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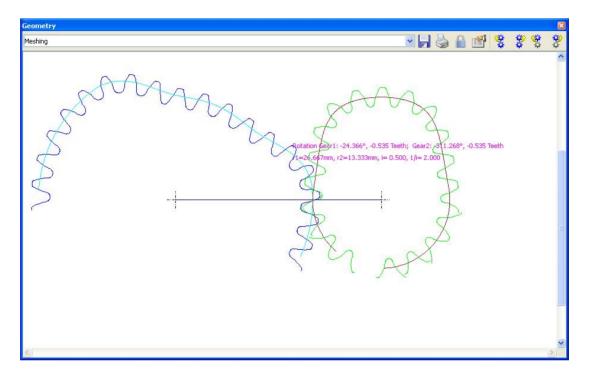
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KISSsoft Instructions:

Strength Calculation for Non-circular Gears



These instructions describe the procedure and strategy to use to estimate the strength of non-circular gearings.

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1 Initial situation

1.1 General notes

Non-circular gears have special toothing forms, which are also not symmetrical. It is possible to calculate their strength using an FEM calculation. Although this procedure calculates the root stresses, it cannot, for example, define the wear. For this reason, these instructions describe how to perform a strength analysis. To do this, first define a circular substitute gear. You can then use the classic gear analysis method specified in ISO 6336 or similar methods. The procedure in these instructions is described using a concrete example.

During normal operation, a constant drive torque of 15 Nm is applied to the small gear (gear 2 in the KISSsoft calculation). The course of circumferential force over the rotation angle is calculated from the contact curves of gears 1 and 2. The data provided internally can be used here. In addition, the static proof with 20 Nm on the small gear must also be performed.

These contact curves on gears 1 and 2 (z-contact curve1.TMP; z-contact curve2.TMP) are recorded in a temporary directory. The directory to be used by KISSsoft is specified in the KISS.ini file in the "PATH" section. You will find the KISS.ini file in the KISSsoft main folder. Before you change the default setting, you must ensure that you have read and write access right to the changed directory. You will also find more detailed information about this in section 2 of the manual, "Setting Up KISSsoft".

📕 Z-V	ValzKurv	e-1.TM	P - Edito	л
Datei	Bearbeiter	n Forma	t Ansicht	t ?
	_vom_130	42008		
\$ 1.3				
	66667 C	.00000	00	
26.66	66667 C	.10000	00	
	66667 C			
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	66667 0			
26.66	66667 1	.00000	00	
26.66	66667 1	10000	00	
	66667 1			
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	66667 1			
	66667 1 CCCC7 1			
26.66	66667 1 66667 1	70000	00	
26.66	66667 1	. 80000	00	
	66667 1			

Figure 1.1-1: Extract of the contact curve for gear 1.

The first 3 lines in the TMP file are predefined. Lines 1 and 2 are where you can add your own comments (text or blank space). Line row 3 must be 1.3 (version number).

The data is now imported to an Excel file so it can undergo further processing. In this case, you must ensure that the reference in the KISSsoft calculation is now set to the angle of rotation of gear 1 (large gear).

2 Procedure

2.1 Analyze the tooth forms

The initial strength analysis for the overall system is performed on the basis of the strength calculation for the "weakest" tooth or the tooth that is subject to the greatest load. A range of different contact settings are analyzed for this purpose. The following figures show the 4 possible variants that can be applied to a strength analysis.

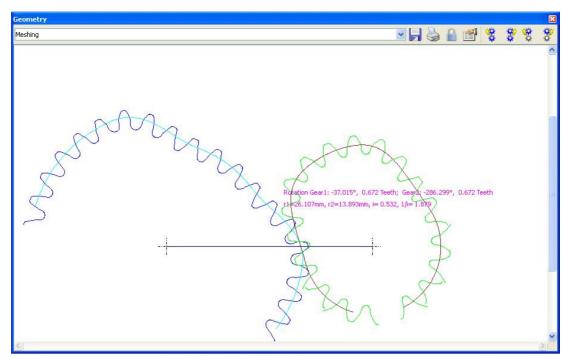


Figure 2.1-1: Weakest tooth in gear 1; tooth thickness at root approximately 2mm.

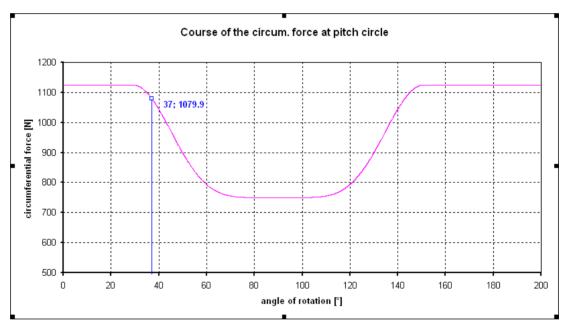


Figure 2.1-2: Nominal circumferential force 1079.9 N at an angle of 37°.

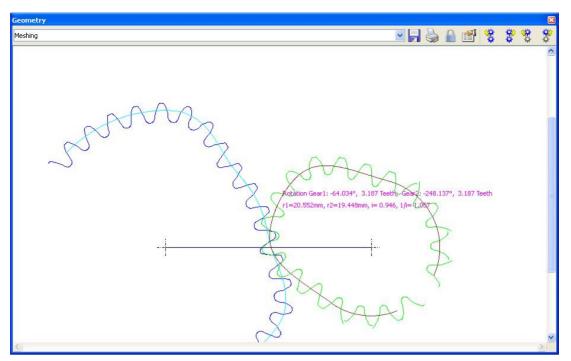


Figure 2.1-3: Weakest tooth in gear 2; tooth thickness at root approximately 2.6 mm.

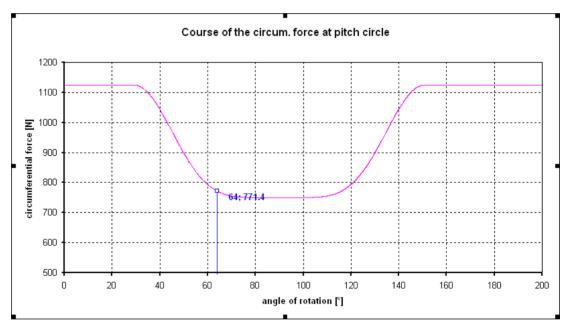


Figure 2.1-4: Nominal circumferential force 771.4 N at an angle of 63.9°.

4

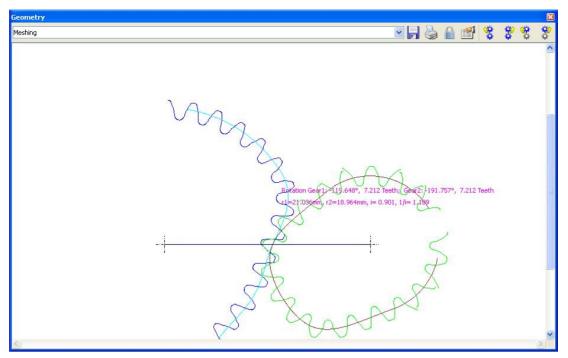


Figure 2.1-5: Weakest tooth in gear 2; tooth thickness at root 2.6 mm.

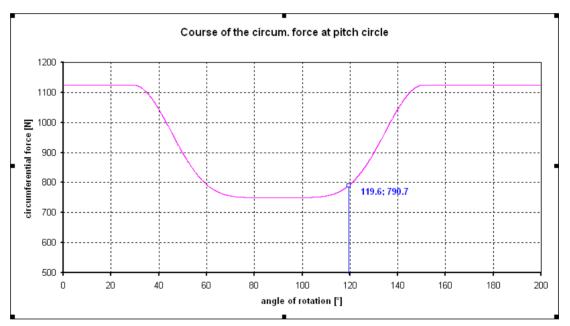


Figure 2.1-6: Nominal circumferential force 790.7 N at an angle of 119.6°.

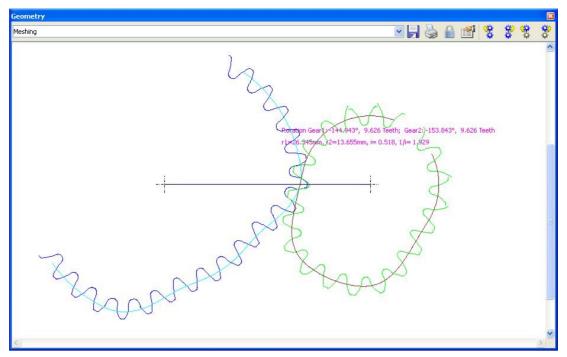


Figure 2.1-7: Weakest tooth in gear 1; tooth thickness at root approximately 2mm.

