4 The Basics

4.1 Structure of a Conveyor Chain

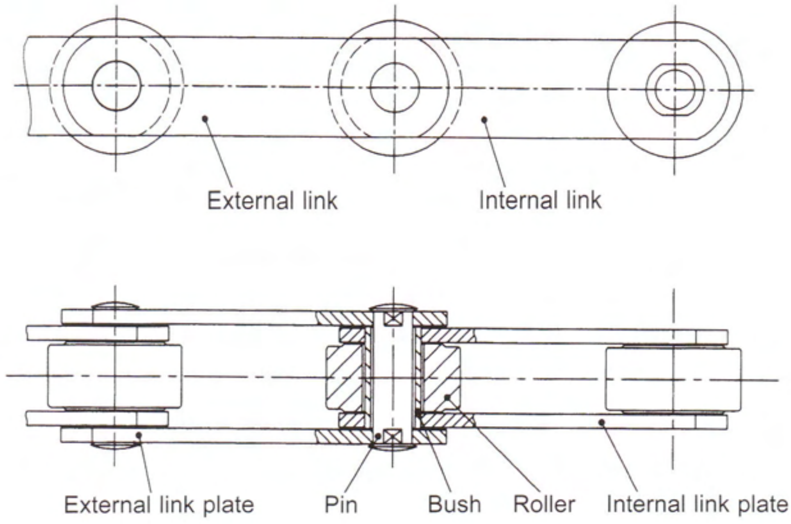


Fig. 1: Structure of a conveyor chain

Link plates	are made of steel according to DIN 17100 or DIN17200 with a minimum tensile strength of 600 N/mm², or of stainless or heat-resisting steel. The surface is strain-hardened by shot-peening to increase the endurance strength. If necessary, a thermal treatment and / or a surface refinement is carried out.
Pins	are made of case hardened steel according to DIN 17210 or of quenched and tempered steel according to DIN 17200 due to being subject to wear, bending and shearing-off. To achieve a high surface hardness and a high toughness of the pin core, the pins are additionally heat-treated, applying the procedures of case hardening, quenching and tempering, and boundary-layer hardening.
Bushes	are subject to wear, bending and surface pressure. As material, mainly case hardened steel is used. Like the pins they are heat-treated to improve their material properties.
Small rollers	are subject to wear and shock. They are made of case hardened or quenched and tempered steel with a corresponding heat treatment.
Large rollers / collar rollers	are subject to high wear. They are made of case hardened steel or of boundary-layer hardenable quenched and tempered steel. Normally, the running surface is hardened. The bearing surface is either hardened, or plain bearings or rolling bearings are used. As plain bearings, especially wear resisting bushes, porous bearings, low-maintenance plain bearings, plastic bushes, etc. can be used. As rolling bearings, mainly deep groove ball bearings, cylindrical roller bearings, or needle roller bearings are used. Plain and rolling bearings are also used if the tensile force of the conveyor chain has to be maintained as low as possible.
Pushing / Fastening links	are chain links to which fastening or pushing elements are bolted or welded on. They are also produced as compact parts. The shape of these elements depends particularly on the type of the material to be conveyed.

If the chain is intended to be used in extraordinary conditions, such as high or low temperatures, water or aggressive media, we select the best suited materials for the construction of the individual parts of the conveyor chain. In the production of our conveyor chains we direct our greatest attention to three important quality features:

• **High pitch accuracy**	to ensure perfect engagement conditions between chain and chain wheel,
• **Exact drive-fit connections**	between pins and link plates, or bushes and link plates, to ensure the resistance against laterally acting forces to be as great as possible,
• **Exact articulation clearance**	adapted to the application, as a prerequisite for low wear and tear and a long lifetime.

4.2 Lubrication of a Conveyor Chain

The links of a conveyor chain are connected with each other by means of pins and bushes (articulation elements). When the chain is guided round the chain wheel, an oscillating movement is produced between pin and bush, leading to energy loss, wear and disturbing noise. These unpleasant side effects, which also have a negative influence on the lifetime, are counteracted by a lubrication adapted to the operational conditions. At the same time the corrosion of the conveyor chain is minimised. The conveyor chains delivered have been provided by the company with a first lubrication and protection against corrosion. It is essential that the user relubricates the chain regulary.

The user should also take into account that the cleaning of the chain depends on the lubrication method. After cleaning you must ensure that there is still sufficient corrosion protection.

