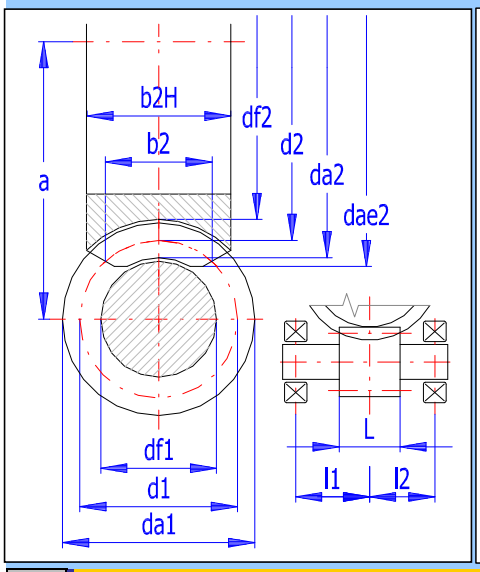
Worm gearing

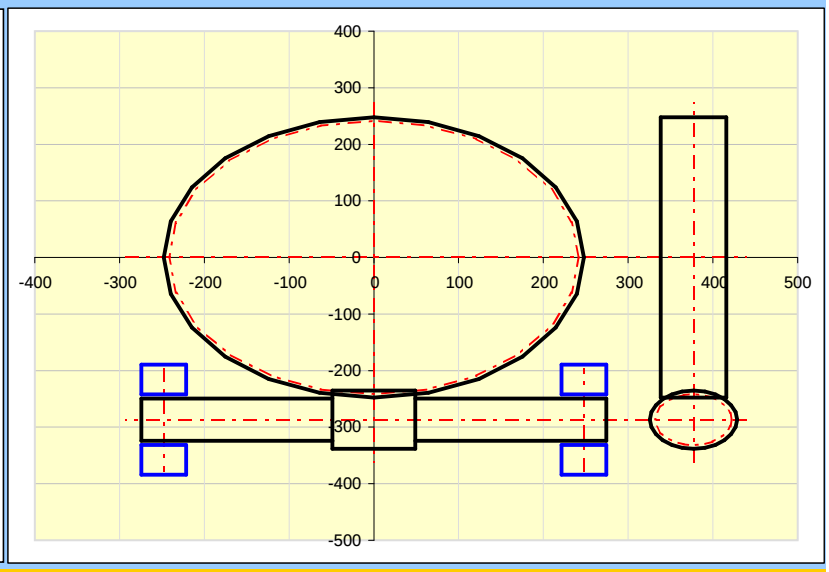
			Worm	Gear	
i	**Calculation without errors.**				
ii	☐ **Project information**				
?	**Input section**				
1.0	☑ **Options of basic input parameters**				
1.1	Calculation units		SI Units (N, mm, kW...)		
1.2	Driven worm / worm gear		Worm		
1.3	Transferred power	Pw [kW]	54.913	50.000	
1.4	Speed (Worm / Worm gear)	n [/min]	1200.00	48.00	[/min]
1.5	Torsional moment (Worm / Gear)	Mk [Nm]	437.02	9947.92	[Nm]
1.6	Transmission ratio / from table	i	25.00		
1.7	Actual transmission ratio / deviation	i	25.00	0.00%	
2.0	☑ **Options of material, loading conditions, operational and production parameters**				
2.1	Material of the worm:		Alloy structural steel 16MnCr5 (Rm=785 MPa) case-hardened		
2.2	Material of the gear :		Bronze (centrifugal cast) CuSn12Ni2-C-GZ (DIN EN 1982) (Rm=300 MPa)		
2.3	Type of worm (profile type)		ZN (N) Wormgear		
2.4	Loading of the gearbox, driving machine - examples		A...Continuous		
2.5	Loading of gearbox, driven machine - examples		A...Continuous		
2.6	Type of lubrication		Oil-spray lubrication		
2.7	Type of oil		Oil based on Polyglycols (PEG)		
2.8	Oil designation - selection		ISO VG - 220 (AGMA no 5)		
2.9	Kinematic viscosity for 40°C and 100°C	ν40,ν100	220.00	40.00	[mm^2/s]
2.10	Lubrication density at 15°C	ρoil15	1.060	[kg/dm^3]	
2.11	Roughness average value of the worm	Ra1	0.50	[microm]	
2.12	Application factor	KA	1.00	1.00 ☑	
2.13	Desired service life	Lh	25000	[h]	
2.14	**Requested coefficients of safety**				
2.15	Wear safety	SW	1.10	≥1.10	
2.16	Pitting safety	SH	1.00	≥1.00	
2.17	Worm deflection safety	Sδ	1.00	≥1.00	
2.18	Tooth strength safety	SF	1.10	≥1.10	
3.0	☑ **Parameters of the tooth profile**				
3.1	Addendum - Coefficient of the height of the tooth head	ha*	1.000	[modul]	
3.2	Unit head clearance	c*	0.250	[modul]	
3.3	Recommended coefficient of the root radius		0.38	[modul]	
3.4	Coefficient of the root radius	rf*	0.38 ☑	[modul]	
4.0	☑ **Design of a geometry of toothing**				
4.1	**Table of proper solutions**				
4.2	Check safety	SW ☑	SH ☑	Sδ ☑	SF ☑
4.3	Range of z1 from - to		1	3	
4.4	Range of q from - to		6	14	
4.5	Sort results according to parameter:		mass		

