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GEARCALC Tutorial 003: GEARCALC

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For release:
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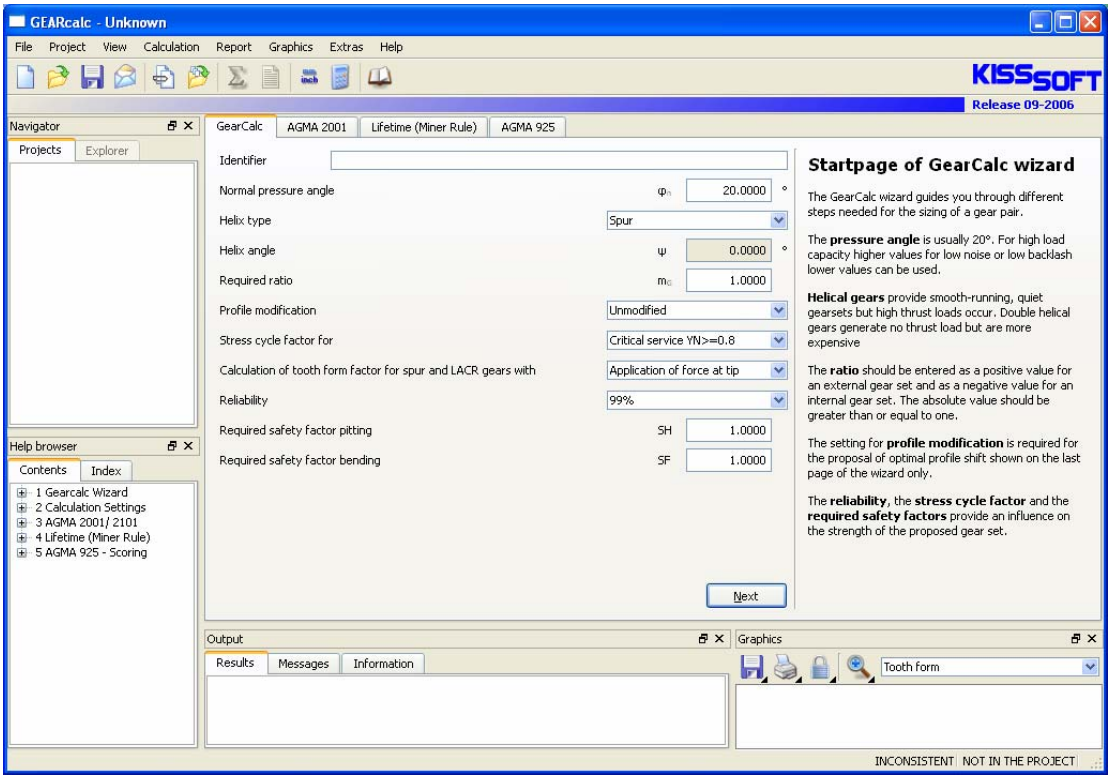
Created / modified: 15.12.2006, M.Fish / 16.12.06 U. Kissling / 18.01.2007, A.Halter
Download:

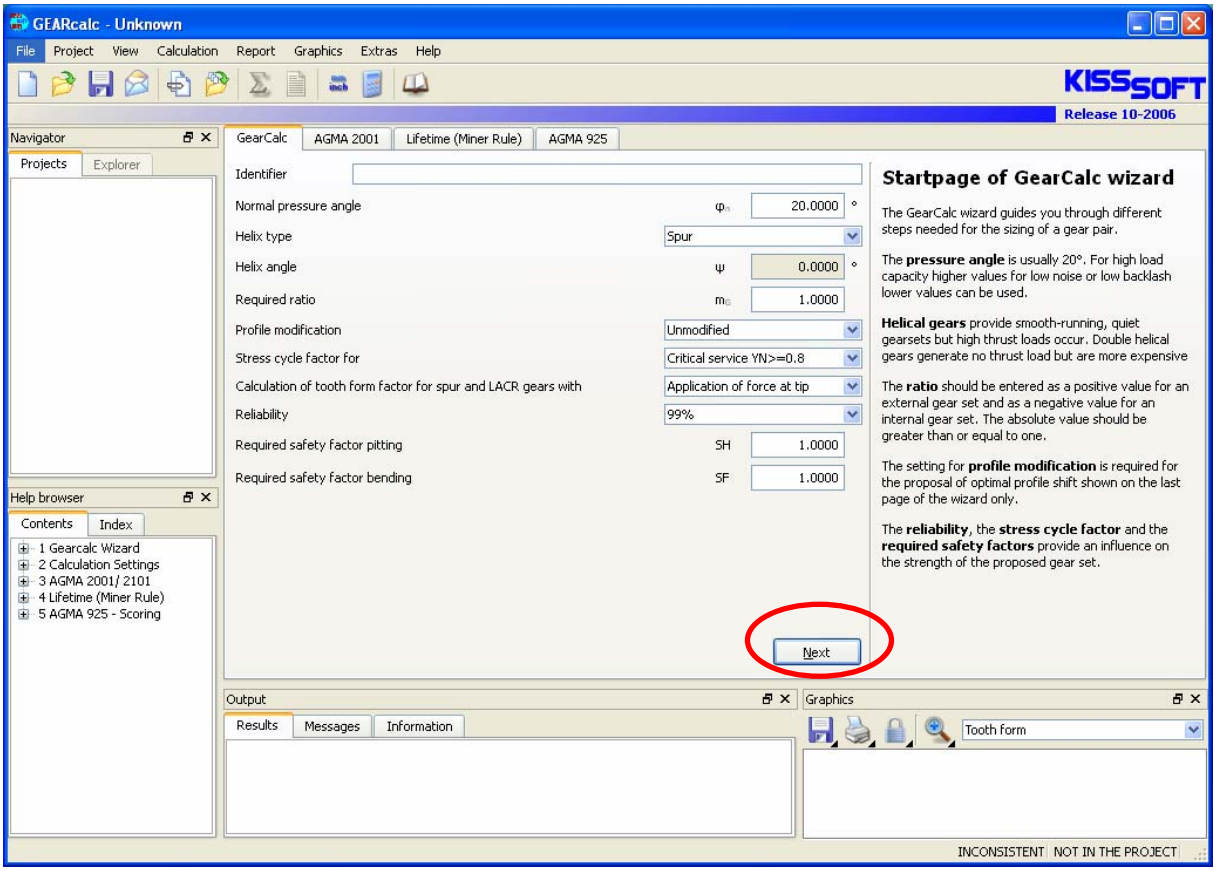
Starting GEARCALC

Starting GEARCALC

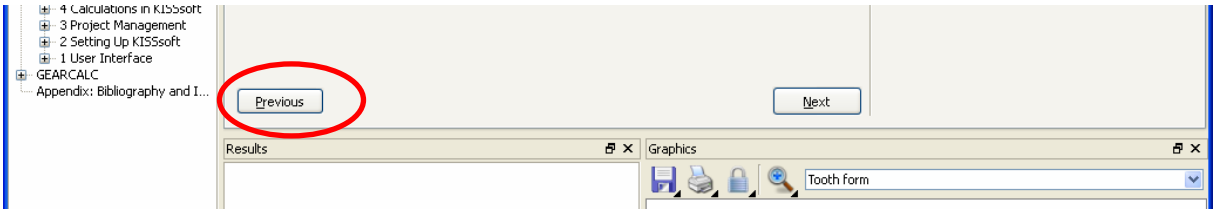
After installation, an icon can be found in the program list accessed using 'Start' in the bottom left hand corner of the screen. Alternatively click on the GEARCALC icon in the Windows Browser under "C:\Programs\GEARCALC\bin\GEARCALC.exe". The following window will appear:



The GEARCALC calculation is carried out on several pages (windows). The macro geometry is defined on the first tab side of the program which is shown by default:



These can be indexed through by clicking on the ‘Next’ button as indicated by the red marker. Data on previous pages can be edited by returning using the ‘Previous’ button.



Enter Data

Task description

A power take off to a 10HP hydraulic pump for a gas turbine accessory for an off-road vehicle is required. The pinion speed is 1260rpm and the gear ratio is exactly 5. The center distance is to be exactly 6.5 inches. The required life is only 132 hours. Minimum weight is desired, so the gear set will be designed for maximum load capacity.

Enter Data

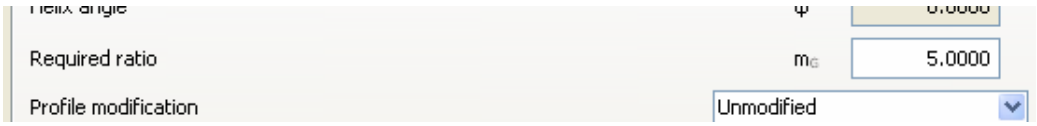
Calculation Geometry [Page 1]

For the application description, some general application characteristics are:

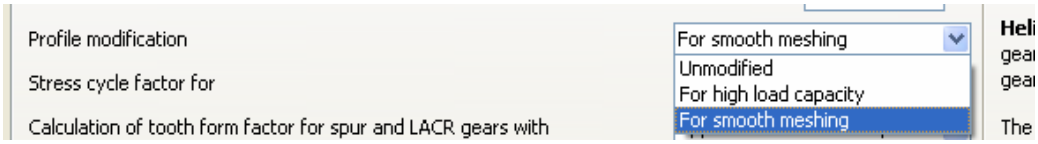
Type : Spur
Helix Angle (ψ) : 0.0°
Normal Pressure Angle (φ_n) : 20.0°

These are entered in the fields in the first page by default. Other criteria must be defined. From the task outline:

Ratio m_G(u) : 5.0



The gears are to be carburized and ground for maximum load capacity. The process permits profile modification. Select smooth running from the profile modification options:

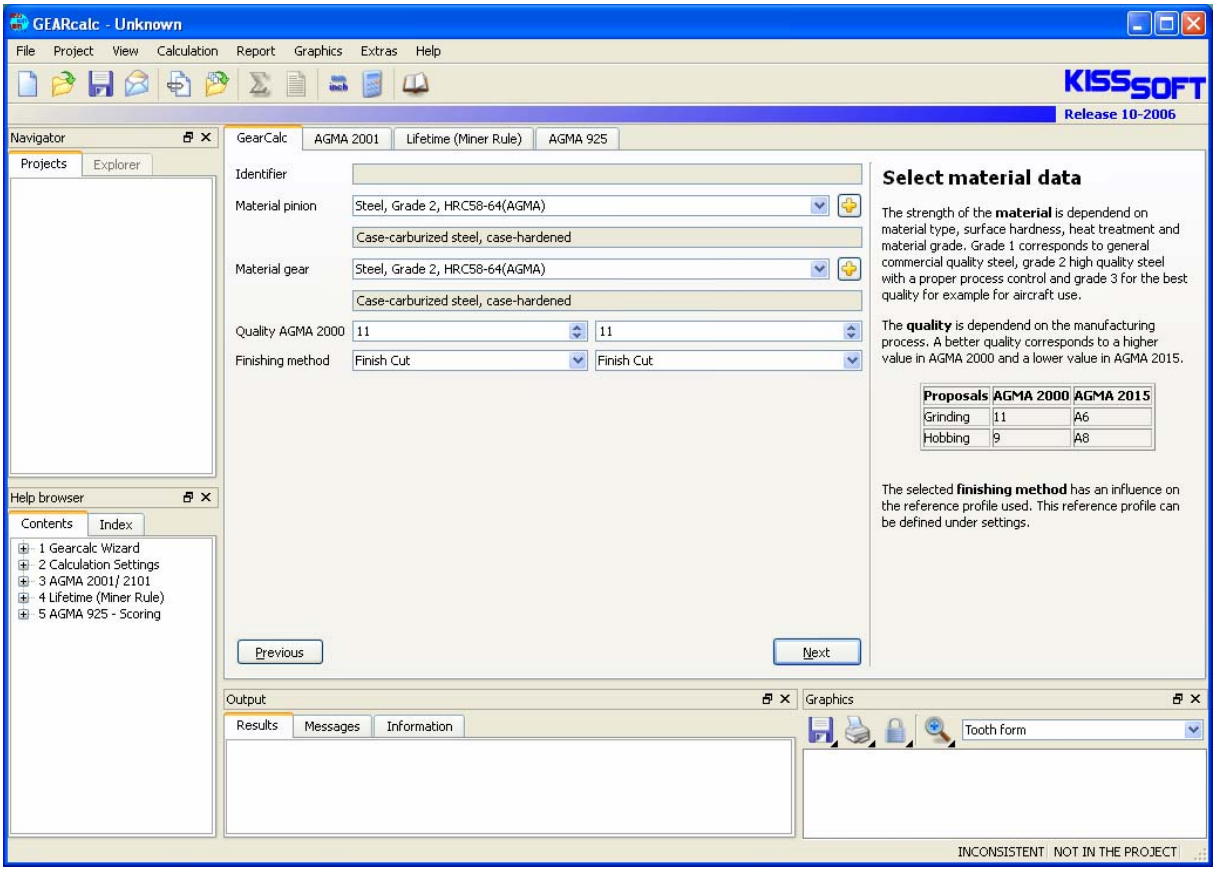


The reliability required will remain at the default of 99%.