Conveyor chains can be constructed in such a way that regreasing can be carried out through lubricating nipples and bore holes. Also automatic lubrication systems are common in transporting plants with conveyor chains. They have the advantage that unexpected dry-running is avoided and an optimal dosage of the lubricant is possible.

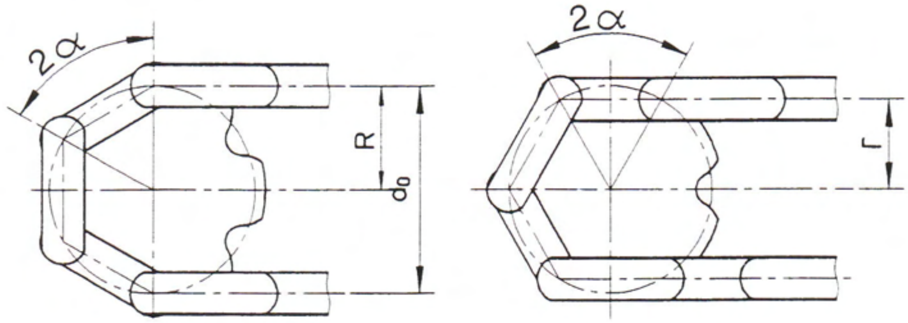
The selection of the chain lubricant depends on the operating conditions of the transporting plant and the requirements of the material to be conveyed. The main features for the selection of a suitable lubricant are:

- Ambient temperature
- Strain on chain conveyor
- Conveying speed
- Aggressiveness and state of aggregation of the surrounding media
- Ability to run after failure of lubricant supply
- Suitability for the intended lubrication method

4.3 Chain Drive Kinematics

4.3.1 Polygon Effect

When the chain is turning round the chain wheel, speed variations are produced due to the fact that the chain does not describe the circuit of the pitch circle, but forms a polygon. It moves towards the centre of the chain wheel causing a chain speed reduction, while rotation remains uniform (polygon effect).



$$V_{max} = \frac{d_0 \cdot \pi \cdot n}{60 \cdot 1000} \left[\frac{m}{s}\right] \qquad V_{min} = \frac{d_0 \cdot \cos\alpha \cdot \pi \cdot n}{60 \cdot 1000} \left[\frac{m}{s}\right]$$

4.3.2 Speed Variations in Dependence on the Number of Teeth

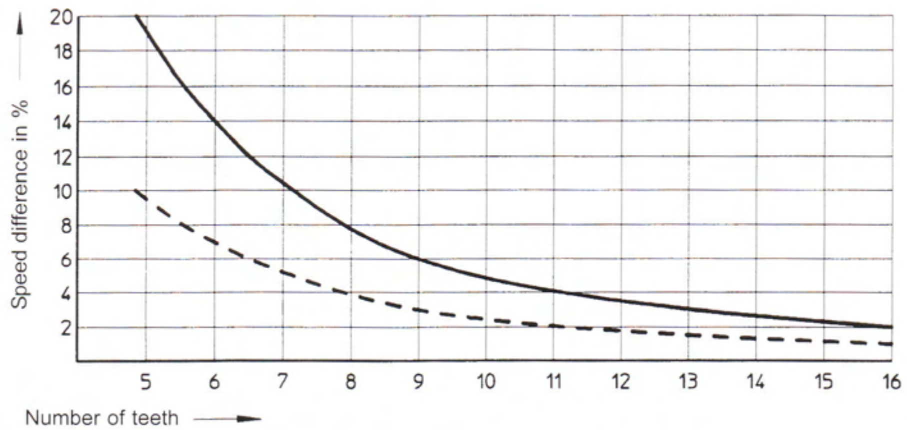


Fig. 3: Speed difference in dependence on the number of teeth

Conveyor chains with rollers running externally allow the chain to be guided on both sides up to the middle of the chain wheel, by which a 50% reduction of the speed difference can be achieved. This means that the run-in speed of the chain link into the chain wheel toothspace is delayed to zero and that the run-in noise is reduced.

