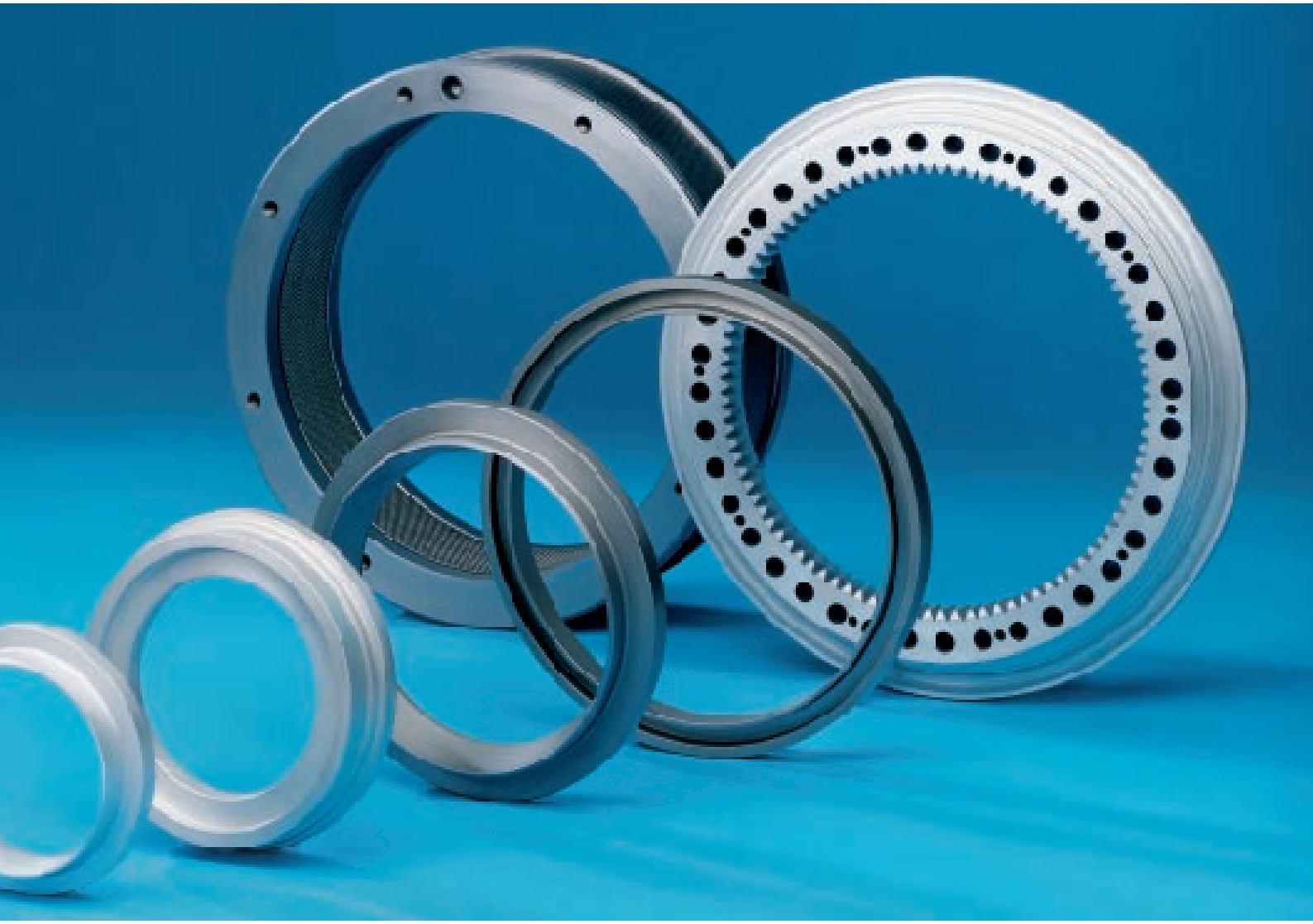
Rothe Erde Rings.

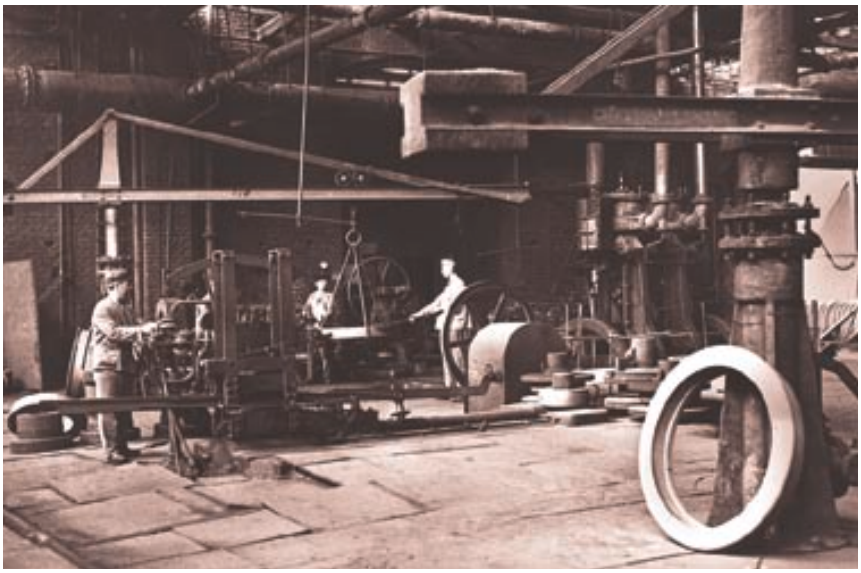


A ThyssenKrupp Technologies company

Rothe Erde

ThyssenKrupp

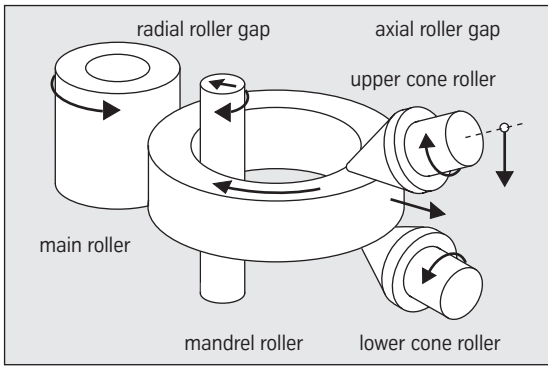
Rothe Erde.
Successfull with seamless rolled rings.