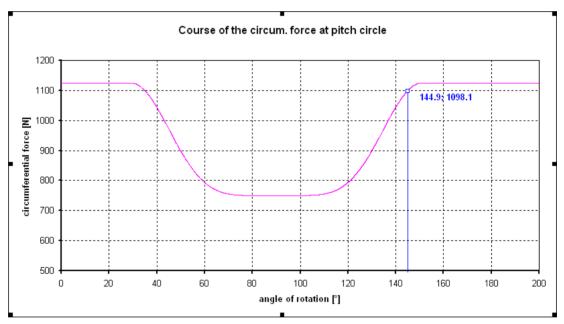


Figure 2.1-8: Nominal circumferential force 1098.1 at an angle of 144.9°.

The highest load appears on gear 1. This is the load represented in **Figure 2.1-1** Although only the second highest circumferential force is present here, the tooth thickness at root for this tooth is the lowest. In this case, the relationship of the tooth thickness compared with the circumferential force for the highest load is the decisive factor, and will therefore be investigated in greater detail.

2.2 Considerations when evaluating the strength

In order to estimate strength, you require a cylindrical gear file [*.Z12] where none of the parameters are set. For this reason, you must open a new, blank cylindrical gear calculation. In the "Module specific settings" window, input the number of teeth with decimal places.

eneral Plastic Sizings Calculation	Required safeties	Summary	
put of quality according to	DIN	3961-3963	~
] Input of normal diametral pitch instead of r	normal module		
] Input of number of teeth with decimal plac	es		
Allow large profile shift			
] Don't abort when geometry errors occur			
] Maintain tip circle when changing profile sh	ift		
] Maintain root circle when changing profile s	hift		
ictor for minimum tooth thickness at tip	0.2000		
pefficient for minimum tip clearance	0.1500		
lues on the x-axis of diagrams	Ang	le of rotation	~

Figure 2.2-1: Change module specific settings.

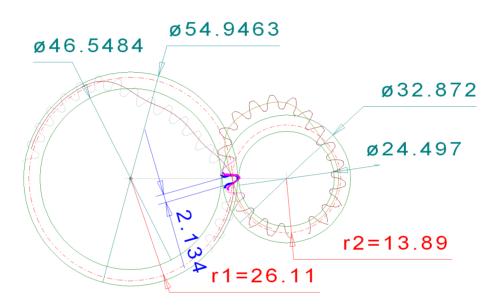


Figure 2.2-2: Defining values for the strength calculation.

The values for the normal module ($m_n=1.56$) and the pressure angle ($\alpha_n=20^\circ$ as the initial value) are specified in the "Basic data" tab, just like for the non-circular gear calculation. The radii of the segments (r_1 , r_2) correspond to the pitch circle radii of the non-circular intermeshing and are taken from the non-circular graphic, see **Figure 2.1-1** with the data $r_1=26.110$ mm etc. The number of teeth for gear 1 is $z_1=2^*r_1/m=33.4743$. The center distance is 40 mm. This center distance must be the same as the center distance for the noncircular intermeshing. Therefore, the number of teeth for gear 2 is calculated as $z_2=17.8077$. In the "Tolerances" tab, select "No backlash" for the tooth thickness deviation. The tolerance of the tip circle diameter is 0.

		Gear	· 1				Gear 2			
Tooth thickness deviation		No backlash	~			1	No backlash	~		
Tooth thickness allowance (upper/lower)	Asn	0.0000	0.0000	mm	۲		0.0000	0.0000	mm	•
Base tangent lengthwance (upper/lower)	Awn	0.0000	0.0000	mm			0.0000	0.0000	mm	
Normal backlash (min/max)	jn	0.0000	0.0000	mm			0.0000	0.0000	mm	
Circumferential backlash (min/max)	jŧ	0.0000	0.0000	mm			0.0000	0.0000	mm	
Tip diameter allowance (upper/lower)	A _{da}	0.0000	0.0000	mm		4	0.0000	0.0000	mm	
Root diameter allowance (upper/lower)	Aar	0.0000	-0.0100	mm			0.0000	-0.0100	mm	
Center distance										
Centre distance tolerance			No backla	sh			~			
Centre distance allowance (upper/lower)			Aa 0	.0000		0.	0000 mm			
Settings										
Number of teeth spanned Gear 1 k1		0		Nun	iber o	f teeth	spanned Gear 2 k ₂		0	
Ball/pin diameter Gear 1 DMI	3	0.0000 mm 📃		Ball,	pin di	ameter	Gear2 D _{M2}	0.0	0000	mm 🔲

Figure 2.2-3: Settings in the "Tolerances" tab.

The sum of the profile shifts of the substitute gearing is also 0. Click the conversion button and input the measured tooth thickness on gear 1 (s=2,134mm) to define the profile shift of gear 1.

Normal module	Oconvert profile shift coef	ncient Ge	ar 1		3	Ge	ear 1	Gear 2	De	tails
Pressure angle at				1	z		33.4743	17.8077]	
spur gear	Number of teeth spanned	k [2	-	ь		3.0000	3,0000	mm	\
Helix angle at refe	Base tangent length O Ball and pin diameter	Wk	7.0410	mm	nt x*		-0.4763	0.4763		🥶 💽
Center distance	Diameter of ball/pin	D.H.	3.2500	mm	Q		6	6		
itrength	Measurement over balls	Max	57.3758	mm 🔿						
Calculation metho	Measurement over 2 pins	MdZR	57.3758	mm O	erence g	ear	Gear 2	~	De	tails
Required service li	Measurement over 3 pins	Md3R	57.3163	mm 💿	ver	Р	0.0	1209 kW	۲	6
Application factor	🔿 Tip circle			*	que	т	20.0	1000 Nm	0	🧀 🙋
Face load factor	Tip diameter	da	54.9463	mm	ed	n	10.0	1/min	0	
Aaterial and lubric	Tooth thickness				-					
Gear 1 C45 (Tooth thickness at reference circle	St	2.1340	mm)					✓
Gear 2 C45 (Input of tooth thickness as arc l	ength, not a	as chordal lengti	1)					V (4
ubrication Greas	Input of tooth thickness in trans	verse sectio	on, not in norma	l section	~	4	Grease	ubrication		v 😔
	Manufacturing profile shift coefficier	nt x"e	-0.4763	1						
	under de berekkelder er ellemennen	al 11 11		-	1					

Figure 2.2-4: Define the profile shift coefficient for gear 1.

Click the "Conversion" button in the "Reference profile" tab to input the tip and root diameter (these diameters correspond to the values of the non-circular gears, see **Figure 2.2-2**). Firstly, select "Own input" for the reference profile.

Basic data Referenc	sic data Reference profile Tolerances Modifications 🖹 Tooth				
Gear 1			Gear 2		
Configuration	Reference profile gear	💌 🔏	Configuration	Reference profile gear	🖌 👔
Processing	Final treatment	× 🔒	Processing	Final treatment	× 🔒
Reference profile	Own Input	🖌 🖌	Reference profile	Own Input	
Label			Label		
Dedendum coefficient	h"# 1.34	15 🐼	Dedendum coefficient	h'# 1.5285	A

Figure 2.2-5: Setting in the "Reference profile" tab for the "Own Input" reference profile.

Then click the appropriate conversion button to define the addendum and dedendum coefficients.

Gear 1	7						
Configuration	Referenc	e profile gea	r	~			
Processing	tment		× (
Reference profile	Own Inp	Own Input 🛛 👻					
.abel							
Dedendum coefficient	h	*rP	1.3415	R			
Convert dedend			46.5484	k mm ⊙			
Root diameter of gear	(maximum)	d _{te}	46.5484	i mm 🔘			
Root diameter of gear	(minimum)	du	46.5484	F mm 🔿			
Dedendum coefficient (reference (profile h"re	1.341	5			

Figure 2.2-6: Setting in the "Reference profile" tab used to convert the addendum and dedendum coefficients.

Then, in "Module specific settings", click the "Maintain tip and root circle when changing profile shift" checkbox.

eneral	Plastic	Sizings	Calculations	Required safeties	Summary
put of q	juality accor	ding to		Cal	culation method for strength
🗌 Input	of normal di	ametral pitc	h instead of norn	nal module	
🛛 Input	of number o	of teeth with	i decimal places		
Allow	large profile	shift			
] Don't	abort when	geometry e	rrors occur		
100 A 100 A 100 A		and the second second second	ing profile shift		

Figure 2.2-7: "Maintain tip and root circle when changing profile shift" checkbox.

9

If necessary, modify the pressure angle to achieve a better tooth form match with the non-circular gear geometry. $\alpha_n=12^\circ$ is assumed for this in our example. You must then click the the profile shift conversion button again to get the profile shift on gear 1 (s_{n1}=2.134mm).

You must reset the parameters in this way to achieve the best possible match between the two tooth forms. The only way to estimate the strength of a non-circular intermeshing is to use a simple cylindrical gear calculation.

