	200	230	150	220
27	325	350	210	245	157	230
28	340	365	225	260	168	240
29	355	385	235	275	176	255
31	370	400	245	285	184	265
32	390	425	255	300	190	280
34	410	450	270	315	202	290
36	430	470	285	330	214	305
37	450	490	300	350	225	320
40	480	525	315	365	236	340
42	505	550	330	390	248	360
44	530	575	350	410	262	380
46	555	605	370	430	276	395
48	580	635	385	450	288	410
51	610	665	405	475	304	435
53	640	695	425	500	318	460
56	670	725	445	525	332	480
59	705	770	470	550	352	500
62	735	800	490	575	366	525
64	765	830	515	605	386	545
67	795	860	540	630	405	570
70	830	910	560	660	420	590
74	865	950	590	690	440	620
77	900	990	610	720	460	640
80	935	1030	640	750	480	670

ROLL SLEEVE FLAT KEYED BORE

f

d1

ROLL SLEEVE SHAPED BORE

f

d2

PINION SLEEVE KEYED BORE

d3
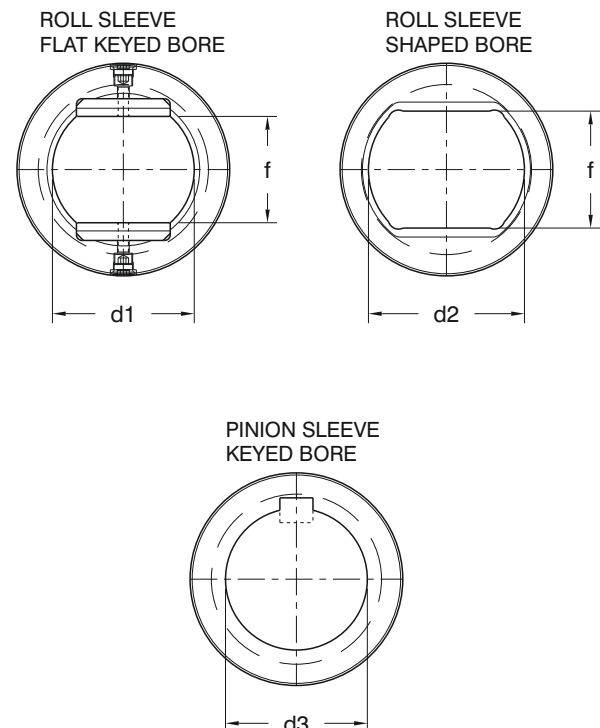
Spindle Head Bore Design

Roll End

Shaped Bore **1**

Flat Wear Plates **2**

Flat & Round Wear Plates **3**

Flat Wear Plates, End Ring Pilot & Inner Centering Bush **4**

Flat Wear Plates, End Ring Pilot & Outer Centering Bush **5**

Pinion End

1 Cylindrical Bore, One Key

2 Cylindrical Bore, Two Keys at 90°

3 Cylindrical Bore, Two Keys at 180°

4 Cylindrical Bore, Two Keys at 120°

5 Cylindrical Bore for Shrink Fit & Oil Pressure Removal

6 Double Diameter Cylindrical Bore for Shrink Fit & Oil Pressure Removal

7 Splined Bore with Pilot Diameter on Both Ends

Spindle Shaft Designs

A Standard Solid Shaft

B Standard Tubular Welded Shaft

C Long Splined Solid Shaft

D Long Splined Tubular Welded Solid Shaft

E Telescopic Solid Shaft

F Telescopic Tubular Welded Solid Shaft

G Shear-Pin Type Solid Shaft

H Shear-Pin Type Tubular Welded Shaft

J Flanged Type Tubular Welded Shaft

K Telescopic Flanged Type Tubular Welded Shaft

L Continuous Lubrication Solid Shaft

How to Identify a Mill Spindle

Head Type			Roll Bore		Pinion Bore		Gear Material		Spindle Shaft		
A	F	U	1	5	1	5	A	X38CrMoV51 SGNG	A	E	J
B	G	V	2		2	6	B	18NiCrMo5 CHG	B	F	K
C	H	W	3		3	7	D	31CrMo12 SGN	C	G	L
D	J	X	4		4		E	42CrMo4 NGN	D	H	
E	L										

See Pages : 3 & 6	See Page : 4	See Page : 4	See Page : 1	See Page : 4

How to identify an Gear Spindle   Mill Spindle type :   A 2 F B 1 C 4 6 0 2 3 0 0

Mill Spindle composed of
- : Roll End Spindle Head **A**
- : Roll End Bore Design **2**
- : Spindle Shaft Design **F**
- : Pinion End Spindle Head **B**
- : Pinion End Bore Design **1**
- : Material & Heat Treatment **C**
- : Spindle Size **46**
- : Distance Between Shaft Ends **02300**

Spindle Head Type   **A 2**   Spindle Shaft Type   **F**   Spindle Head Type   **B 1**