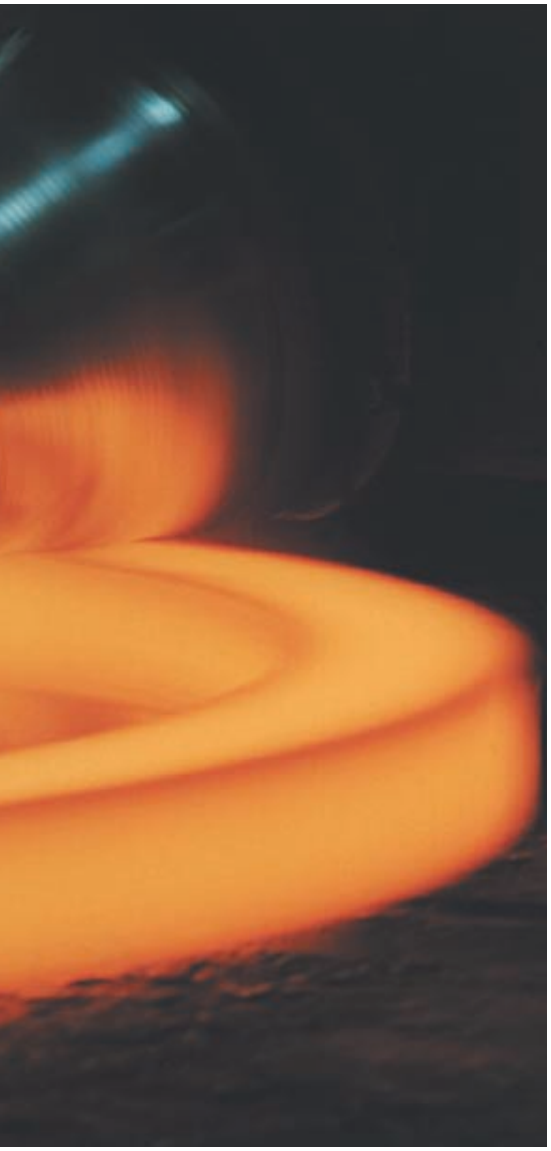
Rothe Erde is one of the world´s leading manufacturers of seamless rolled rings.

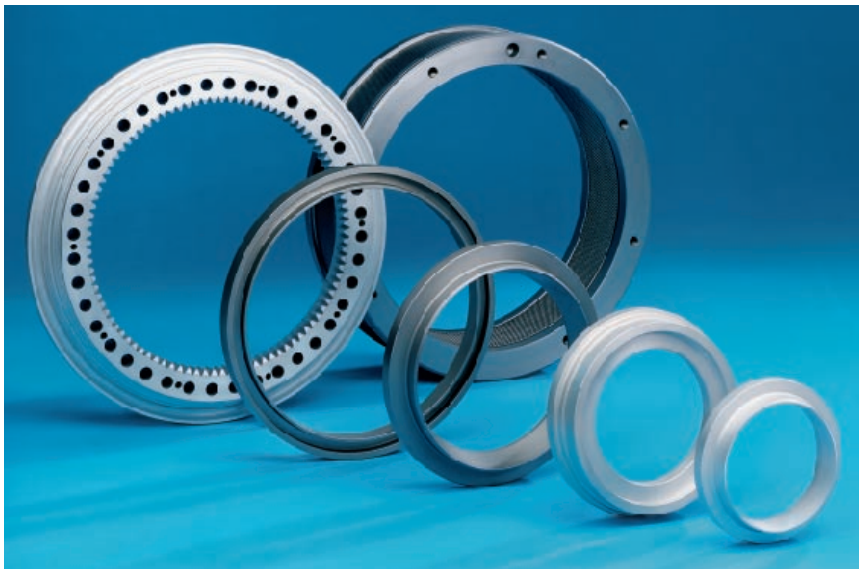
The foundation of our success and capabilities in this sector is more than 100 years of experience in steel working. Extensive know-how in open and close die forging was an excellent starting point for Rothe Erde to diligently apply and continually develop its seamless rolled rings technology. This wealth of experience, gathered over many years, gives Rothe Erde the foundation to actively take on the challenges of the markets of today and tomorrow.

Compared with other methods, e.g. ring production from heavy plate material, the manufacture of seamless rings on ring rolling mills (RAW technology) offers significant economic and technical advantages. Especially the tangential grain orientation typical for a rolled ring ensures isotropic mechanical properties over its entire circumference.



Geometrical model of a ring during the rolling process
(deformation zones shown schematically)

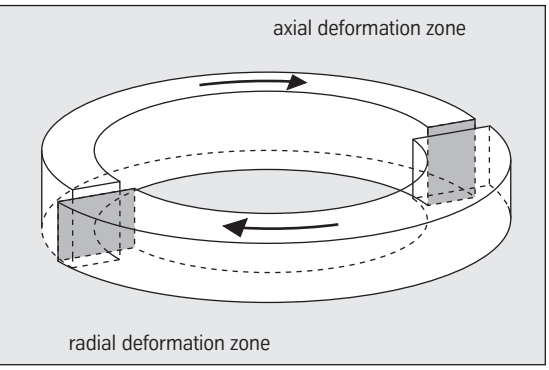




The fact that we listen to our customers has been instrumental in building our capability to offer convincing solutions for a multitude of problems.

Closeness to our customers worldwide is maintained by Rothe Erde´s subsidiaries and branches in all of the major industrialised countries. Rothe Erde is your competent partner assisting you in finding and realising application-specific solutions.

Our production facilities in Germany and in the U.S.A. supply seamless rolled rings according to your requirements, on time and to the highest quality. Our quality management, verified and accredited by independent institutes, complies with the international standard ISO 9002.



Flexibility.
The basis for rationalised ring production.