	[2012] - z34_z18_m1_56_ver_V2.212
File Project View Calculation Rep	port Graphics Extras Help
000000000000000000000000000000000000000	🔉 🖹 🖹 🧊 🕼 🎬 💯 🔣 KISS _{SOFT}
	Release 04-2010
Projects S × Betts and Chains	Basic data Reference profile Tolerances Modifications is Tooth form Geometry Normal module ma 1.5600 mm Gear 1 Gear 2 Details Pressure angle at normal section ma 1.2.0000 * * Number of teeth z 33.4743 17.8077 spur gear w image at reference circle β 0.00000 * Profile shift coefficient x' -0.4763 0.4763 @@ @@ Helix angle at reference circle β 0.00000 m w @ Quality (150 1328) Q 6 6 Strength Calculation method Only geometry calculation w Reference gear Gear 2 W Details Required service life H 0.0001 h @ Power P 0.0229 KW @
	Application factor K _A 1.0000 👔 Torque T 20.0000 Nm 🔿 실 🥺
	Face load factor K 40 1.0500 Image: Speed n 10.0000 1/min O
Modules Projects Explorer	Material and lubrication
Manual & ×	Gear 1 C45 (2), Through hardened steel, flame/ind. hardened, ISO 6336-5 Figure 11/12 (MQ)
General Toothing	Gear 2 C45 (2), Through hardened steel, flame/ind. hardened, ISO 6336-5 Figure 11/12 (MQ)
 Bhafts and Bearings Connections ⇒ Springs ➡ Belts and chain drives 	Lubrication Grease: Isoflex Topas NCA51
Diverse KISSsvs	
Description of the calculation mod	Results 🗗 🗙 2D geometry 🗗 🛪
Bibliography and Index	Results Meshing Image: Constant ratio (fransverse/Overlap/Total) 1.9303/0.0000/1.9303 Gear 1 Gear 2 Actual tip circle d_1 54.946 32.872 mm Number of teets hypanned 2 3
Manual Search	Wk 7.041 12.378 mm Wke/Wki 7.041 12.378 mm Dmeff 3.230 mm Mdk 57.376 34.069 mm Mdke/Mdki 57.376 34.069 mm Results Messages Information V
	CONSISTENT

Figure 2.2-8: Resetting the calculation file parameters for the strength calculation.

We recommend you use the graphical method to achieve a more precise root strength analysis. This is especially useful if the tooth form has a deep undercut. It would therefore differ considerably from a standard tooth form. You will find this setting in the details button for strength calculation.

Define details of strength		
System data		
Profile correction	none (only running-in)	A A A A
Driving gear	Gear 1	~
Life factors Z_{ν_0}, Y_{ν} according to ISO 6336	normal (reduction to 0.85 at 10 ¹⁰ cycles)	~
Form factors Y ₁ , Y ₅	using graphical method	~
Tooth contact stiffness	Following formulae of Standard (normal)	~

Figure 2.2-9: Setting for using the graphical calculation method.

The data you enter for the corresponding torque on gear 2 must be in accordance with the task at the operational point. In our example, the torque on gear 2 is constant. For a permanent load, the torque on gear 2 is 15.0 Nm. Static strength is calculated using a torque on gear 2 of 20.0 Nm. Furthermore, you must ensure that the number of load cycles has been fixed for both gears and the factor for alternating bending loads is specified as 0.7. This data is due to the fact that the mechanism does not perform a complete rotation. It merely oscillates. You must also input this data in the "Define details of strength" window in the "Gear data" area.

Number of load cycles	N.	0.0000	0.0000 106	(
Alternating bending factor	Yя	0.7000	0.7000	🗹 😔 🕃
Grinding notch	t _o /p _o	0.0000	0.0000	
Technology factor	Υ _T	1.0000	1.0000	1

Figure 2.2-10: Setting for calculating changes in load direction and alternating bending loads.

Note: If, in another situation, the circumferential force at the operating point is specified, use the force and the lever arm (pitch circle radii) to determine the torque. To do this, click the conversion button to the right of the field in which you input the torque.

Calculation method Onl	y geometry calculation	O Convert torque	ar 🔣 ar	.	Gear 2 💙	l,	D	etails
Required service life	н	Circumferential force F	1439.8842 N	Р [0.0209	k₩	۲	1
Application factor	Ka	Reference diameter da	27.7800 mm	т [20.0000	Nm	0	2
Face load factor	Кнр			n	10.0000	1/min	\circ	
Material and lubrication -		Torque T ₂	0.0000 Nm					
	rough hardened steel, fla	M Accept Calcula	ate Cancel					-

Figure 2.2-11: Conversion of circumferential force into torque.

2.3 Results

The strength calculation is performed using this data:

- Static (overload failure) with overload coupling 20 Nm at the input (the small gear is gear 2 here)
- Finite life calculation: 100,000 cycles; 15 Nm (drive), alternating bending load, approximately 10 rpm on gear 2
- Lubrication: TOPAS NCA 51/25
- the (load-bearing part) facewidth at the tooth root is assumed as 4 mm
- a 3 mm facewidth is calculated for pitting (reduced load-bearing width due to the manufacturing process – stamping).

material	static calculation			fatigue strength root			fatigue strength flank			
		Gear 1	Gear 2			Gear 1	Gear 2		Gear 1	Gear 2
C45, through	Actual tip circle dae	54.946	32.872	mm		Geari	Gearz		Geari	Gearz
hardened	Root safety R _m /σ _F	0.9324	2.0114			0.4954	0.8866			
naraonoa	Root safety R _p /σ _F 0.6527 1.4080 Root safety U.4954	0.0000	Flank safety	0.3828	0.3828					
C45, surface						Gear 1	Gear 2		Gear 1	Gear 2
head -/ induction- hardened	as aforementioned			Root safety	0.7533	1.2742	Flank safety	0.8647	0.8647	
045						Gear 1	Gear 2		Gear 1	Gear 2
C45, nitrided	as aforementior	ied			Root safety	0.6595	1.0555	Flank safety	0.5759	0.5759
18CrNiMo7-6		Gear 1	Gear 2			Gear 1	Gear 2		Gear 1	Gear 2
	Actual tip circle dag	54.946	32.872	mm						
through hardened	Root safety R _m /σ _F	1.5985	3.4482		Root safety	0.9615	1.5841	Flank safety	1.0632	1.0632
	Root safety R _e /o _F	1.1323	2.4425			0.5015	1.0041	i laint salety		

Table 2.3-1: Overview of calculation results with 3 different material qualities.

To ensure static safety, a safety level of 2 against fracture and a safety level of 1.5 against yield point must be achieved. Using material C, this can only achieved on the small gear (gear 2). In most cases, the flank safety is usually insufficient. This material (material C45) can only just achieve this value if its surface has been heat/induction hardened.

Better static strength values could be achieved by using 18CrNiMo7-6 (or a similar case-hardened steel). This also results in a significant improvement in the finite life calculation for the tooth root and the flank.

3 Other methods of approach (alternatives)

3.1 Perform the strength calculation using an exact tooth form

As an alternative to the procedure described in section 2.2 (tooth form definition by inputting the reference profile and profile shift) you can export the exact tooth form (half tooth) of the non-circular gear from the calculation for non-circular gears (*.Z40). You can then import it into the strength

calculation for circular gear pairs (*.Z12). The procedure for exporting this data is described in the next section 3.2. You should not use this procedure for angular or nonsymmetrical non-circular gears. This is because the tooth form generated in the gear calculation [*.Z12] by the DXF data import will vary too much from the tooth form used in the non-circular gear calculation [*.Z40]. The teeth were slightly inclined (tilted) in the example described above, so therefore this method was not used.

3.2 Options for exporting individual tooth forms

The weakest tooth on gear 1 is tooth number 4. You can now export its data like this. Use a text editor to open the current KISSsoft calculation file (file type [Z40]. For example, you can use "Notepad" or "Workpad".

The **LEFT** flank of the x-th tooth space (therefore the 4th tooth if the "AusgabeKontur=4") is always produced. The existing entry for the variable ZRnc[0].AusgabeKontur=0 for gear 1 is changed to ZRnc[0].AusgabeKontur=4. This change is then saved. The calculation file is now prepared for outputting only tooth number 4 from gear 1.

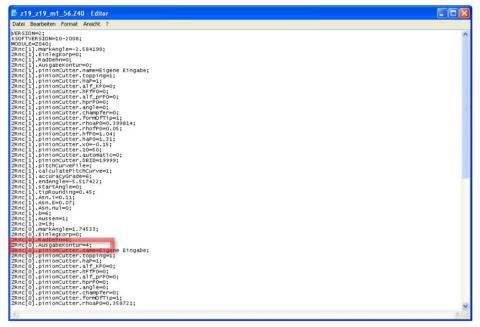


Figure 3.2-1: Changing the entry for variable "ZRnc[0].AusgabeKontur=0".