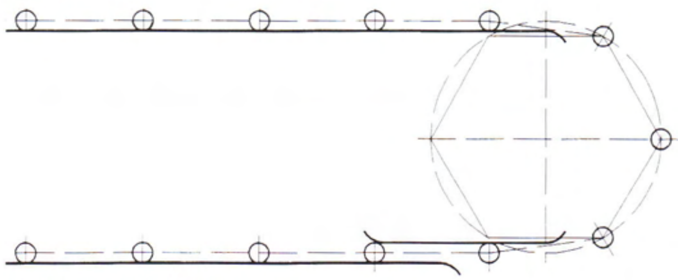


Fig. 4: Measures to reduce the speed difference

4.3.3 Pitch Diameter of the Chain Wheel

$$d_0 = \frac{p}{\sin\left(\frac{180^\circ}{z}\right)} \; [\text{mm}] \qquad p = \text{pitch} \qquad \text{or} \qquad d_0 = p \cdot n$$

z	n	z	n	z	n	z	n	z	n	z	n
6	2,0000	16	5,1258	26	8,2962	36	11,4737	46	14,6536	56	17,8347
7	2,3048	17	5,4422	27	8,6138	37	11,7916	47	14,9717	57	18,1529
8	2,6131	18	5,7588	28	8,9314	38	12,1096	48	15,2898	58	18,4710
9	2,9238	19	6,0755	29	9,2491	39	12,4275	49	15,6079	59	18,7892
10	3,2361	20	6,3925	30	9,5668	40	12,7455	50	15,9260	60	19,1073
11	3,5495	21	6,7095	31	9,8845	41	13,0635	51	16,2441	61	19,4255
12	3,8637	22	7,0267	32	10,2023	42	13,3815	52	16,5622	62	19,7437
13	4,1786	23	7,3439	33	10,5201	43	13,6995	53	16,8803	63	20,0618
14	4,4940	24	7,6613	34	10,8380	44	14,0175	54	17,1984	64	20,3800
15	4,8097	25	7,9787	35	11,1558	45	14,3356	55	17,5166	65	20,6982

Tab. 1: Factor n

p / z	40	50	63	80	100	125	160	200	250	315	400
6	80,00	100,00	126,00	160,00	200,00	250,00	320,00	400,00	500,00	630,00	800,00
7	92,19	115,24	145,20	184,38	230,48	288,10	368,76	460,96	576,20	726,01	921,92
8	104,52	130,65	164,62	209,04	261,31	326,63	418,09	522,62	653,27	823,12	1045,24
9	116,95	146,19	184,19	233,90	292,38	365,47	467,80	584,76	730,95	920,99	1169,52
10	129,44	161,80	203,87	258,88	323,61	404,51	517,77	647,22	809,02	1019,37	1294,44
11	141,98	177,47	223,61	283,96	354,95	443,68	567,92	709,90	887,37	1118,09	1419,80
12	154,54	193,18	243,41	309,09	386,37	482,96	618,19	772,74	965,92	1217,06	1545,48
13	167,14	208,93	263,25	334,28	417,86	522,32	668,57	835,72	1044,65	1316,25	1671,44
14	179,76	224,70	283,12	359,52	449,40	561,75	719,04	898,80	1123,50	1415,61	
15	192,38	240,48	303,01	384,77	480,97	601,21	769,55	961,94	1202,42	1515,05	
16	205,03	256,29	322,92	410,06	512,58	640,72	820,12	1025,16	1281,45	1614,62	
17	217,68	272,11	342,85	435,37	544,22	680,27	870,75	1088,44	1360,55	1714,29	
18	230,35	287,94	362,80	460,70	575,88	719,85	921,40	1151,76	1439,70		
19	243,02	303,77	382,75	486,04	607,55	759,43	972,08	1215,10	1518,87		
20	255,70	319,62	402,72	511,40	639,25	799,06	1022,80	1278,50	1598,12		
21	268,38	335,47	422,69	536,76	670,95	838,68	1073,52	1341,90	1677,37		
22	281,06	351,33	442,68	562,13	702,67	878,33	1124,27	1405,34			
23	293,75	367,19	462,66	587,51	734,39	917,98	1175,02	1468,78			
24	306,45	383,06	482,66	612,90	766,13	957,66	1225,80	1532,26			
25	319,14	398,93	502,65	638,29	797,87	997,33	1276,59	1595,74			
26	331,81	414,81	522,66	663,69	829,62	1037,02	1327,39	1659,24			
27	344,55	430,69	542,66	689,10	861,38	1076,72	1378,20	1722,76			
28	357,25	446,57	562,67	714,51	893,14	1116,42	1429,02				
29	369,96	462,54	582,69	739,92	924,91	1156,13	1479,85				
30	382,67	478,34	602,70	765,34	956,68	1195,85	1530,68				

