GEARTECH Report No. NOM-3

AGMA 901-A92 Annex A Example Calculations

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INPUT DATA		
Example	Janusz-1	Janusz-2
x1	0.1671	0.2727
z1	23	
z2	54	
Pnd	6	
αn	20	
β	32.698	
aw	7.625	7.690
ΔSn1	0.024	
ΔSn2	0.024	
hao1	1.4	
hao2	1.4	
OUTPUT DATA		
Σx	0	0.3987
Δa	0	0.0650
x2	-0.1671	0.1260
ks	0	0.0087
ha1	0.1945	0.2107
ha2	0.1388	0.1862
da1	4.9442	4.9765
da2	10.9724	11.0672
c1	0.0722	0.0722
c2	0.0722	0.0722
xg1	0.1341	0.2397
xg2	-0.2001	0.0930
Σg	-0.0660	0.3327
Sn1	0.2781	0.2909
Sn2	0.2375	0.2731
jwn	0.0080	0.0081

Notes

1. Calculations are in accordance with AGMA 901-A92 Annex A.
2. Example Janusz-1 operates on the reference center distance $a_w = a_{ref} = 7.625$ in.
3. Example Janusz-2 operates on an increased center distance $a_w = 7.690$ in.
4. Profile shift coefficient X1 is chosen for balanced specific sliding for both examples.
5. Tip diameters are designed for standard tip-to-root clearance (option 3).

Program **Profile_shift_2** based on Appendix A of AGMA 901-A92. Use this program when tooth thicknesses sn1 a sn2 are unknown. Profile shift x1 is a design decision and must be known. If x1 is unknown, try iterating x1 until t diameters agree with known values.

Input data

$x1 := 0.1671$	Pinion profile shift
$z1 := 23$	Number of teeth in pinion
$z2 := 54$	Number of teeth in gear (negative for internal gear)
$mn := 0.16666666666666667$	Normal module (mm) Enter mn for metric units Enter 1/Pn for inch units
$\alpha n := 20$	Normal pressure angle (deg)
$\beta := 32.698$	Reference helix angle (deg)
$aw := 7.625$	Operating center distance (mm)
$\Delta sn1 := 0.024$ $\Delta sn2 := 0.024$	Tooth thinning for backlash (normalized)
$hao1 := 1.4$	hob addendum for pinion (normalized
$hao2 := 1.4$	hob addendum for gear (normalized)

Calculations

$\alpha n := \alpha n \cdot \frac{\pi}{180}$ $\beta := \beta \cdot \frac{\pi}{180}$ converts angles to radians

$s := \frac{|z2|}{z2}$ s = +1 for external gearset, -1 for internal gearset

$u := \frac{z2}{z1}$	Gear ratio	$u = 2.34783$
$r1 := \frac{z1 \cdot mn}{2 \cdot \cos(\beta)}$	Pinion reference radius (mm)	$r1 = 2.2776$
$r2 := r1 \cdot \lvert u \rvert$	Wheel reference radius (mm)	$r2 = 5.34741$
$a := r2 + s \cdot r1$	Reference center distance (mm)	$a = 7.625003763$
$rw1 := \frac{aw}{\lvert u \rvert + s}$	Pinion operating radius (mm)	$rw1 = 2.2776$
$rw2 := rw1 \cdot \lvert u \rvert$	Wheel operating radius (mm)	$rw2 = 5.3474$
$\alpha t := \operatorname{atan}\left(\frac{\tan(\alpha n)}{\cos(\beta)}\right)$	Transverse reference pressure angle (rad)	$\alpha t = 0.4082147$
$rb1 := r1 \cdot \cos(\alpha t)$	Pinion base radius (mm)	$rb1 = 2.09045$
$rb2 := rb1 \cdot \lvert u \rvert$	Wheel base radius (mm)	$rb2 = 4.90801$
$\alpha wt := \operatorname{acos}\left[\frac{(rb2 + s \cdot rb1)}{aw}\right]$	Transverse operating pressure angle (rad)	$\alpha wt = 0.40821356$