The KISSsoft file is then loaded again and the tooth form calculation is then performed. The graphic now shows only a half tooth of gear 1. This already has the correct alignment and position for the following import.

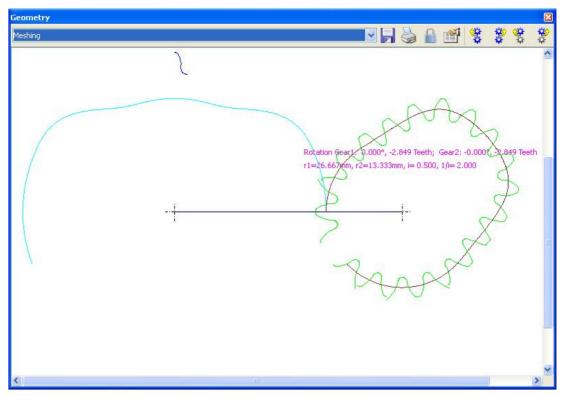


Figure 3.2-2: Effect of changing the entry for variable "ZRnc[0].AusgabeKontur=4".

The tooth form can then be saved in DXF format, as usual, in the display for gear 1.

This process also creates the temporary file ZF-UNRUND-DATHalf-1.TMP. This file contains information that will be required later on to generate the substitute intermeshing.

Crdner 🛛 🛄 🔻	Adresse 🛅 C:'	\Programme\KISSsoft 10-2	2008\TMP\KISS_0	💌 🔁 Wechseln
Name 🔺		Größe Typ	Geändert am	
errmsg.tmp		0 KB TMP-Datei	08.12.2008 10:39	
result_out.tmp		1 KB TMP-Datei	08.12.2008 10:39	
z40mainresult.tmp		1 KB TMP-Datei	08.12.2008 10:39	
]ZF-H1_Rad 1 (Schritt 1			and the second	
] ZF-H1_Rad 1 (Schritt 2). TMP 🕒 ZF-UNRI	UND-DATHalf-1.TMP	- Editor	
] ZF-H1_Rad 2 (Schritt 1).TMP Datei Bearb	eiten Format Ansicht	7	
] ZF-H1_Rad 2 (Schritt 2).TMP IIGS and D>	×F of Tooth No.4		~
E ZF-UNRUND-1.TMP	da = 56.13 df = 48.69			
SF-UNRUND-2.TMP	z' = 34.12			
ZF-UNRUND-DAT-1.TM	p z = 34.00	00		
ZF-UNRUND-DAT-2.TM		0 28.0551 d=56.110		
ZF-UNRUND-DATHalf-1	.TMP 1 0.0109 2 0.0218		1 n=89.8219 1 n=89.7997	
ZF-UNRUND-OPLINE-1.	TMP 3 0.0327	7 28.0550 d=56.110	1 n=89.7774	
E) ZF-UNRUND-OPLINE-2.	TMP 4 0.0436 5 0.0549			
Z-OpPitchPoints-1.TMP	6 0.0654	4 28.0550 d=56.110	1 n=89.7107	
Z-OpPitchPoints-2.TMP	7 0.0763 8 0.0872			
Z-WalzKurve-1.TMP	9 0.0981	1 28.0549 d=56.110	1 n=89.6439	
Z-WalzKurve-2.TMP	10 0.1090			
	12 0.1308	8 28.0548 d=56.110	1 n=89.5771	
	13 0.1417 14 0.1526		1 n=89.5549 1 n=89.5326	
	15 0.1635	5 28.0546 d=56.110		
	16 0.1744 17 0.1853			
	18 0.1962		1 n=89.4436	
	19 0.2071		1 n=89.4213 1 n=89.4239	
	20 0.21/0	J 28.0542 d=56.110	I H=89.4239	~
	2			S

Figure 3.2-3: ZF-UNRUND-DATHalf-1.TMP.

You can also use the same method of approach for gear 2. In this case, you must input the required tooth in variable ZRnc[1].AusgabeKontur= ??? accordingly.

The tooth form, in DXF format, can be imported into a KISSsoft cylindrical gear calculation and then used for the strength calculation.

4 Appendices

4.1 Static strength

KISSsoft-Entwicklung	KISSsoft - Release (s-Version KISSsoft	
Name : z34_z18 Changed by : ho		at: 13:52:08

CALCULATION OF A CYLINDRICAL SPUR GEAR PAIR

Drawing or article number: Gear 1: 0.000.0 Gear 2: 0.000.0

Calculation method Static calculation

		GEAR 1 GEAR 2
Power (W)	[P]	20.9440
Speed (1/min)	[n]	5.3 10.0
Torque (Nm)	[T]	37.6 20.0
Application factor	[KA]	1.00
Required service life	[H]	0.00
Gear driving (+) / driven (-)		+ -

1. TOOTH GEOMETRY AND MATERIAL

(Geometry calculation a	ccording ISO 21	,	GEAR 1		GEAR 2
Center distance (mm)		[a]	GEAR I	40.000	GEAR 2
Centre distance tolerance		[4]		No backl	ash
Normal module (mm)		[mn]	1.5600		
Pressure angle at normal s	ection (°)	[alfn]		12.0000	
Helix angle at reference c		[beta]		0.0000	
Number of teeth		[z]	33.4743		17.8077
Facewidth (mm)		[b]	3.00		3.00
Hand of gear			Spur gear		
Accuracy grade		[Q-ISO1328]	6		6
Inner diameter (mm)		[di]	0.00		0.00
Inside diameter of rim (mm)	[dbi]	0.00		0.00
Material					
Gear 1:		igh hardened steel, gure 11/12 (MO)	flame/ind.	hardened	
Gear 2:	C45 (2), Throu	gure 11/12 (MQ)	flame/ind.	hardened	

Surface hardness		GEAR 1 HRC 57	GEAR 2 HRC 57
Fatigue strength. tooth root stress (N/	mm 2)		
	[sigFlim]	370.00	370.00
Fatique strength for Hertzian pressure	(N/mm ²)		
	[sigHlim]	1220.00	1220.00
Tensile strength (N/mm²)	[Rm]	700.00	700.00
Yield point (N/mm ²)	[Rp]	490.00	490.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[ny]	0.300	0.300
Average roughness, Ra, tooth flank (µm)	[RAH]	0.60	0.60
Mean roughness height, Rz, flank (µm)	[RZH]	4.80	4.80
Mean roughness height, Rz, root (µm)	[RZF]	10.00	20.00
Tool or reference profile of gear 1 : Reference profile (Own input) Addendum coefficient Dedendum coefficient Tip radius factor Root radius factor Tip form height coefficient Protuberance height factor Protuberance angle Ramp angle	[haP*] [hfP*] [rhoaP*] [hFaP*] [hFrP*] [alfprP] [alfKP]	not topping	1.350 1.342 0.000 0.300 0.000 0.000 0.000 0.000
Tool or reference profile of gear 2 : Reference profile (Own input)			
Addendum coefficient Dedendum coefficient	[haP*] [hfP*]		1.156 1.529
Tip radius factor	[nip^] [rhoaP*]		0.000
Root radius factor	[rhofP*]		0.300
Tip form height coefficient	[hFaP*]		0.000
Protuberance height factor	[hprP*]		0.000
Protuberance angle	[alfprP]		0.000
Ramp angle	[alfKP]		0.000
	[311111]	not topping	
		noe coppin	9