Tab. 2: Pitch diameter d_0

4.3.4 Toothing of Chain Wheels

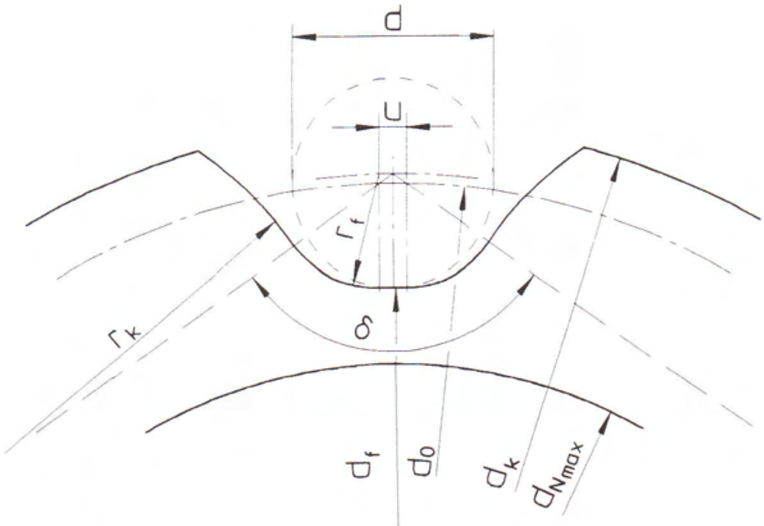


Fig. 5: Toothing of chain wheels

d = Buchsen- oder Rollendurchmesser	siehe Tabellen
d_0 = Teiledurchmesser	$d_0 = \frac{p}{\sin\left(\frac{180°}{z}\right)}$ oder $d_0 = p \cdot n$
d_K = Kopfkreisdurchmesser	$d_K = d_0 + 0{,}25 \cdot d + 10$ für $d \leq 70$ $d_K = d_0 + 0{,}5 \cdot d + 6$ für $d > 70$
d_f = Fußkreisdurchmesser	$d_f = d_0 - d$
p = Teilung g = Laschenbreite	nach Wahl - siehe Tabellen
d_{Nmax} = max. Nebendurchmesser	$d_{Nmax} = d_0 \cdot \cos\left(\frac{180°}{z}\right) - 1{,}2 \cdot g$
u = Zahnlückenspiel	$u = \frac{0{,}2 \cdot d + 0{,}05 \cdot p + 5}{10}$ $u = 0{,}04 \cdot p$ für gegossenes Profil
r_f = Zahnfußradius	$r_f = 0{,}515 \cdot d$ für $d \leq 70$ $r_f = 0{,}51 \cdot d$ für $d > 70$
r_k = Zahnkopfradius	$r_k = 0{,}8 \cdot p - r_f$
δ = Hilfswinkel	$\delta = \left(180° - \frac{360°}{z}\right) - 10$
z = Zähnezahl	$z \geq 6$ nach Wahl

4.3.5 Chain Length L, Distance between Axes a

The chain length L is calculated by multiplying the number of chain links x by the chain pitch p.

$$L = x \cdot p$$

With an equal number of teeth of the chain wheels and the assumed distance a between the axes, the following applies:

$$x = 2 \cdot \frac{a}{p} + z$$

With a different number of teeth of the chain wheels,

$$x = 2 \cdot \frac{a}{p} + \frac{z_1 + z_2}{2} + \left(\frac{z_2 - z_1}{2 \cdot \pi} \right) \cdot \frac{p}{a}$$

applies.

In the case of endless chains, the number of chain links has always to be rounded up, selecting an even number, if possible, in order to avoid offset links.

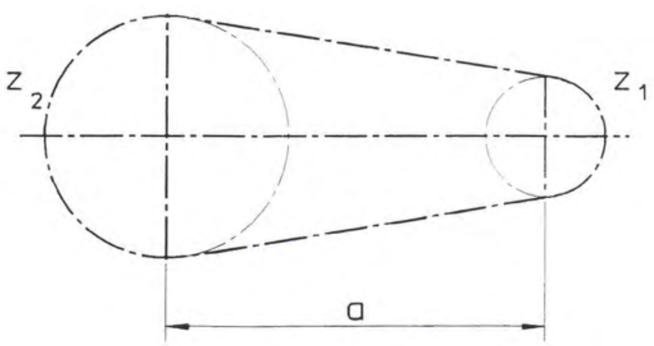


Fig. 6: Distance between axes

The exact distance between axes is calculated as follows:

$$a = \frac{p}{4} \cdot \left[x - \frac{z_1 + z_2}{2} + \sqrt{\left(x - \frac{z_1 + z_2}{2} \right)^2 - 8 \cdot \left(\frac{z_2 - z_1}{2 \cdot \pi} \right)^2} \right]$$