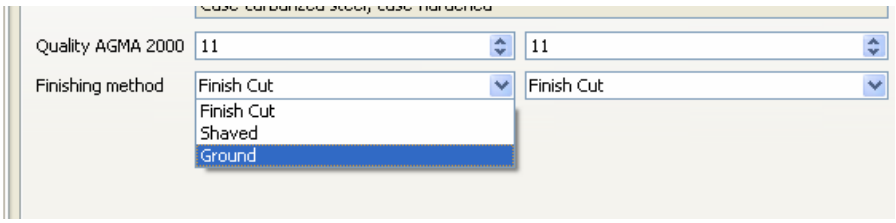
Safety Factors:
$S_F = 1.$
$S_H = 1.$

Materials and Heat Treatment [Page 2]

For maximum capacity choose a high quality, hobbed, carburised and ground gears. Choose the option ‘Steel, Grade 2, HRC58-64(AGMA)’ from the drop down lists for both pinion and gear.

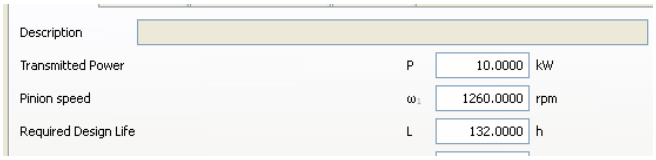


Choose ‘Ground’ from the finishing method options:

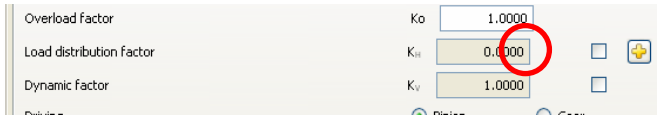


Operating Conditions [Page 3]

The power (P = 10hp), the pinion speed (ω=1260rpm) and life time (L=132h) as defined by the task specification can be entered directly in the cells provided on this tab page.



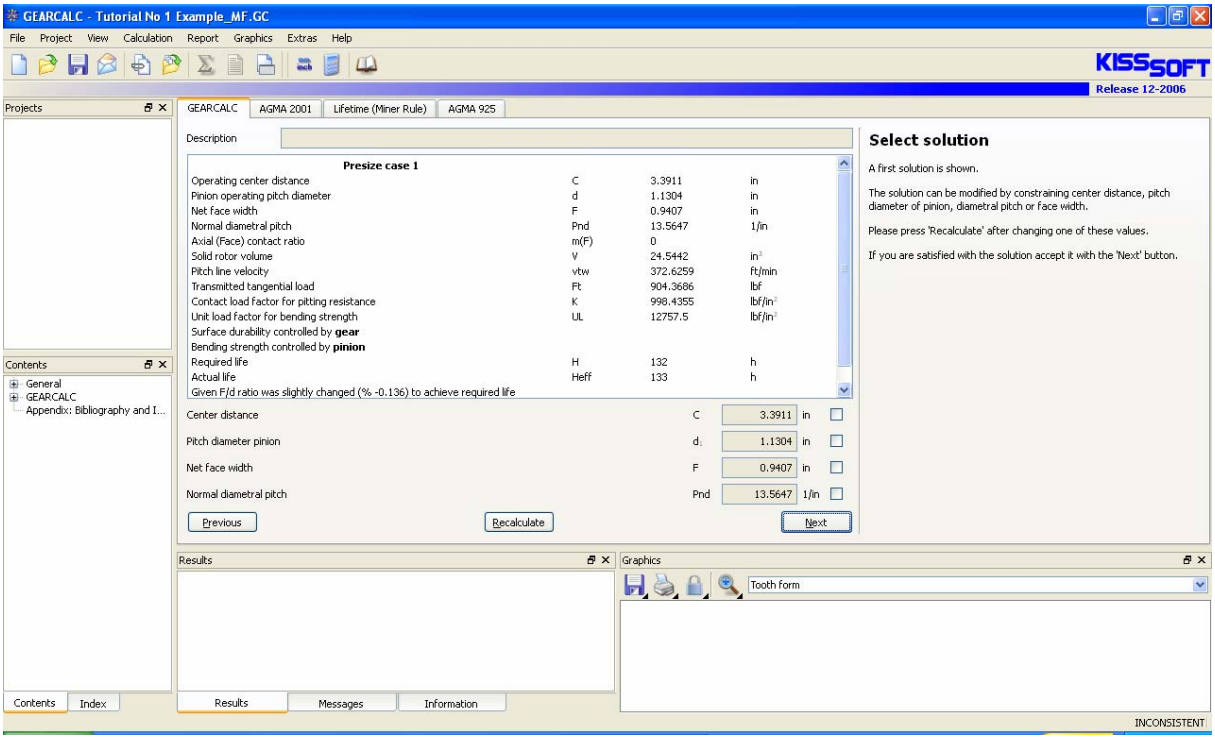
Factors defining the operation are also defined here. The factor for load distribution, $K_m(K_H)$, can be calculated by the program. In this case though, since the housing is aluminium and uneven heat distribution is expected the factor is estimated at 1.4. The value can be entered directly in the cell after ticking the box at the side of the input field.