Sum of reference profile gears:			
Dedendum reference profile (module)	[hfP*]	1.342	1.529
Tooth root radius Refer. profile (module	(rofP*]	0.300	0.300
Addendum Reference profile (module)	[haP*]	1.350	1.156
Protuberance height (module)	[hprP*]	0.000	0.000
Protuberance angle (°)	[alfprP]	0.000	0.000
Buckling root flank height (module) Buckling root flank angle (°)	[hFaP*] [alfKP]	0.000 0.000	0.000 0.000
Buckling 1000 Hank angle ()	[arrive]	0.000	0.000
Type of profile modification:			
		No	
Tip relief (µm)	[Ca]	3.40	3.40
Lubrication type	Gr	ease lubrication	
Type of grease	Gr	ease: Isoflex Topas	NCA51
Lubricant base		nthetic oil based on	
Kinem. viscosity base oil at 40 °C (mm Kinem. viscosity base oil at 100 °C (m		u40] u100]	30.00 6.00
FZG-Test A/8.3/90 step	[FZGtestA		10
Specific density at 15 °C (kg/dm ³)	[roOil]		0.870
Grease temperature (°C)	[TS]		70.000
		GEAR 1	GEAR 2
Overall transmission ratio	[itot]	02111(1	-0.532
Gear ratio	[u]		1.880
Transverse module (mm) Pressure angle at Pitch circle (°)	[mt]		1.560 12.000
Working transverse pressure angle (°)	[alft] [alfwt]		12.000
	[alfwt.e/	i] 12.00	0 / 12.000
Working pressure angle at normal section		n]	12.000
Helix angle at operating pitch circle (°) [betaw]		0.000
Base helix angle (°)	[betab]		0.000
Reference centre distance (mm)	[ad]		40.000
Sum of profile shift coefficients	[Summexi]	0 47.00	0.0000
Profile shift coefficient Tooth thickness (Arc) (module)	[x] [sn*]	-0.4763 1.3683	0.4763 1.7733
, (, (,	1011]		
Tip alteration (mm)	[k]	0.000	0.000
Reference diameter (mm) Base diameter (mm)	[d] [dB]	52.220 51.079	27.780 27.173
Tip diameter (mm)	[da]	54.946	32.872
(mm)	[da.e/i]	54.946 / 54.946	32.872 / 32.872
Tip diameter allowances (mm) Chamfer (1) / Tip rounding (2) / pointed	[Ada.e/i]	0.000 / 0.000 2	0.000 / 0.000 2
Tip chamfer / tip rounding (2) / poinced	[hK]	0.450	0.450
Tip form diameter (mm)	[dFa]	54.328	32.442
(mm)	[dFa.e/i]		32.442 / 32.442
Operating pitch diameter (mm) (mm)	[dw] [dw.e/i]	52.220 52.220 / 52.220	27.780 27.780 / 27.780
Root diameter (mm)	[df]	46.548	24.497
Generating Profile shift coefficient	[xE.e/i]	-0.4763 / -0.4763	0.4763 / 0.4763
Manufactured root diameter with xE (mm) Theoretical tip clearance (mm)	[df.e/i] [c]	46.548 / 46.548 0.278	24.497 / 24.497 0.290
Effective tip clearance (mm)	[c.e/i]	0.278 / 0.278	0.290 / 0.290
Active root diameter (mm)	[dNf]	0.000	0.000
(mm)	[dNf.e/i]		0.000 / 0.000
(Indication 0.0 is for dNf.e/i in case Root form diameter (mm)	[dFf]	51.079	27.173
(mm)	[dFf.e/i]	51.079 / 51.079	27.173 / 27.173
Addendum (mm)	[ha]	1.363	2.546
(mm) Dedendum (mm)	[ha.e/i] [hf]	1.363 / 1.363 2.836	2.546 / 2.546 1.642
(mm)	[hf.e/i]	2.836 / 2.836	1.642 / 1.642
	i_dFa.e/i]		37.371 / 37.371
	i_dNa.e/i]	20.759 / 20.759 0.000 / 0.000	37.371 / 37.371 0.000 / 0.000
	i dFf.e/i]		0.049 / 0.049
Tooth height (mm)	[H]	4.199	4.188
Virtual gear no. of teeth Normal Tooth thickness at Tip cyl. (mm)	[zn] [san]	33.474 1.373	17.808 0.645
(mm)	[san.e/i]	1.373 / 1.373	0.645 / 0.645
(without consideration of tip chamfer/			
Normal space width at tip cylinder (mm)	[efn]	0.000	0.000
(mm) Max. sliding velocity at tip (m/s)	[efn.e/i] [vga]	0.000 / 0.000 0.006	0.000 / 0.000 0.009
Specific sliding at the tip	[zetaa]	1.190	1.000
Specific sliding at the root	[zetaf]	-9999.000	6.255
Sliding factor on tip	[Kga] [Kaf]	0.422	0.599
Sliding factor on root Pitch on reference circle (mm)	[Kgf] [pt]	-0.599	-0.422 4.901
Base pitch (mm)	[pbt]		4.794
Transverse pitch on contact-path (mm)	[pet]		4.794
Length of path of contact (mm) Length T1-A, T2-A (mm) [T1	[ga, e/i]		(9.253 / 9.253) 8.316(8.316/ 8.316)
		.459(4.459/4.459)	3.857 (3.857 / 3.857)
Length T1-C (mm) [T1	C, T2C] 5	.429(5.429/ 5.429)	2.888(2.888/ 2.888)
			3.523 (3.523/ 3.523)
Length T1-E (mm) [T1 Length T1-T2 (mm) [T1			-0.937(-0.937/-0.937) 8.316 / 8.316)
Diameter of single contact point B (mm)		3.010 (

[Diameter of single contact point D (mm)	d-B]	51.852(51.852/51.8	852) 28	3.247 (28.247/28.247)
	d-D]	51.971(51.971/51.9	971) 28	8.071(28.071/28.071)
Addendum contact ratio Minimal length of contact line (mm)	[eps] [Lmin]	0.798(0.798/ 0		1.132(1.132/1.132) 3.000
Transverse contact ratio Transverse contact ratio with allowances Overlap ratio Total contact ratio Total contact ratio with allowances	[eps_b [eps_g	.e/m/i] 1.]]	.930 /	1.930 1.930 / 1.930 0.000 1.930 1.930 / 1.930

2. FACTORS OF GENERAL INFLUENCE

		GEAR 1 GEAR 2
Nominal circum. force at pitch circle (N	[)	
	[Ft]	1439.9
Axial force (N)	[Fa]	0.0
Radial force (N)	[Fr]	306.1
Normal force (N)	[Fnorm]	1472.1
Tangent.load at p.c.d.per mm (N/mm) (N/m	um)	
	[w]	479.96
Only as information: Forces at pitch ci	.rcle:	
Nominal circumferential force (N)	[Ftw]	1439.9
Axial force (N)	[Faw]	0.0
Radial force (N)	[Frw]	306.1
Circumferential speed pitch d (m/sec)	[v]	0.01
Dynamic factor	[KV]	1.000
Width factor - flank	[KHb]	1.000
- Tooth root	[KFb]	1.000
- Scuffing	[KBb]	1.000
Transverse coefficient - flank	[KHa]	1.000
- Tooth root	[KFa]	1.000
- Scuffing	[KBa]	1.000
Helix angle coefficient scuffing	[Kbg]	1.000

3. TOOTH ROOT STRENGTH

----- GEAR 1 ----- GEAR 2 --Calculation of Tooth form coefficients according method: B Calculation of tooth form coefficients with graphical method (Determination of biggest value for YF * YS on the effective tooth shape) Tooth form factor [YF] 3.25 1.50 Working angle (°) [alfen] 7.85 9.89 Force application diameter (mm) 51.97 2.25 28.25 [den] Force application -Bending lever arm (mm) [hr] Tooth thickness at root (mm) [sFn] Tooth thickness (mm) [roF] 1.54 2.56 3.10 0.98 0.61 Tooth root radius (mm) [roF] 0.98 0. (hF* = 1.441/0.985 sFn* = 1.641/1.989 roF* = 0.631/0.391 dsFn = 47.14/24.71 alfsFn = 35.17/47.13) Contact ratio factor 1.000 [Yeps] Helix angle factor [Ybet] 1.000 Deep tooth factor [YDT] 1.000 1.00 3.00 Gear rim factor [YB] 1 000 1 000 Effective facewidth (mm) [beff] 3.00 Nominal shear stress at tooth root (N/mm²) [sigF0] 1000.33 462.96 1000.33 Tooth root stress (N/mm²) [sigF] 462.96 Calculation formulae: sigF0 = Ft / beff / mn * YF * Yeps * Ybeta * YB * YDT sigF = sigF0 * KA * KV * KFa * KFb YF, YS, YB, YDT : ISO6336-3 Yield point (N/mm²) 490.00 490 00 [Rp] 700.00 Tensile strength (N/mm²) [Rm] 700.00 [Ss=Rp/sigF] 0.49 1.06 Safety against plastic deformation [Sb=Rm/sigF] Safety for tensile stress 1.51 Extensions for aerospace industry: Calculation formula: sigF0 = Ft / beff / mn * YF * YS * Yeps * Ybeta * YB * YDT Slgr0 = rt / bell / min fr is reps fiberStress correction factor[YS]1.462.18Tooth root stress (N/mm²)[sigF]1462.661007.48Safety against plastic deformation[Ss=Rp/sigF]0.340.49Safety for tensile stress[Sb=Rm/sigF]0.480.69 6. MEASUREMENTS FOR TOOTH THICKNESS

					GEAR 1	GEAR 2
Tooth thickness	deviation			No	backlash	No backlash
Tooth thickness	allowance ((normal	section) (mm)			
			[As.e/i]	0.000	/ 0.000	0.000 / 0.000