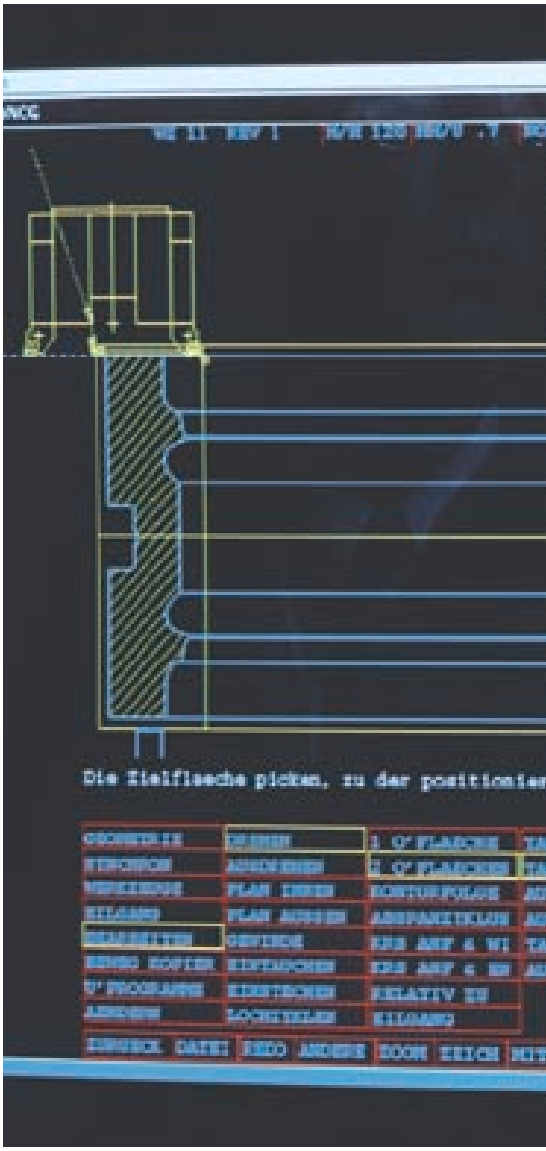
At any one time Rothe Erde holds in stock over 100 different base materials in various dimensions and adequate quantities. These materials include ingots and continuous cast qualities, pre-formed and ESR materials as well as non-ferrous metals, in particular standard aluminium alloys. It is possible to meet nearly every customer request and to keep to delivery deadlines.

Thanks to our worldwide connections, we can quickly procure materials, which are not usually held in stock. In many cases we are also able to suggest alternative materials with identical application properties.

Short throughput times are an important prerequisite for timely delivery. We achieve these by highly flexible order planning and production control.

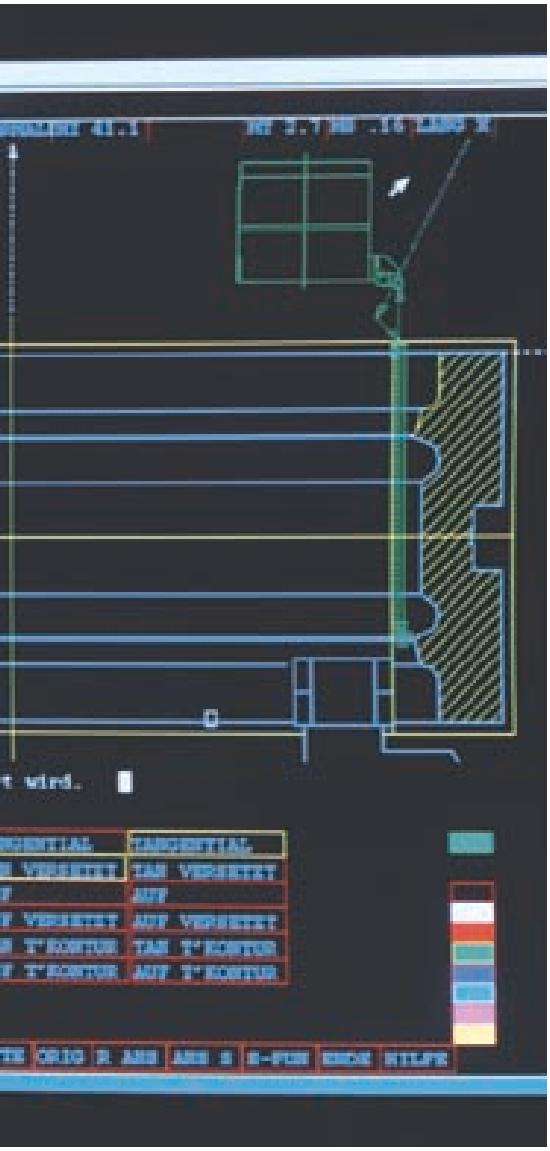
Optimising the ring dimensions as early as during the consultation phase further contributes to this flexibility. The consequent adaption of ring dimensions to the application purpose is further assisted by linked CAD and DNC programmes.

CAD-assisted optimisation of ring geometry



Simulation for DNC-controlled final machining

Partial view of the raw material stockyard



Depending on the customer´s requirements from the "simple" blank to the ready-to-install component.

The very tight manufacturing tolerances can only be achieved by precise adherence to the specified weights when the ingot is cut to length. This is ensured by modern high-powered saws with integrated weighing systems, which at the same time produce documented records for quality assurance purposes.

High-performance band saw

Productivity.
A structured production sytem.

Rothe Erde´s ring rolling mills are among the most advanced manufacturing plants of their type. They are equipped with CNC-control, automatic rolling systems and volume computers and cover a production range from 400 to 8000 millimetres outer diameter. They are the core elements of an electronically controlled, rationalised production flow with automatic loading, handling and conveying equipment.

Manipulator

RAW 80 ring rolling mill

Control desk of the RAW 315 ring rolling mill

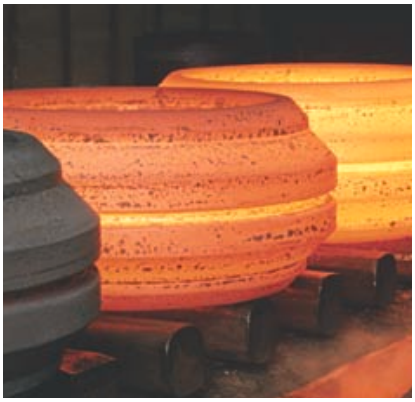
Elaborate CNC ring rolling programmes allow hitherto unattainable reproducibility and quality in the manufacture of seamless rolled rings.

It is therefore possible to select the most suitable and economical production equipment for each ring type and size for the quantity required.