Begin AGMA 901-A92 algorithm for profile shift

$invαt := \tan(αt) - αt$	Involute function for $αt$ (rad)	$invαt = 0.024295597$
$invαwt := \tan(αwt) - αwt$	Involute function for $αwt$ (rad)	$invαwt = 0.024295384$
$Σx := a \cdot \frac{(invαwt - invαt)}{mn \cdot \tan(αt)}$	Sum of profile shift coeffs	$Σx = -2.25761 \times 10^{-5}$
$Δa := aw - a$	Center distance change (mm)	$Δa = -3.762689397 \times 10^{-6}$
$ks := Σx - \frac{Δa}{mn}$	Tip shortening coefficient	$ks = 2.97684642 \times 10^{-11}$
$x2 := Σx - s \cdot x1$	Wheel profile shift coefficient	$x2 = -0.167122576$
$ha11 := (1 + x1) \cdot mn$	Pinion addendum full length (mm)	$ha11 = 0.1945$
$ha21 := (1 + x2) \cdot mn$	Wheel addendum full length (mm)	$ha21 = 0.1388$
$ha12 := \left(1 + x1 - \frac{ks}{2}\right) \cdot mn$	Pinion addendum std working depth (mm)	$ha12 = 0.1945$
$ha22 := \left(1 + x2 - \frac{ks}{2}\right) \cdot mn$	Wheel addendum std working depth (mm)	$ha22 = 0.1388$
$ha13 := (1 + x1 - ks) \cdot mn$	Pinion addendum std tip-to-root clearance (mm)	$ha13 = 0.1945$
$ha23 := (1 + x2 - ks) \cdot mn$	Wheel addendum std tip-to-root clearance (mm)	$ha23 = 0.1388$
$ra11 := r1 + ha11$	Pinion tip radius full length teeth (mm)	$ra11 = 2.4721$
$ra21 := r2 + s \cdot ha21$	Wheel tip radius full length teeth (mm)	$ra21 = 5.4862$
$ra12 := r1 + ha12$	Pinion tip radius std working depth (mm)	$ra12 = 2.4721$
$ra22 := r2 + s \cdot ha22$	Wheel tip radius std working depth (mm)	$ra22 = 5.4862$
$ra13 := r1 + ha13$	Pinion tip radius std tip-to-root clearance (mm)	$ra13 = 2.4721$
$ra23 := r2 + s \cdot ha23$	Wheel tip radius std tip-to-root clearance (mm)	$ra23 = 5.4862$

$d1 := 2 \cdot r1$ $\quad αt := αt \cdot \frac{180}{\pi}$ $\quad αwt := αwt \cdot \frac{180}{\pi}$

$d2 := 2 \cdot r2$

$dw1 := 2 \cdot rw1$ $\quad db1 := 2 \cdot rb1$

$dw2 := 2 \cdot rw2$ $\quad db2 := 2 \cdot rb2$

$da11 := 2 \cdot ra11$ $\quad da12 := 2 \cdot ra12$ $\quad da13 := 2 \cdot ra13$

$da21 := 2 \cdot ra21$ $\quad da22 := 2 \cdot ra22$ $\quad da23 := 2 \cdot ra23$

$xg1 := x1 - \left(\frac{\Delta sn1}{2 \cdot \tan(\alpha n)}\right)$ Pinion generating rack shift coeff. $xg1 = 0.1341$

$xg2 := x2 - s \cdot \left(\frac{\Delta sn2}{2 \cdot \tan(\alpha n)}\right)$ Wheel generating rack shift coeff. $xg2 = -0.2001$

$\Sigma xg := xg2 + s \cdot xg1$ Sum of generating rack shift coeffs $\Sigma xg = -0.066$

$sn1 := \left[\left(\frac{\pi}{2}\right) + 2 \cdot xg1 \cdot \tan(\alpha n)\right] \cdot mn$ Pinion tooth thinning for backlash $sn1 = 0.2781$

$sn2 := \left[\left(\frac{\pi}{2}\right) + s \cdot 2 \cdot xg2 \cdot \tan(\alpha n)\right] \cdot mn$ Wheel tooth thinning for backlash $sn2 = 0.2375$

$jwn := mn \cdot (\Delta sn1 + \Delta sn2) \cdot \left(\frac{aw}{a}\right)$ Normal circular operating backlash (mm) $jwn = 0.008$