4.6 z1	z2	i	n2	q	m	DP	eta	gama	a	d1	d2	mass	SW	SH	Sd	SF	ST
4.7 3	75	25.00	48.00	14.00	6.30	4.03	0.911	12.09	286.71	90.20	483.23	216.20	3.54	1.03	1.04	2.07	1.67

4.8	**Design of a geometry**					
4.9	Number of teeth Worm / Worm Gear	z1,z2	3	75		
4.10	Normal pressure angle	α	20.00	20		[°]
4.11	Diameter quotient (q = d1 / m)	q	14.00	6 - 25	◉	
4.12	Mean diameter of worm	d1	90.2023	~ 61.29	○	[mm]
4.13	Pitch angle	γ	12.0948	11	○	[°]
4.14	Pitch direction		Right			
4.15	Module / Standardized value	mn	6.300			[mm]
4.16	Circular Pitch / Diametral Pitch	CP/DP	0.7792	4.0317		
4.17	Distance of left/right bearing (% of wheel diameter)	l1%,l2%	50.00	50.00		[% da2]
4.18	Distance of left/right bearing	l1,l2	247.91	247.91	☑	[mm]
4.19	Worm face width	L	97.65	97.65	☑	[mm]
					☑	

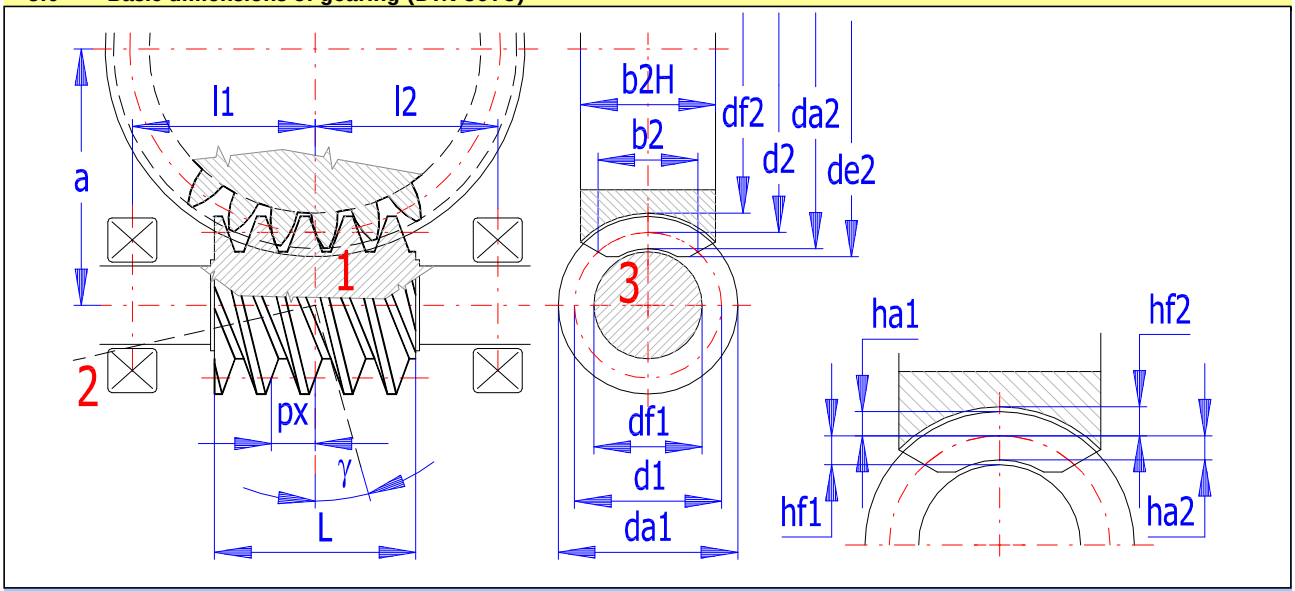
4.20	Wormgear face width	b2H	77.32	77.32	☑	[mm]
4.21	Addendum modification coefficient for Wormgear	x [modul]	0.0000	> -1		
4.22	Reference diameter Worm / Wormgear	d1, d2	90.202	483.226		[mm]
4.23	**Calculation of gearing for the given axis distance**					
4.24	Required centre distance / current	a [mm]	180.000	286.714		
4.25	Fitt the axis distance by changing the parameter	Diameter quotient q <6;25> (285.266;317.26)				
4.26	Approximate weight of the gearbox / gears	m	216.202	120.139		[kg]
4.27	Total efficiency / Max. theoretical	µges, µmax	91.05	95.37		[%]
4.28	Safety coefficient (wear, pitting)	SW, SH	3.54	1.03		
4.29	Safety coefficient (deflection, fatigue failure)	Sδ, SF	1.04	2.07		