Number of teeth spanned Base tangent length (no backlash) (mm) Actual base tangent length ('span') (mm) Diameter of contact point (mm)	[k] [Wk] [Wk.e/i] [dMWk.m]	2.000 7.041 7.041 / 7.041 51.562	3.000 12.378 12.378 / 12.378 29.859
	[DMeff] [MrK] [MrK.e/i] [dMMr.m]	3.044 3.250 28.718 28.718 / 28.718 53.189 (mm)	3.061 3.250 17.095 17.095 / 17.095 29.524
Actual dimension over balls (mm) Theor. dimension over two pins (mm) Actual dimension over rolls (mm) Dimensions over 3 pins without clearance	[MdK] [MdK.e/i] [MdR] [MdR.e/i] (mm) [Md3R]	57.376 57.376 / 57.376 57.376 57.376 / 57.376 57.316	34.069 34.069 / 34.069 33.949
Actual dimensions over 3 rolls (mm)	[Md3R.e/i]	57.316 / 57.316	33.949 / 33.949
Chordal tooth thickness (no backlash) (m	m) ['sn]	2.134	2.762
Actual chordal tooth thickness (mm) Reference chordal height from da.m (mm) Tooth thickness (Arc) (mm)	['sn.e/i] [ha] [sn]		2.762 / 2.762 2.615 2.766
Backlash free center distance (mm) [aC Backlash free center distance, allowance		40.000 / 4	
Centre distance allowances (mm) Circumferential backlash from Aa (mm) Radial clearance (mm) Circumferential backlash (transverse sec	[Aa.e/i] [jt_Aa.e/i] [jr] tion) (mm)	0.000 / 0 0.000 / 0 0.000 / 0	.000 .000 .000
Torsional angle using fixed values gear Normal backlash (mm)	[jt] 1 (°) [jn]	0.000 / 0 0.0000 /0 0.000 / 0	.0000
7. TOLERANCES			
		GEAR 1	GEAR 2
According ISO 1328: Accuracy grade Single normal pitch deviation (µm) Base circle pitch deviation (µm) Cumulative circular pitch deviation over		6 7.50 7.50 n)	6 7.00 7.00
Profile deviation (µm) Profile angular deviation (µm) Profile total deviation (µm) Helix form deviation (µm) Helix slope deviation (µm)	[Fpz/8] [ffa] [fHa] [Fa] [ffb] [fHb]	12.00 6.50 5.50 8.50 6.00 6.00	9.50 5.50 4.60 7.50 6.00 6.00
Tooth helix deviation (µm) Total cumulative pitch deviation (µm) Runout tolerance (µm) Total radial composite tolerance (µm) Tooth-to-tooth radial composite toleranc	[Fb] [Fp] [Fr] [Fi"]	8.50 26.00 21.00 31.00 9.50	8.50 20.00 16.00 26.00 9.50
Total tangential composite deviation (μm)		
Tooth-to-tooth tangential composite devi		40.00	33.00 13.00
Tolerance for alignment of axes (recomme	[fi'] ndation acc. ISC		

	6)
Maximum value for deviation error of axis (µm)	
[fSigbet]	8.50
Maximum value for inclination error of axes (µm)	
[fSigdel]	17.01

9. DETERMINATION OF TOOTHFORM

Calculation of Gear 1

Gar 1 (Step 1): Automatically (Tool: Hobbing cutter) haP*= 1.350, hfP*= 1.342, rofP*= 0.300 Gear 1 (Step 2): Automatically (tip chamfer/rounding) (Tool: Hobbing cutter) r= 0.450 mm, in transverse section

Calculation of Gear 2

Gear 2 (Step 1): Automatically (Tool: Hobbing cutter) haP*= 1.156, hfP*= 1.529, rofP*= 0.300 Gear 2 (Step 2): Automatically (tip chamfer/rounding) (Tool: Hobbing cutter) r= 0.450 mm, in transverse section

REMARKS:

- Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances Specifications with [.m] imply: Mean value within tolerance - For the backlash tolerance, the center distance tolerances and the tooth thickness

deviation are taken into account. Shown is the maximal and the minimal backlash corresponding the largest resp. the smallest allowances The calculation is done for the Operating pitch circle..

End report

lines: 363

----- GEAR 1 ----- GEAR 2 --

0.300

20.00

1.350

1.342

0.000

0.300

0.000

0.000

0.000

not topping

4.80

0.300 0.60 4.80

10.00

4.2 **Example endurance limit (flank)**

KISSsoft-Ent		Release 04-2010 KISSsoft AG	CH-8634 HOMBRECHTIKON
Name :	z34_z18_m1_56_ver_V2	File	13:53:43
Changed by :	ho on: 22.04.3	2010 at:	

CALCULATION OF A CYLINDRICAL SPUR GEAR PAIR

Drawing or article number: Gear 1: 0.000.0 Gear 2: 0.000.0

Calculation method ISO 6336:2006 Method B

Power (W)	[P]	20.94	140
Speed (1/min)	[n]	5.3	10.0
Torque (Nm)	[T]	37.6	20.0
Application factor	[KA]	1.	.00
Required service life	[H]	0	.00
Gear driving (+) / driven (-)		+	-

1. TOOTH GEOMETRY AND MATERIAL

(Geometry calculation according ISO 21771)

(Geometry calculation according IS	0 21771)		
		GEAR 1	GEAR 2
Center distance (mm)	[a]	40.0	00
Centre distance tolerance		No	backlash
Normal module (mm)	[mn]	1.56	00
Pressure angle at normal section (°)	[alfn]	12.00	00
Helix angle at reference circle (°)	[beta]	0.00	00
Number of teeth	[z]	33.4743	17.8077
Facewidth (mm)	[b]	3.00	3.00
Hand of gear		Spur gear	
Accuracy grade	[Q-ISO1328]	6	6
Inner diameter (mm)	[di]	0.00	0.00
Inside diameter of rim (mm)	[dbi]	0.00	0.00
Material			
	hrough hardened st Figure 11/12 (MQ)	teel, flame/ind. hard)	ened

C45 (2), Through hardened steel, flame/ind. hardened Gear 2: ISO 6336-5 Figure 11/12 (MQ)

----- GEAR 1 ----- GEAR 2 --Surface hardness HRC 57 HRC 57 Material treatment according to ISO6336: Normal (Life factors ZNT and YNT >=0.85) Fatigue strength. tooth root stress (N/mm $^{\rm 2})$ [sigFlim] 370.00 370.00 Fatigue strength for Hertzian pressure (N/mm²) 1220.00 1220.00 [sigHlim] 700.00 [Rm] Tensile strength (N/mm²) 700.00 Yield point (N/mm^2) [Rp] 490 00 206000 Young's modulus (N/mm²) [E] 206000

[haP*]

[hfP*]

[rhoaP*]

[rhofP*]

[hFaP*]

[hprP*]

[alfprP]

[alfKP]

Poisson's ratio [ny] Average roughness, Ra, tooth flank (µm) [RAH] Mean roughness height, Rz, flank (µm) Mean roughness height, Rz, root (µm) [RZH] [RZF]

Tool or reference profile of gear 1 : Reference profile (Own input) Addendum coefficient Dedendum coefficient Tip radius factor Root radius factor Tip form height coefficient Protuberance height factor Protuberance angle Ramp angle

Tool or reference profile of gear 2 : Reference profile (Own input) Addendum coefficient [haP*] 1.156