$rf1 := r1 - (hao1 - xg1) \cdot mn$ $rf1 = 2.0666$

$rf2 := r2 - s \cdot (hao2 - s \cdot xg2) \cdot mn$ $rf2 = 5.0807$

$c11 := s \cdot (aw - rf2) - ra11$ $c11 = 0.0722$

$c21 := s \cdot (aw - ra21) - rf1$ $c21 = 0.0722$

$c12 := s \cdot (aw - rf2) - ra12$ $c12 = 0.0722$

$c22 := s \cdot (aw - ra22) - rf1$ $c22 = 0.0722$

$c13 := s \cdot (aw - rf2) - ra13$ $c13 = 0.0722$

$c23 := s \cdot (aw - ra23) - rf1$ $c23 = 0.0722$

$df1 := 2 \cdot rf1$ $df1 = 4.1332$

$df2 := 2 \cdot rf2$ $df2 = 10.1614$

Output data

Reference diameters

$d1 = 4.5552$

$d2 = 10.6948$

Operating pitch diameters

$dw1 = 4.5552$

$dw2 = 10.6948$

Base diameters

$db1 = 4.1809$

$db2 = 9.816$

Root diameters

$df1 = 4.1332$

$df2 = 10.1614$

Transverse pressure angles

$\alpha t = 23.388979434$

$\alpha wt = 23.388914063$

Profile shift coefficients