Results section

5.0 ☑ **Basic dimensions of gearing (DIN 3975)**



5.1	Module: Normal / transverse / axiale	mn,mt,mx	6.3000	30.0674	6.4430	[mm]
5.2	Pitch: Normal / transverse / axiale	pn,pt,px	19.7920	94.4596	20.2413	[mm]
5.3	Pressure angle: Normal / transverse / axiale	alfan,alfat,alfax	20.0000	60.0720	20.4169	[°]
5.4	Number of teeth Worm / Worm Gear	z1,z2		3	75	
5.5	Tip diameter	da1,da2		102.8023	495.8265	[mm]
5.6	Reference diameter	d1,d2		90.2023	483.2265	[mm]
5.7	Root diameter	df1,df2		74.4523	467.4765	[mm]
5.8	Pitch cylinder diameter	dw1,dw2		90.2023	483.2265	[mm]
5.9	Mean diameter	dm1,dm2		90.2023	483.2265	[mm]
5.10	Outside diameter of wormgear	de2		502.2700	501.1-520.2 ☑	[mm]

5.11	Addendum	ha1,ha2	6.3000	6.3000	[mm]
5.12	Dedendum	hf1,hf2	7.8750	7.8750	[mm]
5.13	Center distance	a	286.7144		[mm]
5.14	Worm face width / Wormgear face width	L/b2H	97.6500	77.3200	[mm]
5.15	Pitch angle on: Mean diameter / Pitch diameter	γ, γw	12.0948	12.0948	[°]
5.16	Tooth thickness in normal plane	sn1,sn2	9.8960	9.8960	[mm]
5.17	Tooth thickness in centr-line plane	sx1,sx2	10.1207	10.1207	[mm]
5.18	Tooth space thickness in normal plane	en1,en2	9.8960	9.8960	[mm]
5.19	Tooth space thickness in centr-line plane	ex1,ex2	10.1207	10.1207	[mm]

6.0 ☑ Efficiency and losses (DIN 3996)

6.1	Sliding velocity	vgm	5.7964	[m/s]	
6.2	Size factor	YS	0.6325		
6.3	Geometry factor	YG	1.1957		
6.4	Material factor	YW	0.9500		
6.5	Roughness factor affecting surface durability	YR	1.0000		
6.6	Basic coefficient of friction	μ0T	0.0235		
6.7	Mean coefficient of friction	μzm	0.0169		
6.8	Friction angle	ρz	0.9681	[°]	
6.9	Efficiency of gearing	ηz	0.9236		
6.10	No-load losses	PV0	0.3254	[kW]	
6.11	Bearing losses	PVLP	0.4055	[kW]	B..Fixed/floating bearing
6.12	Sealing losses	PVD	0.2300	[kW]	
6.13	Gearing losses	PVz	3.9522	[kW]	
6.14	Total power loss	PV	4.9131	[kW]	
6.15	Total efficiency	ηges	0.9105		