Directly heated preheating furnaces with high precision control and supervising systems allow the processing of each material at its material-specific temperature range.

The hydraulic presses integrated into the production flows are adapted to the capacities of the respective ring rolling mills. They are capable of producing all required preforms, even profiled ones.

Economical material usage in its ring production is a matter of course for Rothe Erde. Optimisation during the forming stage contributes to assuring optimum material utilisation while saving costs for the customer (near-net-shape).



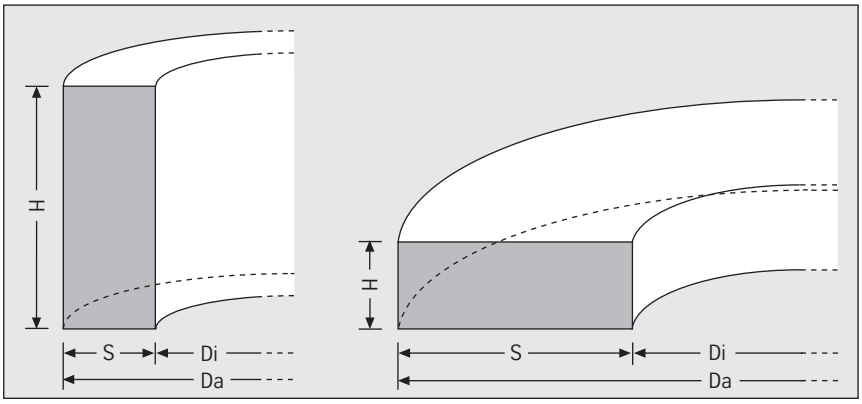
Profiled rings on the cooling bed

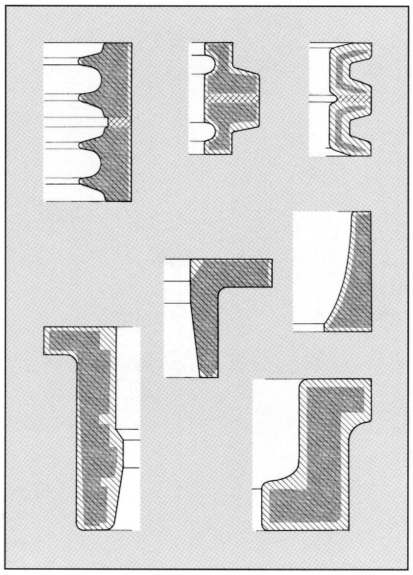
Due to their diversity, the applications of rolled rings require a large number of different cross sections and dimensions. Modern RAW ring rolling technology is flexible enough to meet such requirements. Some of Rothe Erde´s manufacturing capabilities are illustrated on this page.

The limit values indicated are not always transferable to higher-alloyed materials with very high deformation resistance.

If the ring dimensions reach two limit values in combination, the rollability must be analysed separately. With rings up to 6500 mm in diameter, it is possible to adjust the mechanical properties by appropriate heat treatment.

A complete illustration of all forming capabilities is, of course, not possible here. For further information, or for assistance with your particular needs, please contact our Customer Consultation Dept.





Examples of Near-net-shape-profiles

Production range for medium-alloyed steel (geometrical forms from cylinder to disk shapes):

Da max.:	**8000 mm**
Da min.:	**400 mm**
Di min.:	**300 mm**
Height H:	**50-900 mm**
Wall thickness S max.:	**700 mm**
Weight:	**25-25000 kgs**

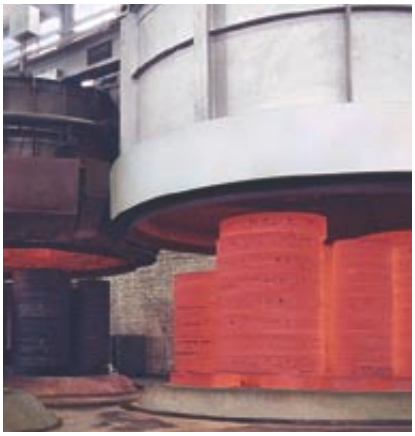
For optimum results.
Material-specific heat treatment and processing.

The achievement of optimum processing and application properties in modern materials relies on material-specific heat treatment process. In addition to know-how and experience, this requires the most advanced technical equipment and procedures.

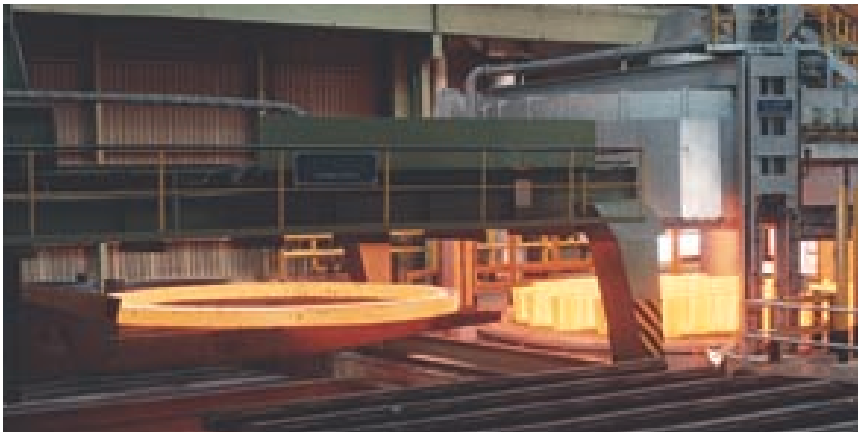
Apart from standard processes like normalising, annealing, soft annealing etc., programme-controlled processes allow precise adherence to specific time-temperature specifications for special materials (ferrous and non-ferrous alloys).

The existing installations also meet the stringent requirements for aviation and space applications.