Dedendum coefficient Tip radius factor Root radius factor Tip form height coefficient Protuberance height factor Protuberance angle Ramp angle	[hfP* [rhoa] [rhof] [hFaP [hFrP [alfp] [alfK]	P*] P*] *] rP]	1.529 0.000 0.300 0.000 0.000 0.000 0.000 pping
Sum of reference profile gears: Dedendum reference profile (module) Tooth root radius Refer. profile (module)	[hfP*]	1.342	1.529
Addendum Reference profile (module) Protuberance height (module) Protuberance angle (°) Buckling root flank height (module) Buckling root flank angle (°)	[rofP*] [haP*] [hprP*] [alfprP] [hFaP*] [alfKP]	0.300 1.350 0.000 0.000 0.000 0.000 0.000	0.300 1.156 0.000 0.000 0.000 0.000 0.000
Type of profile modification:		No	
Tip relief (µm)	[Ca]	3.40	3.40
	Gre Syn (n)	ease lubrication ease: Isoflex Topas nthetic oil based on u40] u100]]	
Overall transmission ratio Gear ratio Transverse module (mm) Pressure angle at Pitch circle (°) Working transverse pressure angle (°) Working pressure angle at normal section		i] 12.00	GEAR 2 -0.532 1.880 1.560 12.000 12.000 0 / 12.000 12.000
Helix angle at operating pitch circle (°) Base helix angle (°) Reference centre distance (mm) Sum of profile shift coefficients Profile shift coefficient Tooth thickness (Arc) (module)	[betaw] [betab] [ad] [Summexi] [x] [sn*]	-0.4763 1.3683	0.000 0.000 40.000 0.0000 0.4763 1.7733
Tip alteration (mm) Reference diameter (mm) Base diameter (mm) Tip diameter (mm) (mm) Tip diameter allowances (mm)	[k] [d] [dB] [da] [da.e/i] [Ada.e/i]		0.000 27.780 27.173 32.872 32.872 / 32.872 0.000 / 0.000
Chamfer (1) / Tip rounding (2) / pointed Tip chamfer / tip rounding (mm) Tip form diameter (mm) (mm)	tooth (3) [hK] [dFa] [dFa.e/i]	2 0.450 54.328 54.328 / 54.328	2 0.450 32.442 32.442 / 32.442
Operating pitch diameter (mm) (mm) Root diameter (mm) Generating Profile shift coefficient Manufactured root diameter with xE (mm) Theoretical tip clearance (mm) Effective tip clearance (mm) Active root diameter (mm) (mm)	[dw] [dw.e/i] [df] [xE.e/i] [df.e/i] [c] [c.e/i] [dNf] [dNf.e/i]	$\begin{array}{c} 52.220\\ 52.220 \\ 46.548\\ -0.4763 \\ 46.548\\ 0.278\\ 0.278\\ 0.278 \\ 0.000\\ 0.000 \\ 0.000 \\ 0.000 \end{array}$	$\begin{array}{c} 27.780\\ 27.780 \\ 24.497\\ 0.4763 \\ 0.4763 \\ 24.497\\ 0.290\\ 0.290 \\ 0.290 \\ 0.290 \\ 0.000\\ 0.000 \\ 0.000 \end{array}$
(Indication 0.0 is for dNf.e/i in case of Root form diameter (mm) (mm)	of contact [dFf] [dFf.e/i]	interference) 51.079 51.079 / 51.079	27.173 27.173 / 27.173
Addendum (mm) (mm) Dedendum (mm) (mm)	[ha] [ha.e/i] [hf] [hf.e/i]	1.363 1.363 / 1.363 2.836 2.836 / 2.836	2.546 2.546 / 2.546 1.642 1.642 / 1.642
Roll angle to dNa (°) [xsi Roll angle to dNf (°) [xsi	dFa.e/i] dNa.e/i] dNf.e/i] dFf.e/i] [H] [zn] [san] [san.e/i]	20.759 / 20.759 20.759 / 20.759 0.000 / 0.000 0.036 / 0.036 4.199 33.474 1.373 1.373 / 1.373	37.371 / 37.371 37.371 / 37.371 0.000 / 0.000 0.049 / 0.049 4.188 17.808 0.645 0.645 / 0.645
<pre>(without consideration of tip chamfer/ t Normal space width at tip cylinder (mm)</pre>	ip roundin [efn] [efn.e/i] [vga]	ng) 0.000 0.000 / 0.000 0.006	0.000 0.000 / 0.000 0.009
Specific sliding at the tip Specific sliding at the root Sliding factor on tip Sliding factor on root Pitch on reference circle (mm)	[zetaa] [zetaf] [Kga] [Kgf] [pt]	1.190 -9999.000 0.422 -0.599	1.000 6.255 0.599 -0.422 4.901
Base pitch (mm) Transverse pitch on contact-path (mm)	[pbt] [pet]		4.794 4.794

[ga, e/i] 9.253 (9.253 / 9.253) [T1A, T2A] 0.000(0.000/ 0.000) 8.316(8.316/ 8.316) [T1B, T2B] 4.459(4.459/ 4.459) 3.857(3.857/ 3.857) [T1C, T2C] 5.429(5.429/ 5.429) 2.888(2.888/ 2.888) [T1D, T2D] 4.794(4.794/ 4.794) 3.523(3.523/ 3.523) [T1E, T2E] 9.253(9.253/ 9.253) -0.937(-0.937/-0.937) [T1T2] 8.316 (8.316 / 8.316) Length of path of contact (mm) Length T1-A, T2-A (mm) Length T1-B (mm) Length T1-C (mm) Length T1-D (mm) Length T1-E (mm) Length T1-T2 (mm) Diameter of single contact point B (mm) [d-B] 51.852(51.852/51.852) 28.247(28.247/28.247) Diameter of single contact point D (mm) [d-D] 51.971(51.971/51.971) 28.071(28.071/28.071) [eps] 0.798(0.798/0.798) 1.132(1.132/1.132) [Lmin] 3.000 Addendum contact ratio Minimal length of contact line (mm) Transverse contact ratio [eps a] 1.930 Transverse contact ratio with allowances [eps_a, e/m/i] 1.930 / 1.930 / 1.930 0.000 Overlap ratio [eps_b] Total contact ratio [eps_g] 1,930 [eps_g.e/m/i] 1.930 / 1.930 / 1.930 Total contact ratio with allowances

2. FACTORS OF GENERAL INFLUENCE

Nominal circum force at nitch circle (N	\	GEAR 1	GEAR 2
Nominal circum. force at pitch circle (N) [Ft]	1439.9	3
Axial force (N)	[Fa]	0.0	
Radial force (N)	[Fr]	306.1	
Normal force (N)	[Fnorm]	1472.1	L
Tangent.load at p.c.d.per mm (N/mm) (N/m	m)		
	[w]	479.96	5
Only as information: Forces at pitch ci			
Nominal circumferential force (N)	[Ftw]	1439.9	
Axial force (N)	[Faw]	0.0	
Radial force (N)	[Frw]	306.1	
Circumferential speed pitch d (m/sec)	[V]	0.01	L
Running-in value (µm)	[qv]	0.6	
Running-in value (µm)	[yf]	0.5	
Correction coefficient	[CM]	0.80	00
Gear body coefficient	[CR]	1.00	00
Reference profile coefficient	[CBS]	0.74	11
Material coefficient	[E/Est]	1.00	00
Singular tooth stiffness (N/mm/µm)	[c']	9.33	39
	[cgalf]	15.85	55
Meshing stiffness (N/mm/µm)	[cgbet]	13.47	77
Reduced mass (kg/mm)	[mRed]	0.00	207
Resonance speed (min-1)	[nE1]	24955	5
Nominal speed (-)	[N]	0.000)
Subcritical range			
Running-in value (µm)	[ya]	0.6	
Bearing distance 1 of pinion shaft (mm)		6.000	
Distance s of pinion shaft (mm)	[s]	0.600	
Outside diameter of pinion shaft (mm)	[dsh]	3.000	
	[-]	4	ł
0:a), 1:b), 2:c), 3:d), 4:e)			
coefficient K' following ISO 6336/1 Diag	[K']	-1.00	
Without support effect	[L]	-1.00	
	[Fby]	2.55	
from deformation of shaft (um)	[fsh*B1]	4.36	
Tooth without tooth trace correction	[]		
Position of Contact pattern: favorable			
	[fma*B2]	8.49	
Tooth trace deviation, theoretical (µm)	[Fbx]	3.00	
Running-in value (µm)	[yb]	0.4	
Dynamic factor	[KV]	1.000)
Width factor - flank	[KHb]	1.050)
- Tooth root	[KFb]	1.034	
- Scuffing	[KBb]	1.050	
Transverse coefficient - flank	[KHa]	1.000)
- Tooth root	[KFa]	1.000)
- Scuffing	[KBa]	1.000)
			、 、
Helix angle coefficient scuffing	[Kbg]	1.000	J
Number of load changes (in mio.)	[NL]	0.100	0.100
		0.200	0.100

3. TOOTH ROOT STRENGTH

		GEAR 1	- GEAR 2
Calculation of Tooth form coefficients	according method: B		
Calculation of tooth form coefficients	with graphical method	1	
(Determination of biggest value for YF	* YS on the effective	e tooth shape)	
Tooth form factor	[YF]	3.25	1.50
Stress correction factor	[YS]	1.46	2.18
Working angle (°)	[alfen]	7.85	9.89
Force application diameter (mm)	[den]	51.97	28.25
Bending lever arm (mm)	[hF]	2.25	1.54
Tooth thickness at root (mm)	[sFn]	2.56	3.10