7.0 ☑ Wear load capacity (DIN 3996)

7.1	Equivalent modulus of elasticity E	Ered	149673.38	[MPa]	
7.2	Mean contact stress	σHm	348.39	[MPa]	
7.3	Constant, used instead of the viscosity exponent	cα	0.000000013	[m^2/N]	
7.4	Temperature of the wheel	ϑM	127.23	[°C]	
7.5	Lubricant density at bulk temperature	ρoilM	0.97569	[kg/dm^3]	
7.6	Kinematic viscosity at bulk temperature	νM	23.68883	[mm^2/s]	
7.7	Dynamic viscosity at bulk temperature	η0M	0.02311	[Ns/m^2]	
7.8	Mean lubricant film thickness	hminm	0.21976	[microm]	
7.9	Load cyle	NL	7.2000E+07		
7.10	Sliding path	sWm	1545483675	[mm]	
7.11	Lubricant structure factor	WS	3.738102591	[-]	
7.12	Parameter - lubricant structure / film thickness	KW	0.82147188	[-]	
7.13	Relative wear intensity	J0T	1.97295E-10	[-]	
7.14	Run-up coefficient / No of starts per hour	WNS	1	0	
7.15	Material/lubricant factor - wear	WML	1.75		
7.16	Wear intensity of a material	JW	3.45266E-10		
7.17	Abrasive wear in the normal section	δWn	0.533603341	[mm]	
7.18	Permissible wear of the tooth side	δWlimn	1.890	< 5.31 ☑	[mm]
7.19	Wear safety	**SW**	**3.54**		

8.0 ☑ Pitting Resistance (DIN 3996)

8.1	Life factor	Zh	1.000		
8.2	Speed factor	Zv	0.714		
8.3	Size factor	Zs	0.970		
8.4	Transmission ratio factor	Zu	1.000		
8.5	Lubricant factor	Zoil	1.000		
8.6	Pitting Resistance	σHlimT	520.00	[MPa]	
8.7	Limiting value of the contact stress	σHG	360.45	[MPa]	
8.8	Pitting safety	**SH**	**1.03**		

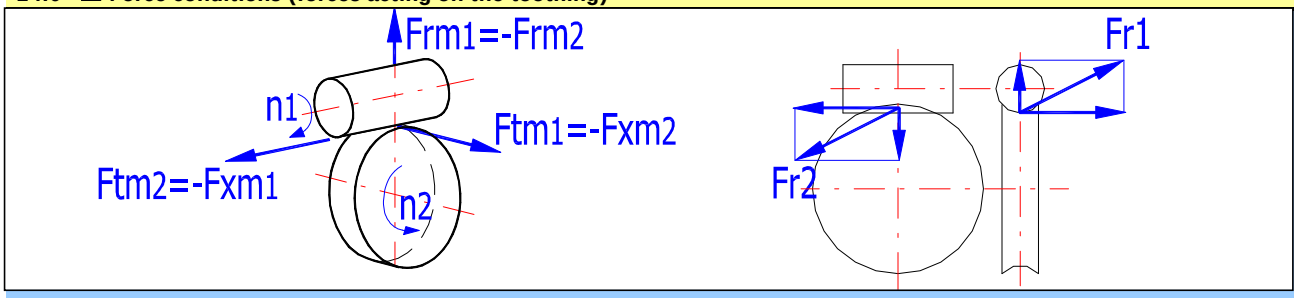
9.0 ☑ Worm deflection (DIN 3996)