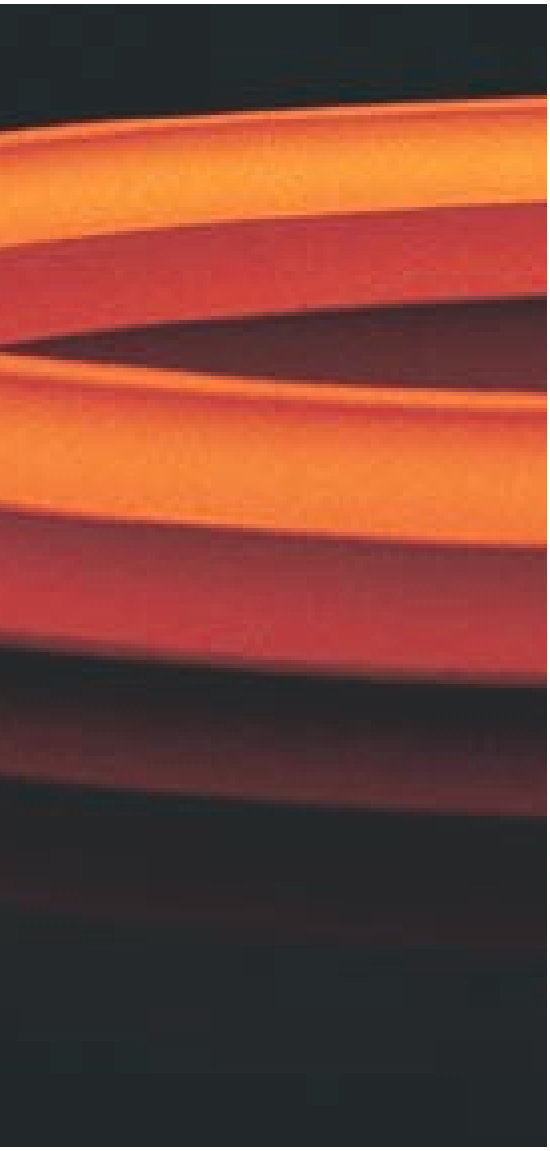
Rolled rings on the cooling bed



Bell-type annealing plant with 3 workstations

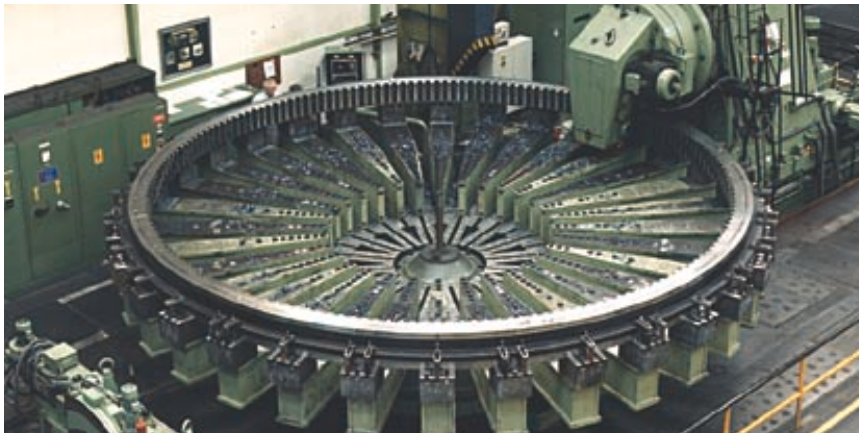


Bell-type annealing plant with manipulator for large ring diameters



We not only supply rings as rolled but will also carry out all kinds of machining in our highly capable workshops, upon request.

This includes turning, drilling and especially gear cutting. Proven facilities are available for tip circle diameters from 400 to 8000 mm. Internal gear cutting with straight teeth or external gear cutting with straight/angled teeth, and depending on the stresses that must be withstood, with inductive tooth flank or root hardening. Special procedures such as nitriding complement our programme.



Gear cutting machine

CNC processing centre

Flange machining

Rothe Erde Rings.
A single programme for individual applications.

Seamless rolled rings are gaining more and more importance as structural elements. A few examples of applications:

- High-power gears
- Turbines
- Generators
- Transformers

Gear rings

Ring for bulk-feed presses

Profile rolled titan rings for aircraft jet engines

- Hydraulic motors
- Wind energy plants
- Offshore technology
- Large valves
- Rings and supporting rings for large-diameter antifriction bearings
- Tanks/Pressure vessels
- Gear rings
- Bulk-feed presses
- Aviation and astronautics
- Mechanical engineering
- Steel mills

Finish-machined flanged rings

Structural element for offshore application

Gear rings

Rothe Erde Rings.
Quality to ISO 9002.

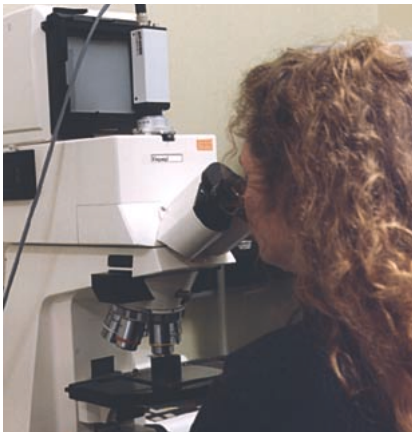
Our comprehensive quality system is approved to ISO 9002 and is regularly audited by internal and external experts.

Quality Assurance uses all of the latest procedures for destructive and non-destructive material testing. Special quality tests are carried out in close cooperation with the specialist labs of Thyssen Krupp AG and Krupp Entwicklungszentrum GmbH.

Rothe Erde uses the most advanced measuring and analysis techniques:

- Light and stereo microscopes with electronic image memory and printer
- Scanning electron microscopes with EDX analysis
- Electron beam microprobe (EMA)
- Damping pendulum
- Deformation dilatometer
- Quantitative image analyses (IBAS)

3-coordinate measuring instrument



Metallographic microstructure analysis

Scanning electron microscope

Ultrasonic testing

Rothe Erde is accredited by all leading classification and acceptance agencies such as Technischer Überwachungsverein (TÜV), Lloyd´s Register of Shipping (LRS), Det Norske Veritas (DNV) and Bureau Veritas (BV).

Worldwide operations increasingly need to be familiar with and respect international standards. It is, therefore, important to know to what extent identical analyses or application-identical material properties are meeting the requirements.

The following tables show various international standards applicable for unalloyed structural steels, quenched and tempered steels, high-alloyed steels and wrought aluminium alloys. Considering the multitude of formable materials, these lists cannot be comprehensive. Please contact Rothe Erde Customer Consultation for more information.