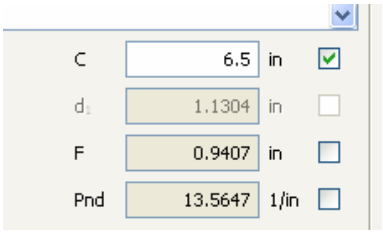
The dynamic factor K_V will be determined by the program. Further, the gear set has one contact mesh, one way rotation and the pinion is driving with no idlers or planet gears. In this case, the remaining settings remain as they appear by default:

Presize [Page 4]

When opening the 'Presize' window (Page 4) the values for the presize case 1 (center distance C, pinion pitch diameter d1, face width F and normal diametral pitch Pnd are proposed by the algorithm) will be presented automatically:



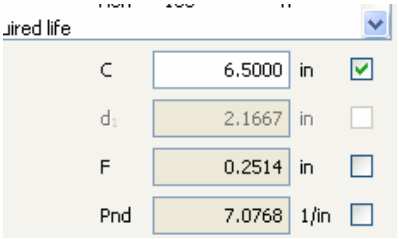
In this example the centre distance is fixed to 6.5 inches. This value can be entered directly be ticking the box at the side of the entry field.



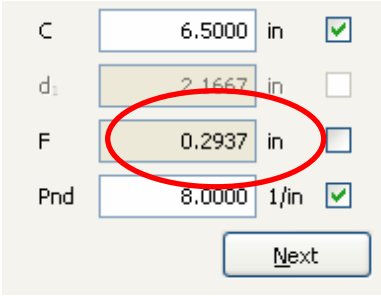
Then the program has do be asked to redo the presizing by clicking on 

button.

Now presize case 2 (center distance C is given, face width F and normal diametral pitch Pnd are proposed by the algorithm) is presented:

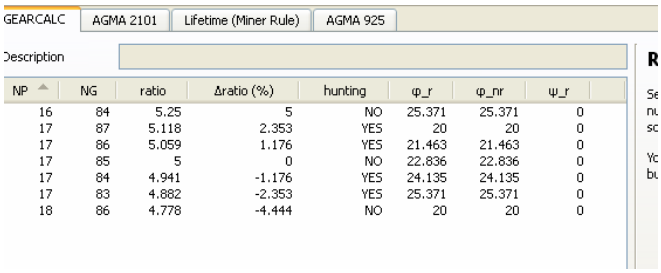


As the center distance has been fixed, then so has the diameter d_1. We decide to round P_{nd} to 8.0 after ticking the box at the side of the field. Face width F(0.2937) will be redefined after pressing recalculate.



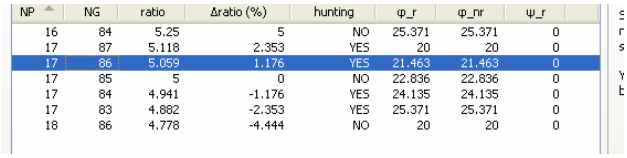
Select a solution [Page 5]

The tab sheet on page 5 now presents the properties in a range of potential solutions.



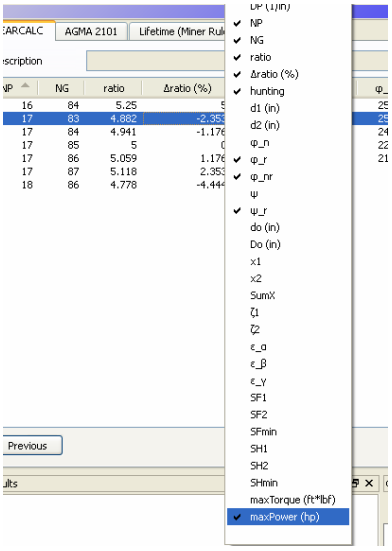
NP	NG	ratio	Δratio (%)	hunting	φ_r	φ_nr	ψ_r
16	84	5.25	5	NO	25.371	25.371	0
17	87	5.118	2.353	YES	20	20	0
17	86	5.059	1.176	YES	21.463	21.463	0
17	85	5	0	NO	22.836	22.836	0
17	84	4.941	-1.176	YES	24.135	24.135	0
17	83	4.882	-2.353	YES	25.371	25.371	0
18	86	4.778	-4.444	NO	20	20	0

A solution can be selected by clicking the left mouse button anywhere on the line containing the required properties. In this case the solution where $N_P = 26$ and $N_G = 130$ is selected.