9.1	Distance of the left bearing	l1	247.9132	[mm]	
9.2	Distance of the right bearing	l2	247.9132	[mm]	

9.3	Reaction in the left bearing	RA	9183.15		[N]	
9.4	Reaction in the right bearing	RB	9183.15		[N]	
9.5	Wormshaft deflection	δm	0.09786		[mm]	
9.6	Permisible wormshaft deflection	δlim	0.10153		[mm]	
9.7	Worm deflection safety	**Sd**	**1.04**			
10.0	☑ **Root-strength of teeth (DIN 3996)**					
10.1	Gear ratio factor	Yε	0.5000			
10.2	Tooth form factor	YF	1.14			
10.3	Lead factor	Yγ	1.0227			
10.4	Thickness of rim	SK	12.90	12.90 ☑	[mm]	
10.5	Rim thickness coefficient	YK	1.0000			
10.6	Life factor / Accuracy grade	YNL	1.00	7+ ☑		
10.7	Shear endurance limit	τFlimT	100.00		[MPa]	
10.8	Limiting value of the shearstress at tooth root	τFG	100.00		[MPa]	
10.9	Shear stress at tooth root	τF	48.25		[MPa]	
10.10	Tooth strength safety	**SF**	**2.07**			
11.0	☑ **Thermal safety (DIN 3996), Thermal analyse**					
11.1	Ambient air temperature	ϑ0	20.00		[°C]	
11.2	Extreme temperature of gearbox (oil)	ϑSlim	110.00	☑	[°C]	
11.3	Cooling of gearbox		Cooling with fan			
11.4	Total power loss		4.91		[kW]	
11.5	**Oil bath lubrication, method C**					
11.6	Gearbox temperature	ϑS	86.76		[°C]	
11.7	Thermal safety	**ST**	**1.27**			
11.8	**Thermal analyse**					
11.9	Requested max. temperature of gearbox (oil)	ϑSmax	100.00	☑	[°C]	
11.10	Ribbing of the gearbox		Optimal ribbed			
11.11	Gearbox surface	A	2.2082	☑	[m^2]	
11.12	Heat transfer coefficient	k	36.3918	☑	[W/m2*K]	
11.13	Oil cooler power (inside / outside) if is used	PK1	0.000	☑	[kW]	
11.14	**Oil-spray lubrication**					
11.15	Use of oil cooler		Cooling without cooler			
11.16	Temperature difference of the lubrication oil	Δϑ	3.00	☑	[°C]	
11.17	Oil specific heat	coil	1900.000	☑	[Ws/Kg/°K]	
11.18	Oil spray volume	Qoil	0.202	☑	[litre/s]	
11.19	Oil cooling power	PK2	1.22		[kW]	
11.20	Gearbox temperature	ϑS	65.97		[°C]	
11.21	Thermal safety	**ST**	**1.67**			
11.22	Temperature of the wheel	ϑM	127.23		[°C]	
12.0	☑ **Dimensions of cylindrical wormgearing (AGMA 6022-C93)**					
12.1	Number of teeth Worm / Worm Gear	NW, NG	3	75		
12.2	Transmission ratio	mG	25.00			
12.3	Centre distance, worm axial pitch	C, px	11.288	0.7969	[in]	
12.4	Worm pitch diameter (recomendet)	dmin - dmax	2.779 - 5.211		[in]	
12.5	Worm pitch diameter, Wormgear pitch diameter	d,D	3.5513	19.0247	[in]	
12.6	Worm lead, Lead angle	L,λ	2.3907	12.0948	[in],[°]	
12.7	Worm and wormgear adendum, dedendum	a,b	0.2537	0.2935	[in]	
12.8	Outside diameter worm, wormgear	do,Do	4.0586	19.7857	[in]	
12.9	Worm root diameter, wormgear throat diameter	dr,Dt	2.9643	19.5320	[in]	
12.10	Clearance	c	0.0398		[in]	
12.11	Worm face width,wormgear face width	FWmax,FG	6.2134	3.1539	[in]	
13.0	☑ **Safety (ANSI / AGMA 6034-B92)**					
13.1	Sliding velocity	v	1140.99		[ft/min]	
13.2	Transmission ratio factor	Cm	0.823			
13.3	Speed factor	Cv	0.239			
13.4	Friction coefficient	μ	0.0195			
13.5	Material factor	Cs	1000.00	Centrifugally část		