Tooth root radius (mm) (hF* = 1.441/0.985 sFn* = 1.641/1.9 35.17/47.13)	[roF] 89 roF* = 0.631/0.391	0.98 dsFn = 47.14/2	
Contact ratio factor	[Yeps]		1.000
Helix angle factor	[Ybet]		1.000
Deep tooth factor	[YDT]		1.000
Gear rim factor	[YB]	1.000	1.000
Effective facewidth (mm)	[beff]	3.00	3.00
Nominal shear stress at tooth root (N/mm²)		
	[sigF0]	1462.66	1007.48
Tooth root stress (N/mm^2)	[sigF]	1513.01	1042.16
Permissible bending stress at root o	f Test-gear		
Support factor	[YdrelT]	0.885	1.032
Surface factor	[YRrelT]	1.001	0.975
Size coefficient (Tooth root)	[YX]	1.000	1.000
Finite life factor	[YNT]	1.476	1.476
[YdrelT*YRre	lT*YX*YNT]	1.307	1.486
Alternating bending coefficient	[YM]	0.700	0.700
Stress correction factor	[Yst]		2.00
Limit strength tooth root (N/mm²)	[sigFG]	677.28	769.50
Permissible tooth root stress (N/mm ²)		
	[sigFP=sigFG/SFmin]	516.22	586.51
Required safety	[SFmin]	1.31	1.31
Safety for Tooth root stress	[SF=sigFG/sigF]	0.45	0.74
Transmittable power (W)	[kWRating]	7.15	11.79

4. SAFETY AGAINST PITTING (TOOTH FLANK)

		GEAR 1	GEAR 2
Zone factor	[ZH]	Olini(1	3.136
Elasticity coefficient (N^.5/mm)	[ZE]		189.812
Contact ratio factor	[Zeps]		0.831
Helix angle factor	[Zbet]		1.000
Effective facewidth (mm)	[beff]		3.00
Nominal flank pressure (N/mm ²)	[sigH0]	2	543.65
Surface pressure at Operating pitch cir			
	[sigHw]	2	606.55
Single tooth contact factor	[ZB,ZD]	1.00	1.00
Flank pressure (N/mm ²)	[sigH]	2606.55	2606.55
Lubrication factor	[ZL]	1.000	1.000
Speed factor	[ZV]	1.000	1.000
Roughness factor	[ZR]	1.000	1.000
Material mating factor	[ZW]	1.000	1.000
Finite life factor	[ZNT]	1.600	1.600
[ZL*ZV*	ZR*ZNT]	1.600	1.600
Small amount of pitting permissible (0=	=no, 1=yes)	0	0
Size coefficient (flank)	[ZX]	1.000	1.000
Limit strength pitting (N/mm²)	[sigHG]	1952.00	1952.00
Permissible surface pressure (N/mm ²) [s	sigHP=sigHG/SHmin]	2041.84	2041.84
Safety for surface pressure at pitch ci	ircle		
	[SHw]	0.75	0.75
Required safety	[SHmin]	0.96	0.96
Transmittable power (W)	[kWRating]	12.85	12.85
Safety for stress at single tooth conta	act		
-	[SHBD=sigHG/sigH]	0.75	0.75
(Safety regarding nominal torque)	[(SHBD)^2]	0.56	0.56

6. MEASUREMENTS FOR TOOTH THICKNESS

		GEAR 1	GEAR 2
Tooth thickness deviation		No backlash	No backlash
Tooth thickness allowance (normal sectio	n) (mm)		
	[As.e/i]	0.000 / 0.000	0.000 / 0.000
Number of teeth spanned	[k]	2.000	3.000
Base tangent length (no backlash) (mm)			12.378
Actual base tangent length ('span') (mm)	[Wk.e/i]	7.041 / 7.041	12.378 / 12.378
Diameter of contact point (mm)	[dMWk.m]	51.562	29.859
	[DM]	3.044	3.061
Eff. Diameter of ball/pin (mm)			
Theor. dim. centre to ball (mm)	[MrK]	28.718	17.095
Actual dimension centre to ball (mm)	[MrK.e/i]	28.718 / 28.718	17.095 / 17.095
Diameter of contact point (mm)	[dMMr.m]	53.189	29.524
Diametral measurement over two balls wit			
	[MdK]	57.376	34.069
Actual dimension over balls (mm)	[MdK.e/i]	57.376 / 57.376	34.069 / 34.069
Theor. dimension over two pins (mm)	[MdR]	57.376	34.069
Actual dimension over rolls (mm)	[MdR.e/i]	57.376 / 57.376	34.069 / 34.069
Dimensions over 3 pins without clearance	(mm)		
-	[Md3R]	57.316	33.949
Actual dimensions over 3 rolls (mm)	[Md3R.e/i]	57.316 / 57.316	33.949 / 33.949
Chordal tooth thickness (no backlash) (m	,		
		2.134	
Actual chordal tooth thickness (mm)			
Reference chordal height from da.m (mm)	[ha]	1.385	2.615
Tooth thickness (Arc) (mm)	[sn]	2.135	2.766

(mm)	[sn.e/i]	2.135 / 2.135	2.766 / 2.766
Backlash free center distance (mm) Backlash free center distance, allowa		40.000 /	40.000
	[jta]	0.000 / 0	.000
Centre distance allowances (mm)	[Aa.e/i]	0.000 / 0	.000
Circumferential backlash from Aa (mm)	[jt Aa.e/i]	0.000 / 0	.000
Radial clearance (mm)	[jr]	0.000 / 0	.000
Circumferential backlash (transverse	section) (mm)		
	[jt]	0.000 / 0	.000
Torsional angle using fixed values ge	ear 1 (°)	0.0000 /0	.0000
Normal backlash (mm)	[jn]	0.000 / 0	.000

7. TOLERANCES

		GEAR 1	GEAR 2
According ISO 1328:			
Accuracy grade	[Q-ISO1328]	6	6
Single normal pitch deviation (µm)	[fpt]	7.50	7.00
Base circle pitch deviation (µm)	[fpb]	7.50	7.00
Cumulative circular pitch deviation over	z/8 pitches	(mu)	
	[Fpz/8]	12.00	9.50
Profile deviation (µm)	[ffa]	6.50	5.50
Profile angular deviation (µm)	[fHa]	5.50	4.60
Profile total deviation (µm)	[Fa]	8.50	7.50
Helix form deviation (µm)	[ffb]	6.00	6.00
Helix slope deviation (µm)	[fHb]	6.00	6.00
Tooth helix deviation (µm)	[Fb]	8.50	8.50
Total cumulative pitch deviation (µm)	[Fp]	26.00	20.00
Runout tolerance (µm)	[Fr]	21.00	16.00
Total radial composite tolerance (µm)	[Fi"]	31.00	26.00
Tooth-to-tooth radial composite tolerand	e (µm)		
	[fi"]	9.50	9.50
Total tangential composite deviation (µm)		
	[Fi']	40.00	33.00
Tooth-to-tooth tangential composite devi	ation (µm)		
	[fi']	13.00	13.00
Tolerance for alignment of axes (recomme	ndation acc.	ISO/TR 10064, Quality 6)	
Maximum value for deviation error of axi	s (µm)		

Maxımum	value	ior	deviation error of axis (µm)	
			[fSigbet]	8.50
Maximum	value	for	inclination error of axes (µm)	
			[fSigdel] 1	L7.01

8. ADDITIONAL DATA

Maximal possible centre distance (eps_a=1.0)			
	[aMAX]	41.331	
Torsional stiffness (MNm/rad)	[cr]	0.0	0.0
Mean coeff. of friction (acc. Niemann)	[mum]	0.200	
Wear sliding coef. by Niemann	[zetw]	2.146	
Power loss from gear load (W)	[PVZ]	1.119	
(Meshing efficiency (%)	[etaz]	94.656)	
Weight - calculated with da (g)	[Mass]	55.70	19.94
Moment of inertia (System referenced to wheel 1):			
calculation without consideration of th	e exact tooth	shape	
single gears ((da+df)/2di) (kgm²)	[TraeghMom]	1.529e-005	1.561e-006
System ((da+df)/2di) (kgm²)	[TraeghMom]	2.081e-005	

9. DETERMINATION OF TOOTHFORM

Calculation of Gear 1

Gear 1 (Step 1): Automatically (Tool: Hobbing cutter) haP*= 1.350, hfP*= 1.342, rofP*= 0.300 Gear 1 (Step 2): Automatically (tip chamfer/rounding) (Tool: Hobbing cutter)
r= 0.450 mm, in transverse section

Calculation of Gear 2

Gear 2 (Step 1): Automatically (Tool: Hobbing cutter) haP*= 1.156, hfP*= 1.529, rofP*= 0.300 Gear 2 (Step 2): Automatically (tip chamfer/rounding) (Tool: Hobbing cutter) r= 0.450 mm, in transverse section

REMARKS: - Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances Specifications with [.m] imply: Mean value within tolerance - For the backlash tolerance, the center distance tolerances and the tooth thickness deviation are taken into account. Shown is the maximal and the minimal backlash corresponding the largest resp. the smallest allowances
The calculation is done for the Operating pitch circle..
- Details of calculation method: cg according to method B KV according to method B KHb, KFb according method C fma following equation (64), fsh following (57/58), Fbx following (52/53/57) KHa, KFa according to method B

End report

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