Unalloyed structural steels

(DIN 17 100)	EN 10025	United Kingdom BS	France NF	Italy UNI	Sweden SS/SIS	Spain UNE	USA/Canada ASTM-A	Japan JIS
St 33-2	Fe 310-0	–	A 33-2	Fe 33	1300-00	A 33-0	283 Grade A	–
USt 34-2	–	–	A 34-2	Fe 34 B FU	–	–	–	SS 34
RSt 34-2	–	–	A 34-2 NE	Fe 34 B FN	–	–	–	–
USt 37-2	Fe 360-B FU	–	E 24-2	Fe 37 B FU	1311-00	A 37-b-E	283 Grade C	–
RSt 37-2	Fe 360-B FN	–	E 24-2 NE	Fe 37 B FN	1312-00	A 37-b NE	284 Grade B	–
St 37-3 U	Fe 360-C	–	E 24-3	Fe 37 C FN	1313-00	A 37-c	–	–
St 37-3 N	Fe 360-D	–	E 24-4	Fe 37 D	–	A 37-d	–	–
USt 42-2	–	40 A	E 26-2	–	–	–	283 Grade D	SS 41
RSt 42-2	–	40 B	E 26-2 NE	Fe 42 B	–	A 42-b	284 Grade D	SM 41 B
St 42-3 U	–	40 C	E 26-3	Fe 42 C FN	–	A 42-c	572 Grade 42	SM 41 C
St 42-3 N	–	40 D	E 26-4	Fe 42 D	–	A 42-d	–	–
St 46-3 U	Fe 430-C	43 C	E 30-3	Fe 44 C	1413-00	A 44-c	572 Grade 45	–
St 46-3 N	Fe 430-D	43 D	E 30-4	Fe 44 D	1414-00	A 44-d	–	–
St 52-3 U	Fe 510-C	50 C	E 36-3	Fe 52 C	2133-01	A 52-c	440	SM 53 B
St 52-3 N	Fe 510-D	50 D	E 36-4	Fe 52 D	2134-01	A 52-d	–	SM 53 C
St 50-2	Fe 490-2	50 B	A 50-2	Fe 50	2172-00	A 50-2	572 Grade 55	SS 50
St 60-2	Fe 590-2	55 C	A 60-2	Fe 60	–	A 60-2	572 Grade 65	SM 58
St 70-2	Fe 690-2	–	A 70-2	Fe 70	–	A 70-2	–	–

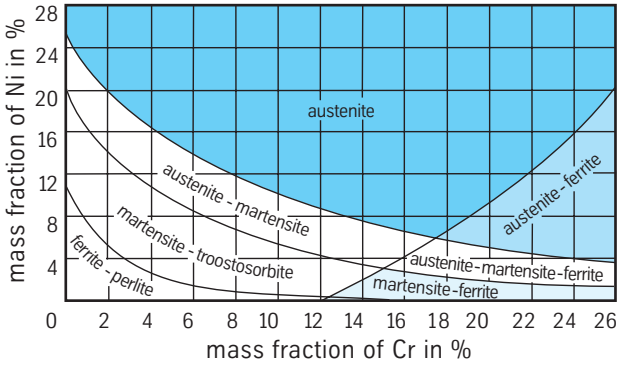
Quenched and tempered steels

(DIN 17 200)	EN 10083	United Kingdom BS 970	France NF	Italy UNI	Sweden SS/SIS	Spain UNE	USA/Canada SAE/AISI	Japan JIS
C 22	1 C 25	050 A 20	CC 20	–	–	–	1020	–
C 35	1 C 35	060 A 35	CC 35	–	1572	–	1035	–
C 45	1 C 45	080 M 46	CC 45	–	1672	–	1045	–
C 55	1 C 55	070 M 55	–	–	1674	–	1055	–
C 60	1 C 60	080 A 62	–	–	–	–	1060	–
Ck 22	2 C 25	050 A 20	XC 25	C 20	–	C 25 k	–	S 22 C
Ck 35	2 C 35	060 A 35	XC 32	C 35	–	C 35 k	–	S 35 C
Ck 45	2 C 45	080 M 46	XC 42	C 45	–	C 45 k	–	S 45 C
Ck 55	2 C 55	070 M 55	XC 55	C 50	–	C 55 k	–	S 55 C
Ck 60	2 C 60	080 A 62	XC 65	C 60	–	–	–	S 58 C
28 Mn 6	28 Mn 6	150 M 28	35 M 5	–	2120	36 Mn 6	1330	SMn 1
38 Cr 2	38 Cr 2	120 M 36	38 C 2	–	–	38 Cr 3	–	SMn 2
46 Cr 2	46 Cr 2	605 M 36	42 C 2	–	2120	–	–	SMn 3
34 Cr 4	34 Cr 4	530 A 32	32 C 4	–	–	–	5132	SCr 2
37 Cr 4	37 Cr 4	530 A 36	38 C 4	–	–	38 Cr 4	5135	SCr 3
41 Cr 4	41 Cr 4	530 M 40	42 C 4	40 Cr 4	–	42 Cr 4	5140	SCr 4
25 CrMo 4	A 25 CrMo 4	–	25 CD 4	25 CrMo 4	2225	30 CrMo 4	4130	SCM 2
34 CrMo 4	34 CrMo 4	708 A 37	35 CD 4	35 CrMo 4	2234	35 CrMo 4	4137	SCM 3
42 CrMo 4	42 CrMo 4	708 M 40	42 CD 4	40 CrMo 4	2244	40 CrMo 4	4140	SCM 4
32 CrMo 12	32 CrMo 12	722 M 24	30 CD 12	–	2240	–	–	–
36 CrNiMo 4	39 NiCrMo 3	816 M 40	40 NCD 3	40 NiCrMo 7	–	40 NiCrMo 4	–	SNC M 8
34 CrNiMo 6	35 CrNiMo 6	817 M 40	35 NCD 6	30 NiCrMo 12	2541	40 NiCrMo 7	4340	SNC M 9
30 CrNiMo 8	30 CrNiMo 8	823 M 30	30 NCD 8	–	2534	32 NiCrMo 16	–	SNC M 5
50 CrV 4	51 CrV 4	–	50 CV 4	50 CrV 4	–	F-143	6150	SUP 10