13.6	Effective face width	Fe	2.38	[in]
13.7	Acceptable tangential load	Wt	4942.27	[lbf]
13.8	Friction force	Wf	105.16	[lbf]
13.9	Torgue at wormgear	TG	47012.52	[lb*in]
13.10	Rated input power	Pi	39.45	[HP]
13.11	Rated output power	Po	35.82	[HP]
13.12	Efficiency	η	90.78	[%]
13.13	Wormshaft deflection	Δw	0.00385	[in]
13.14	Permisible wormshaft deflection	Δwmax	0.00446	[in]

14.0 ☑ Force conditions (forces acting on the toothing)



14.1	Peripheral speed	v1,v2	5.668	1.214	[m/s]
14.2	Tangential force	Ftm1,Ftm2	9689.00	41169.86	[N]
14.3	Axial force	Fxm1,Fxm2	-41169.86	-9689.00	[N]
14.4	Radial force	Frm1,Frm2	15602.69	-15602.69	[N]
14.5	Total radial force	Fr1,Fr2	18366.29	44027.28	[N]
14.6	Normal force	Fn	45619.23		[N]

15.0 ☑ Parameters of the chosen material

15.1	Density	Ro	7870	8800	[kg/m^3]
15.2	Young's Modulus (Modulus of Elasticity)	E	206	98.1	[GPa]
15.3	Tensile Strength, Ultimate	Rm	785	300	[MPa]
15.4	Tensile Strength, Yield	Rp0.2	588	180	[MPa]
15.5	Poison's Ratio		0.30	0.35	
15.6	Contact Fatigue Limit	SHlim	1270	510	[MPa]
15.7	Bending Fatigue Limit	SFlim	700	325	[MPa]
15.8	Tooth Hardness - Side	VHV	650	230	[HV]
15.9	Tooth Hardness - Core	JHV	250	230	[HV]
15.10	Base Number of Load Cycles in Contact	NHlim	1.00E+08	5.00E+07	
15.11	Wohler Curve Exponent for Contact	qH	10	10	
15.12	Base Number of Load Cycles in Bend	NFlim	3.00E+06	3.00E+06	
15.13	Wohler Curve Exponent for Bend	qF	9	6	

Additions section

16.0 ☑ Calculation of gearing for the given axis distance

16.1	Number of teeth Worm / Worm Gear	z1, z2	1	50	
16.2	Required centre distance	a	180.00		[mm]

16.3	z1 |	z2 |	m |	DP |	q |	i |	x
16.4	1 |	49 |	6.30 |	4.03 |	8.50 |	49.00 |	-0.3768

17.0 ☑ Preliminary design of shaft diameters (steel)

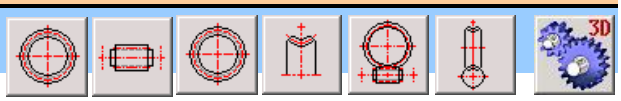
	Recommended shaft diameter for:				
17.1	- Main power-transmitting shafts	DA	92.79	262.71	[mm]
17.2	- Small, short shafts	DB	72.11	204.15	[mm]

18.0 ☑ Auxiliary calculations

18.1	Transmission ratio calculation using the number of teeth	z1,z2 = i	2	50	= 25.0000
18.2	Transmission ratio calculation using the speed	n1,n2 = i	1600.0	80.0	= 20.0000
18.3	Power calculation using the pinion speed and torque moment	Mk2,n2=Pw2	6000.0	100.0	= 62.8272

19.0 ☑ Graphical output, CAD systems

19.1	2D drawing output to:	DXF File
19.2	2D Drawing scale	Automatic



19.3	Shaft shoulder (diameter, width)	ds, t	68.200	1.600	☑	[mm]
19.4	Angle of worm shrink	β	10			[°]

19.5	**Text description (Information for BOM)**	**Worm**	
	Row 1 (BOM attribute 1)	Worm gear - Worm	☑
	Row 2 (BOM attribute 2)	z1=3, mn=6.3	
	Row 3 (BOM attribute 3)	Material: 16MnCr5	
		Gear	
	Row 1 (BOM attribute 1)	Worm gear - Gear	☑
	Row 2 (BOM attribute 2)	z2=75, mn=6.3	
	Row 3 (BOM attribute 3)	Material: CuSn12Ni2-C-GZ (DIN EN 1982)	

19.6 Table of parameters: Table of worm parameters