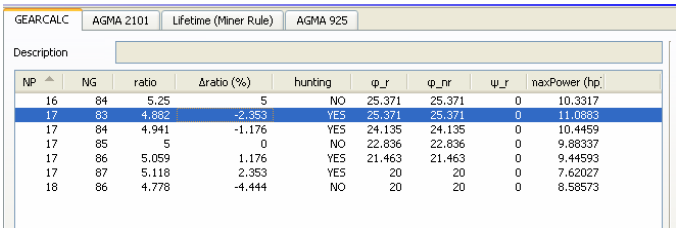


NP	NG	ratio	Δratio (%)	hunting	φ_r	φ_nr	ψ_r
16	84	5.25	5	NO	25.371	25.371	0
17	87	5.118	2.353	YES	20	20	0
17	86	5.059	1.176	YES	21.463	21.463	0
17	85	5	0	NO	22.836	22.836	0
17	84	4.941	-1.176	YES	24.135	24.135	0
17	83	4.882	-2.353	YES	25.371	25.371	0
18	86	4.778	-4.444	NO	20	20	0

Other parameters (such as contact ratio, ε_α, for example) can be added to the table by pressing the right mouse button:



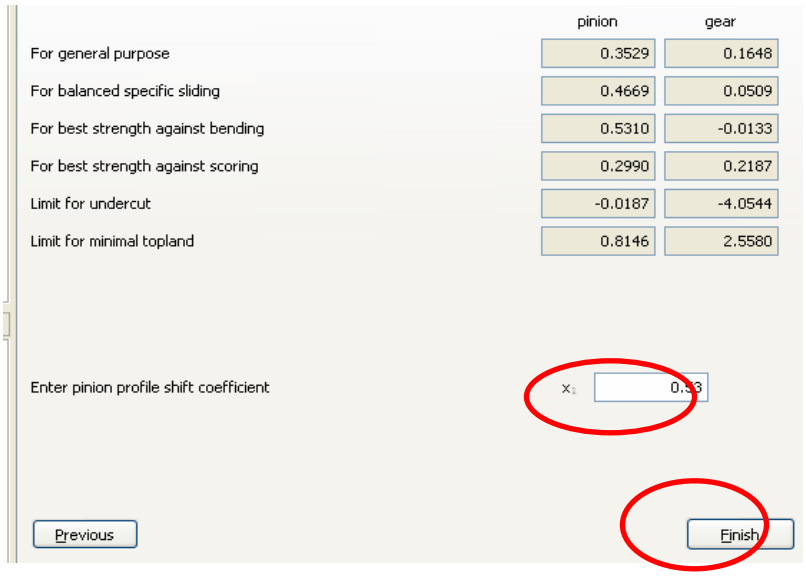
We add “maxPower” to the list. As every solution (with different tooth numbers) will have a slightly different transmittable power rating, this information may be helpful.



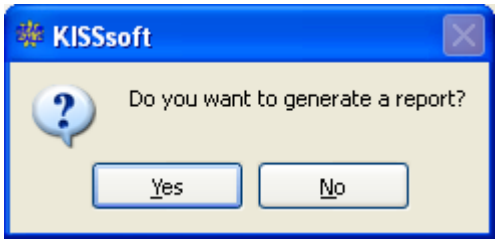
NP	NG	ratio	Δratio (%)	hunting	φ_r	φ_nr	ψ_r	maxPower (hp
16	84	5.25	5	NO	25.371	25.371	0	10.3317
17	83	4.882	-2.353	YES	25.371	25.371	0	11.0883
17	84	4.941	-1.176	YES	24.135	24.135	0	10.4459
17	85	5	0	NO	22.836	22.836	0	9.88337
17	86	5.059	1.176	YES	21.463	21.463	0	9.44593
17	87	5.118	2.353	YES	20	20	0	7.62027
18	86	4.778	-4.444	NO	20	20	0	8.58573

Addendum Modification [Page 6]