Ferritic and martensitic steels

Austenitic-ferritic steels

Austenitic steels



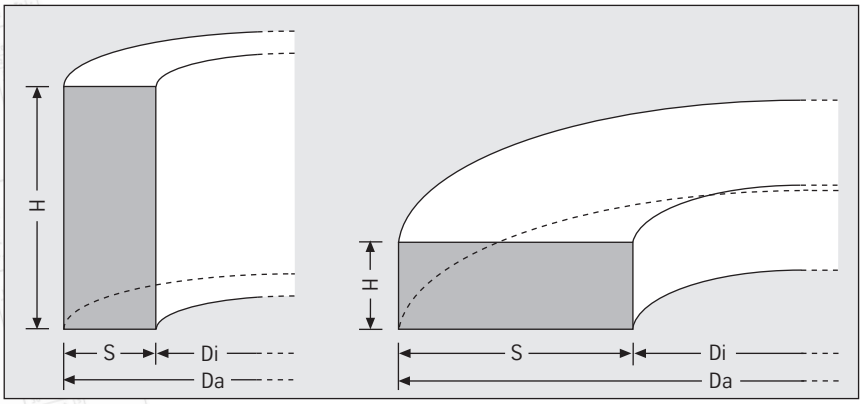
High-alloyed steels

Steel grade DIN 17 440/SEW 400 Mat. No.	Designation	ISO-Standard 683/13	EURO Standard 88-86	United Kingdom BS	France NF	Sweden SS/SIS	Spain UNE	USA Canada AISI UNS	Japan JIS
1.4000	X 6 Cr 13	1	X 6 Cr 13	403 S 17	Z 6 C 13	(2301)	3110	410 S	410 S
1.4002	X 6 CrAl 13	2	X 6 CrAl 13	405 S 17	Z 6 CA 13	–	3111	405	405
1.4006	X 10 Cr 13	3	X 10 Cr 13	(410 S 21)	(Z 12 C 13)	2302	(3401)	(410)	(410)
1.4104	X 12 CrMoS 17	9 a	X 14 CrMoS 17	–	Z 10 CF 17	2383	3117	–	430 F
1.4105	X 4 CrMoS 18	–	–	–	–	–	–	–	–
1.4510	X 6 CrTi 17	8 b	X 5 CrTi 17	–	Z 8 CT 17	2326	3114	439	430 LX
1.4512	X 6 CrTi 12	1 Ti	X 6 CrTi 12	409 S 19	Z 6 CT 12	–	–	409	409
1.4021	X 20 Cr 13	4	X 20 Cr 13	(420 S 29)	(Z 20 C 13)	2303	3402	(S 42010)	420 J 1
1.4024	X 15 Cr 13	3	X 15 Cr 13	(420 S 29)	(Z 12 C 13)	2302	(3401)	(410)	(410)
1.4028	X 30 Cr 13	5	X 30 Cr 13	420 S 45	(Z 30 C 13)	2304	3403	420 B	420 J 2
1.4031	X 38 Cr 13	–	X 40 Cr 13	–	(Z 40 C 14)	–	(3404)	420 X	420 J 2
1.4034	X 46 Cr 13	–	X 45 Cr 13	–	Z 40 C 13	–	3405	420 C	–
1.4057	X 20 CrNi 17 2	9 b	X 19 CrNi 17 2	431 S 29	Z 15 CN 16.02	2321	3427	431	431
1.4112	X 90 CrMoV 18	–	–	–	(Z 90 CDV 18)	–	–	(440 B)	440 B
1.4116	X 45 CrMoV 15	–	–	–	(Z 50 CD 13)	–	–	–	–
1.4120	X 20 CrMo 13	–	–	–	Z 20 CD 13	–	–	–	–
1.4122	X 35 CrMo 17	–	–	–	–	–	–	–	–
1.4125	X 105 CrMo 17	–	–	–	Z 100 CD 17	–	–	440 C	440 C
1.4418	X 4 CrNiMo 16 5	–	–	–	Z 5 CND 17.05	2387	–	–	–
1.4460	X 4 CrNiMoN 27 5 2	–	–	–	(Z 8 CND 26.05)	2324	–	329	(329 J 1)
1.4462	X 2 CrNiMoN 22 5 3	–	–	–	Z 2 CND 22.5 AZ	2377	–	S 31803	–
1.4301	X 5 CrNi 18 10	11	X 5 CrNi 18 10	304 S 15/16/31	Z 6 CN 18.09	2332	3504	304	304
1.4303	X 5 CrNi 18 12	13	X 5 CrNi 18 12	305 S 19	Z 4 CN 18.12	–	3513	(305)	305 J 1
1.4305	X 10 CrNiS 18 9	17	X 10 CrNiS 18 9	303 S 31	Z 10 CNF 18.09	2346	3508	303	303
1.4306	X 2 CrNi 19 11	10	X 2 CrNi 18 10	304 S 11	Z 2 CN 18.10	2352	3503	304 L	304 L
1.4311	X 2 CrNiN 18 10	10 N	X 2 CrNiN 18 10	(304 S 61)	Z 2 CN 18.10 AZ	2371	–	304 LN	304 LN
1.4541	X 6 CrNiTi 18 10	15	X 6 CrNiTi 18 10	321 S 31	Z 6 CNT 18.10	2337	3523	321	321
1.4550	X 6 CrNiNb 18 10	16	X 6 CrNiNb 18 10	347 S 31	Z 6 CNNb 18.10	2338	3524	347	347
1.4401	X 5 CrNiMo 17 12 2	20	X 5 CrNiMo 17 12 2	316 S 31	Z 6 CND 17.11	2347	3534	316	316
1.4404	X 2 CrNiMo 17 13 2	19	X 2 CrNiMo 17 13 2	316 S 11	Z 2 CND 17.12	2348	3533	316 L	316 L
1.4406	X 2 CrNiMoN 17 12 2	19 N	X 2 CrNiMoN 17 12 2	(316 S 61)	Z 2 CND 17.12 AZ	–	–	316 LN	316 LN
1.4429	X 2 CrNiMoN 17 13 3	19 a N	X 2 CrNiMoN 17 13 3	(316 S 63)	Z 2 CND 17.13 AZ	2375	3534	316 LN	316 LN
1.4435	X 2 CrNiMo 18 14 3	19 a	–	316 S 13	Z 2 CND 17.13	2353	3533	316 L	316 L
1.4436	X 5 CrNiMo 17 13 3	20 a	X 5 CrNiMo 17 13 3	316 S 33	Z 6 CND 17.12	2343	–	316	316
1.4438	X 2 CrNiMo 18 16 4	24	X 2 CrNiMo 18 16 4	317 S 12	Z 2 CND 19.15	2367	–	(317 L)	317 L
1.4439	X 2 CrNiMoN 17 13 5	–	X 2 CrNiMoN 17 13 5	–	–	–	–	–	–
1.4539	X 1 NiCrMoCu 25 20 5	A-4	–	–	Z 1 CNDU 25.20	2562	–	–	–
1.4571	X 6 CrNiMoTi 17 12 2	21	X 6 CrNiMoTi 17 12 2	320 S 31	Z 6 CNDT 17.12	2350	3535	316 Ti	–