Spindle Arrangement   **A 2 F B 1**   Material & Size   **C 4 6**

Distance Between Shaft Ends   **0 2 3 0 0**
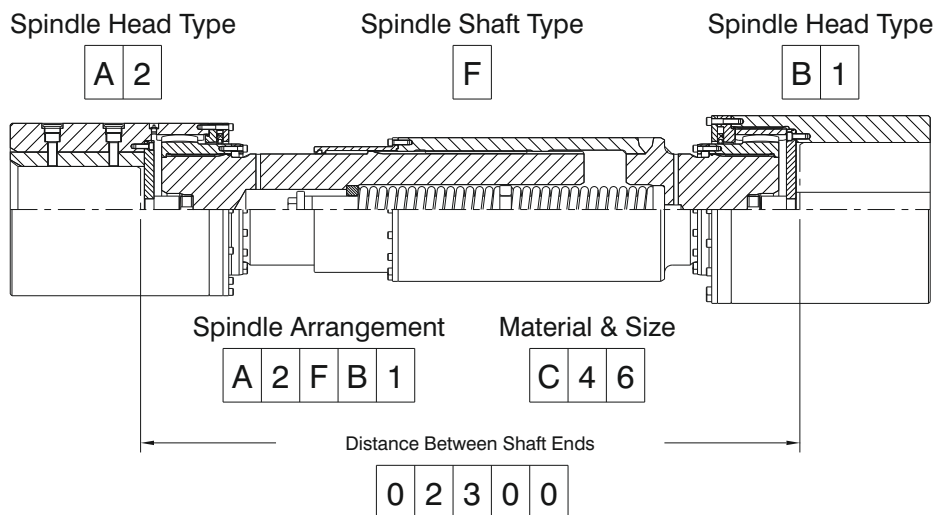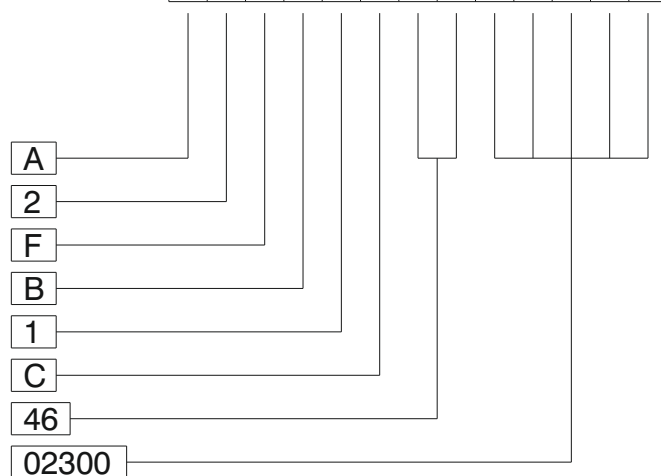
Spindle Head Special Designs
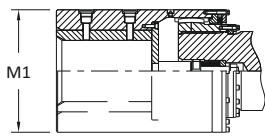
Spindle Head - type C
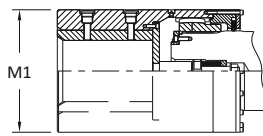
Spindle Head - type G
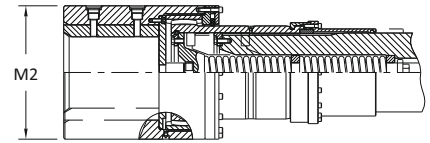
Spindle Head - type D
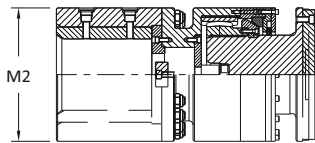
Spindle Head - type U
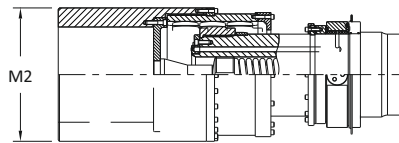
Spindle Head - type V
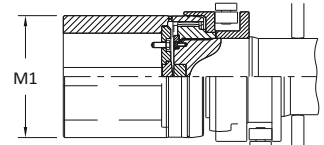
Spindle Head - type W
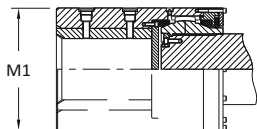
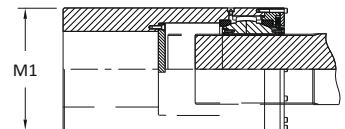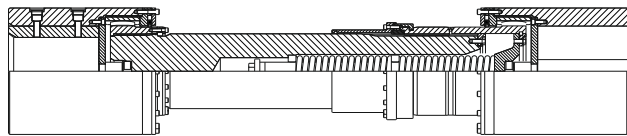Spindle Head - type H
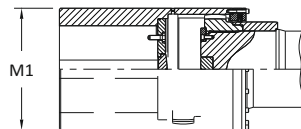
Spindle Head - type X
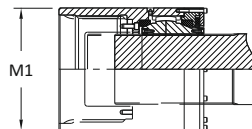
Spindle Head - type L

Spindle Head - type J

Mill Spindle Arrangements
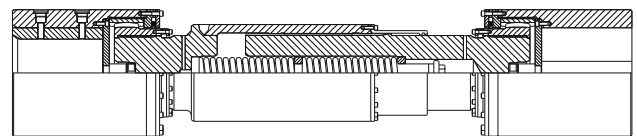
Telescopic Arrangement (stroke on sliding head)