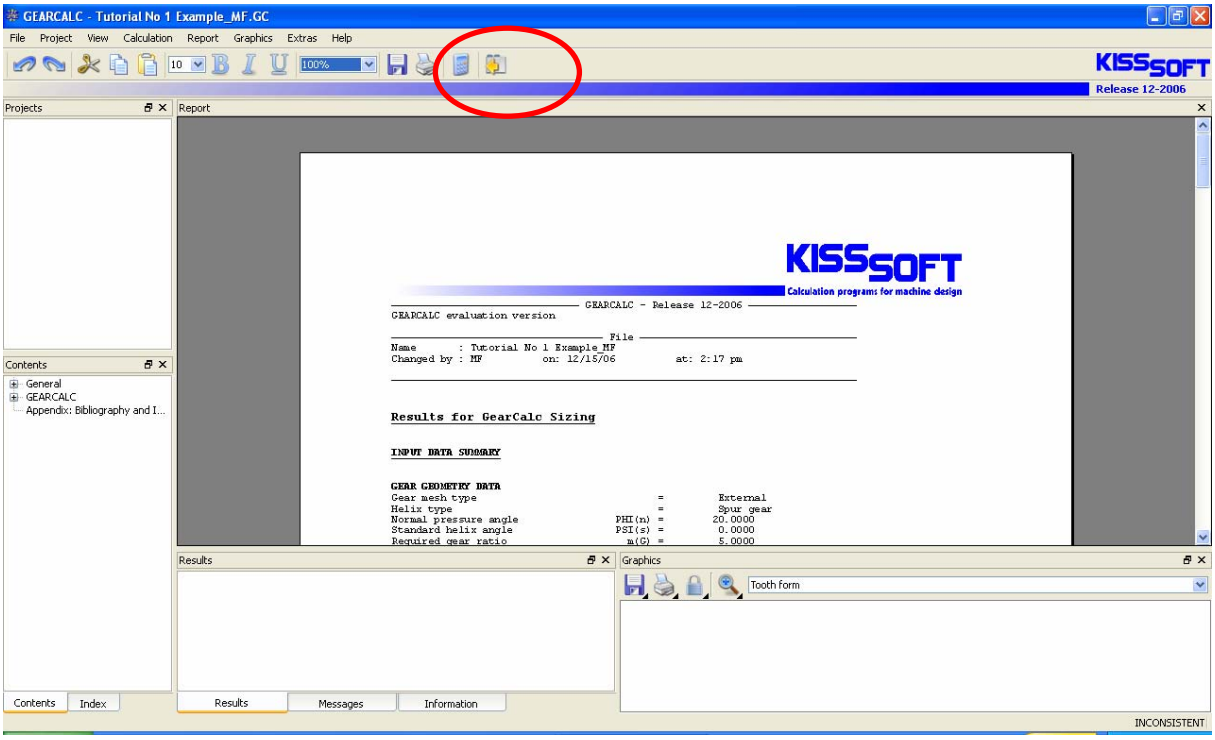
For this application, the bending strength should be optimised if possible.
Choose $X_1 = 0.53$.



The required input is now complete. On pressing ‘Finish’ the following message will appear :



Selecting ‘Yes’ will generate a text report in the work space ready from printing. A copy of the report has been included as an Annex to this tutorial.



On closing the report and returning to the calculation using the icon  , then the complete set of data will be transferred to the AGMA 2001 window. See the tutorial 001 (AGMA 2001) for further information.

ANNEX

KISSSOFT
Calculation programs for machine design

GEARCALC - Release 12-2006
GEARCALC evaluation version

File
Name : Tutorial No 1 Example
Changed by : uk on: 12/16/06 at: 8:58 pm

Results for GearCalc Sizing

INPUT DATA SUMMARY

GEAR GEOMETRY DATA

Gear mesh type		=	External
Helix type		=	Spur gear
Normal pressure angle	PHI(n)	=	20.0000
Standard helix angle	PSI(s)	=	0.0000
Required gear ratio	m(G)	=	5.0000
Profile modification		=	for uniform mesh

NOTE: All dims in in, all angles in degrees, all stresses in lb/in².

MATERIALS/HEAT-TREATMENT DATA			**Pinion**	**Gear**
Material (Pinion) =	Steel, Grade 2, HRC58-64(AGMA) AGMA 2001-C95; AGMA 2101-C95			
Material (Gear) =	Steel, Grade 2, HRC58-64(AGMA) AGMA 2001-C95; AGMA 2101-C95			
Material type		=	Case-carburized stee	Case-carburized stee
Heat-treatment		=	case-hardened	case-hardened
Modulus of elasticity (lb/in²)	EP,EG	=	30000000	30000000
Poisson's ratio	MU(P),MU(G)	=	0.3000	0.3000
Surface hardness			HRC 60	HRC 60
Allowable contact stress	SAC(P), SAC(G)	=	225000	225000
Allowable bending stress	SAT(P), SAT(G)	=	65000	65000
Finishing method (0=Finish, 1=Shaved 2=Ground)		=	2	2