Wrought aluminium alloys

DIN 1725	DIN 17007	ISO	Int. Reg. Record (AA)	United Kingdom BS (old)	France NF (old)	Italy UNI	Sweden SS/SIS	Spain UNE	Japan JIS (old)
AlMn 1	3.0515	Al-Mn 1	3103	N 3	–	3568	4054	L-3810	–
AlMnCu	3.0517	Al-Mn 1 Cu	3003	–	A-M 1	7780	–	–	A 2 x 3
AlMn 1 Mg 1	3.0526	–	3004	–	A-MG 1	6361	–	L-3820	–
AlMg 1	3.3315	Al-Mg 1	(5005 A)	N 41	A-G 06	5764	4106	L-3350	A 2 x 8
AlMg 1,5	3.3316	Al-Mg 1,5	(5050 B)	–	–	3573	–	L-3380	–
AlMg 3	3.3535	Al-Mg 3	5754	–	A-G 3 M	3575	4133	L-3390	–
AlMg 4,5	3.3345	–	5082	–	A-G 4,5	5420	–	–	–
AlMg 5	3.3555	Al-Mg 5	5056 A	N 6	–	3576	4146	L-3320	A 2 x 2
AlMg 2,7 Mn	3.3537	Al-Mg 3 Mn	5454	N 51	A-G 2,5 MC	7789	–	–	(A 2 x 9)
AlMg 4 Mn	3.3545	Al-Mg 4 Mn	5086	–	A-G 4 MC	5452	–	L-3322	–
AlMg 4,5 Mn	3.3547	Al-Mg 4,5 Mn	5083	N 8	A-G 4,5 MC	7790	4140	L-3321	A 2 x 7
AlMgSiCu	3.3211	Al-Mg 1 SiCu	6061	H 20	A-GSUC	6170	–	L-3420	A 2 x 4
AlMgSi 1	–	Al-Si 1 MgMn	6082	H 30	A-SGM 07	3571	4212	L-3451	–
–	–	Al-Si 1 Mg	6351	–	–	–	–	–	–
AlCu 2,5 Mg 0,5	3.1305	Al-Cu 2 Mg	2117	3 L 86	A-U 2 G	3577	–	L-3180	A 3 x 3
AlCuMg 1	3.1325	Al-Cu 4 MgSi	2017 A	–	A-U 4 G	3579	–	L-3120	A 3 x 2
AlCuMg 2	3.1355	Al-Cu 4 Mg 1	2024	–	A-U 4 G 1	3583	–	L-3140	A 3 x 4
AlCuSiMn	3.1255	Al-Cu 4 SiMg	2014	H 15	A-U 4 SG	3581	4338	L-3130	A 3 x 1
–	–	–	2001	–	A-U 6 MGT	–	–	–	–
AlZn 1	3.4415	Al-Zn 1	7072	–	A-Z 1	–	–	L-3721	–
AlZn 4,5 Mg 1	3.4335	Al-Zn 4,5 Mg 1	7020	H 17	A-Z 5 G	7791	4425	L-3741	7 N 01
(AlZn 5 Mg)	–	–	7005	–	–	–	–	–	–
AlZnMgCu 0,5	3.4345	–	7022	–	A-Z 4 GU	–	–	–	–
AlZnMgCu 1,5	3.4365	Al-Zn 6 MgCu	7075	2 L 95	A-Z 5 GU	3735	–	L-3710	A 3 x 6
(AlZn 8 MgCu)	(3.4394)	–	7049 A	–	A-Z 8 GU	3737	–	–	–
(AlCu 63)	–	–	2219	–	–	–	–	–	–
(AlZnMg 2 Cu 1,7 Zr)	–	–	7010	–	–	–	–	–	–

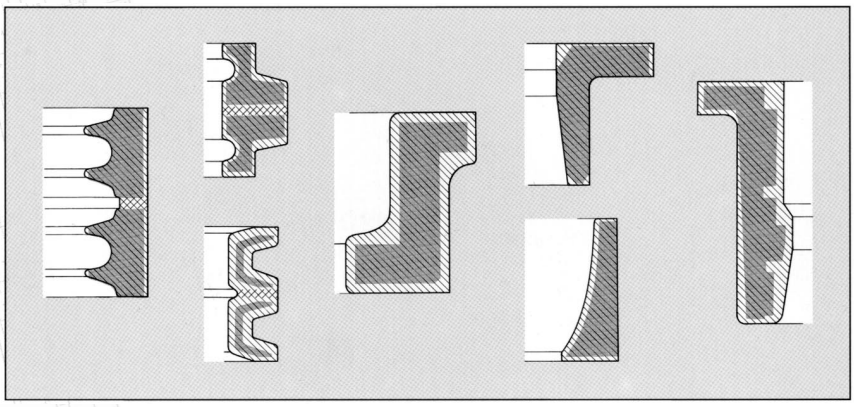
Manufacturing range in medium-alloyed steels



Geometrical forms from cylinder to disk shapes:

Da max.:	**8000 mm**
Da min.:	**400 mm**
Di min.:	**300 mm**
Height H:	**50-900 mm**
Wall thickness S max.:	**700 mm**
Weight:	**25-25000 kgs**

Examples of Near-net-shape-profiles



Rothe Erde would like to offer you the most cost-effective solution for your application. Please help us by making your inquiry as precise as possible, by enclosing for example data on batch sizes or finished parts drawings.

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