Head - type A   Shaft - type C   Head - type D

Telescopic Arrangement (stroke on telescopic shaft)

Head - type A   Shaft - type E   Head - type A

Disengageable Arrangement

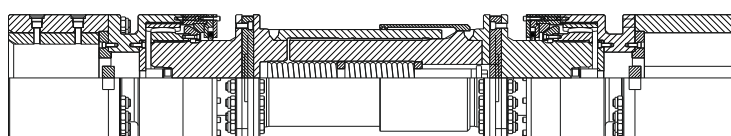Head - type W   Shaft - type A   Head - type X

Shear-Pins Arrangement
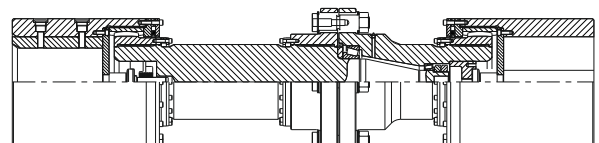
Head - type A   Shaft - type G   Head - type A
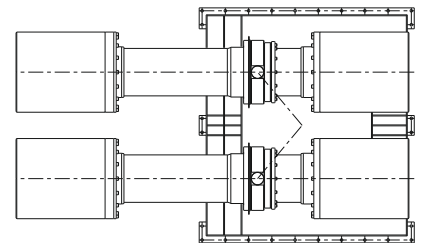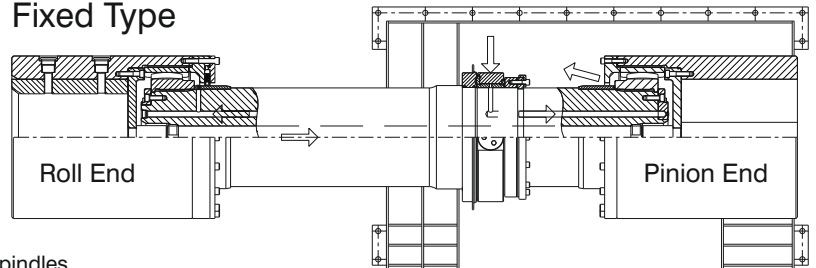
Easy Maintenance Arrangement

Head - type U   Shaft - type K   Head - type U

Circulating Oil Spindle Arrangement

This arrangement can solve technical and economic problems of lubrication, wear, heating and environmental pollution.

Fixed Type

Roll End — Pinion End

Realization

The device can be used either with fixed and telescopic spindles. To realize it, you must have a recirculating oil system or you have to connect to the centralized lubrication system for gearboxes and pinions.

The recirculating oil system must be equipped with:

* Motor pump able to feed the required quantity of oil at a pressure of 1.5-2 bar
* Adjusting equipment (pressure and capacity)
* Devices for filtering (40-63 micron) and cooling (40-45°C)
* Safety and alarm equipment.

The return oil has to be collected in a pinion side fixed sump, to be then conveyed in the oil tank.

The spindle feed system is very simple and has limited dimensions. It consists of a rotating distributor, receiving oil from the fixed feed system, and conveying it by means of pipes to the two rotating heads. The oil coming from the roll head is conveyed in the pinion head and then transferred in the collection sump.

Telescopic Type

Roll End — Pinion End
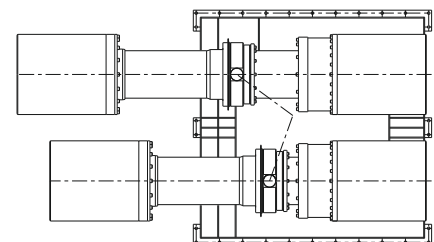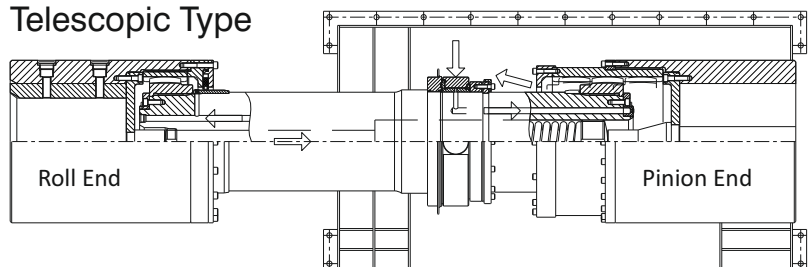
Advantages of forced lubrication.

It reduces environmental pollution and maintenance costs, as it eliminates weekly lubrication and environment cleaning, while considerably reducing lubricant consumption.

The forced lubrication and cooling system assures a long tooth lifetime and allows to reach high and concomitant angles, speed, torque, extreme working cycles which otherwise would not permit the spindle natural cooling.

As a matter of fact, by continuously conveying fresh and cool oil in the meshing area, it is possible to cool the spindles and to keep, among the teeth flanks, a coat of oil having a lubricant height able to avoid any metal/metal contact.

Also the knuckle performance is improved, so that, by reducing power loss, you can save energy.