LOAD DATA

Transmitted power (HP)	P	=	10.0000	
Pinion speed (rpm)	n(P)	=	1260.0000	
Required life (HRS)	L	=	132	
Overload (or application) factor	Ko	=	1.0000	
Dynamic factor	Kv	=	1.1152	
Load distribution factor	Km	=	1.4000	
Pitting safety factor	SH	=	1.0000	
Bending fatigue safety factor	SF	=	1.0000	
Reliability	R	=	99 %	
Driving:		=	PINION	
Number of contacts per revolution		=	1	1
Reversed bending (0=No; 1=Yes)		=	0	0
Spur gear loading type		=	TIP	
Stress cycle factors, Curve chosen, Figs. 17 & 18		=	Lower	(for critical applications)

*** DESIGN OPTIONS ***
Operating center distance: By Input
Operating center distance (in) C = 6.5000

LAST PRESIZE SOLUTION (Case 7): INPUT OUTPUT

Pinion operating pitch dia. (in)	d =	2.1667	2.1667	
Face width (in)	F =	0.0000	0.2937	
Normal diametral pitch (1/in)	Pnd =	8.0000	8.0000	

Durability & Bending criteria are not balanced

Selection of Variants:

NP	NG	ratio	?ratio (%)	hunting	?_r	?_nr	?_r
16	84	5.25	5	NO	25.371	25.371	0
17	87	5.118	2.353	YES	20	20	0
17	86	5.059	1.176	YES	21.463	21.463	0
17	85	5	0	NO	22.836	22.836	0
17	84	4.941	-1.176	YES	24.135	24.135	0
17	83	4.882	-2.353	YES	25.371	25.371	0
18	86	4.778	-4.444	NO	20	20	0

(z1 is NP, z2 is NG)

Tooth number combination chosen	NP,NG =	17	86
Addendum modification coeff. selected	x1 =	0.5300	

ADDENDUM MODIFICATION COEFF. OPTIONS

Options for profile shift coefficient:	**x1**	**x2**
- For general purpose	0.3529	0.1648
- For balanced specific sliding	0.4669	0.0509
- For best strength against bending	0.4450	0.0727
- For best strength against scoring	0.3000	0.2177
- Limit for undercut	0.1754	-3.8603
- Limit for minimal topland	0.8146	2.5580
- Choosen profile shift coefficient	0.5300	-0.0123

GEOMETRY SUMMARY

		Pinion	**Gear**
Tooth number	NP,NG =	17	86
Net face width	F1,F2 =	0.2937	0.2937
Outside diameter	do,Do =	2.5053	10.9947
Normal diametral pitch	Pnd =	8.0000	
Normal pressure angle	PHI(n) =	20.0000	
Standard helix angle	PSI(s) =	0.0000	
Operating center distance	C =	6.5000	
Gear geometry data for Pnd = 1.0			
Profile shift coefficient	X1,X2 =	0.53000	-0.01227
Thinning for backlash del.sn1,	del.sn2 =	0.02400	0.02400
Stock allow. per side for finishing	Us1,Us2 =	0.04920	0.04920
Tool geometry data for Pnd = 1.0			
Tool normal tooth thickness	tce1,tce2 =	1.5708	1.5708
Tool addendum (Precutting)	hao1,hao2 =	1.4000	1.4000
Tool addendum (Finish)	hao1,hao2 =	1.2648	1.2648
Tool tip radius	rTe1,rTe2 =	0.3500	0.3500
Tool protuberance DELTA(o1),DELTA(o2)	=	0.0502	0.0502
Tool protuberance ANGLE(1),ANGLE(2)	=	10.0000	10.0000

REFERENCE DATA

		Pinion	**Gear**
Operating transverse pressure angle	PHI(t) =	21.4625	
Operating normal pressure angle	PHI(n) =	21.4625	
Operating helix angle	PSI =	0.0000	
Actual gear ratio	mG =	5.0588	
Transverse (profile) contact ratio	mp =	1.4861	
Axial (face) contact ratio	mF =	0.0000	
Face width/Pinion dia. ratio (F/d)	m(a) =	0.1369	
Solid rotor volume (IN^3)	V =	1.1401	26.4691
Tooth number combo (Hunting/Non-Hunting)	=	Hunting	
Pitch line velocity (FPM)	vt =	707.8	
Transmitted tangential load (LB.)	Wt =	470.8	

Contact load factor for pitting resist.	K =	885.9		
Unit load factor for bending strength	U(L) =	12696.9		
Hardness ratio factor	C(H) =	1.0000	1.0000	
Temperature factor	K(T) =	1.0000	1.0000	
Reliability factor	K(R) =	1.0000		
Stress cycle factor (Contact)	Z(N) =	1.0001*a*	1.0951*a*	
Stress cycle factor (Root)	Y(N) =	1.0001*a*	1.0930*a*	
Allow. contact stress No. (lb/in²)	Sac =	225023	246407	
Allow. bending stress No. (lb/in²)	Sat =	65006	71042	