$x1 = 0.1671$

$x2 = -0.1671$

$\Sigma x = -2.2576 \times 10^{-5}$

Tip shortening coefficient

$ks = 0$

Generating rack shift coefficients

$xg1 = 0.1341$

$xg2 = -0.2001$

$\Sigma xg = -0.066$

Normal circular tooth thickness

$sn1 = 0.2781$

$sn2 = 0.2375$

Normal circular operating backlash

$jwn = 0.008$

Tip diameters for full length teeth

$da11 = 4.9442$

$da21 = 10.9724$

Tip diameters for standard working depth

da12 = 4.9442

da22 = 10.9724

Tip diameters for standard tip-to-root clearance

da13 = 4.9442

da23 = 10.9724

Tip clearance for full length teeth

c11 = 0.0722

c21 = 0.0722

Tip clearance for standard working depth

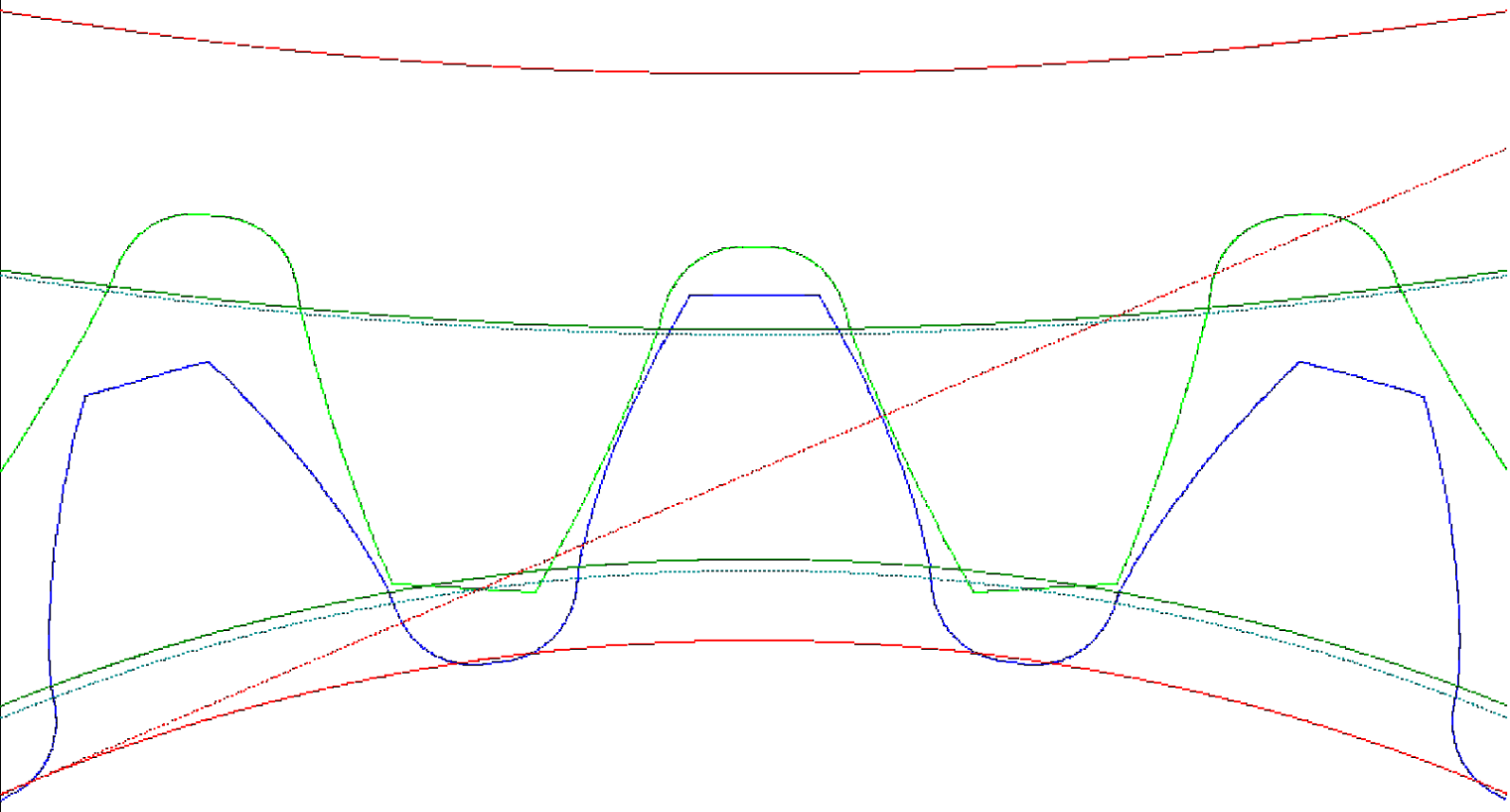
c12 = 0.0722

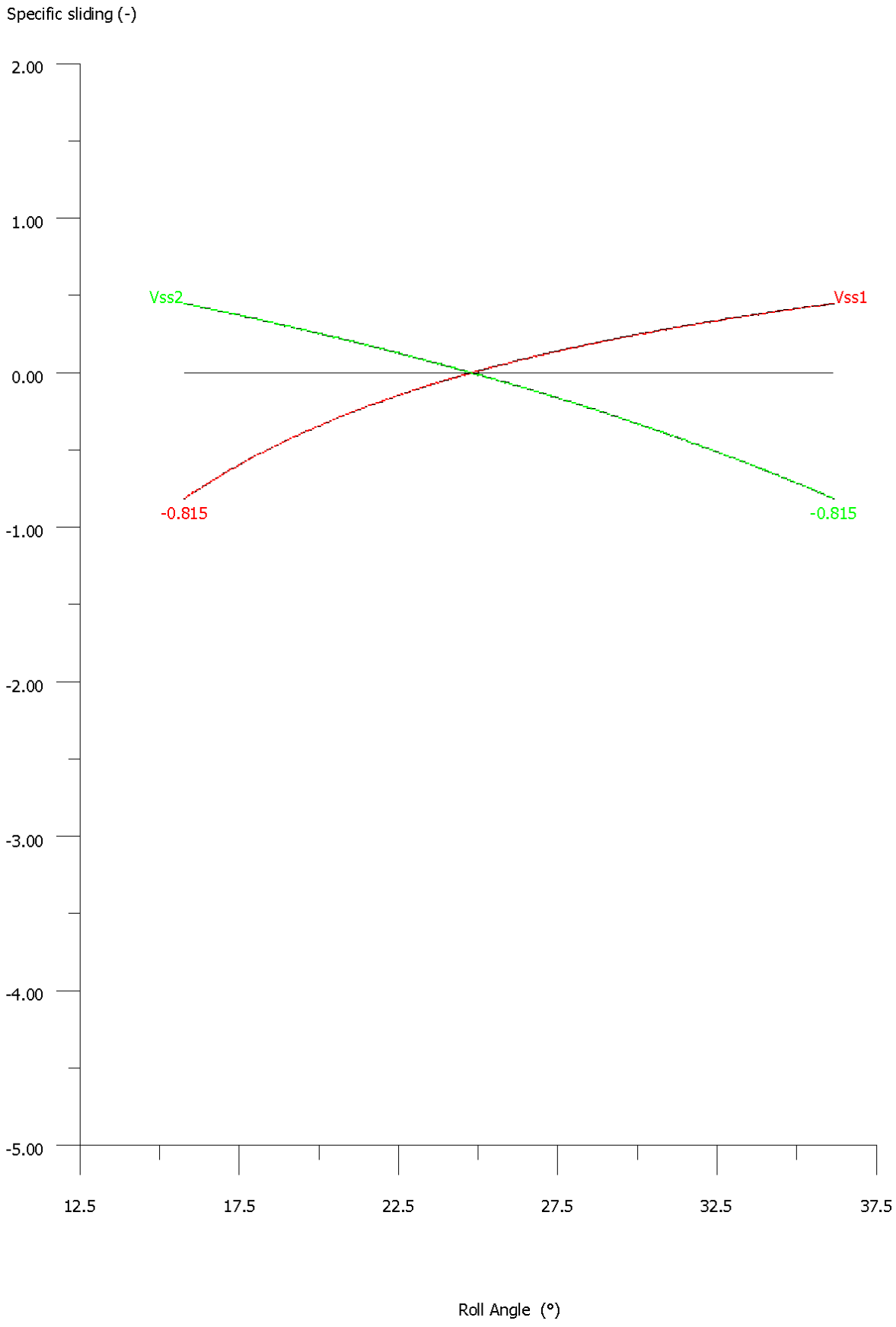
c22 = 0.0722

Tip clearance for standard tip-to-root clearance

c13 = 0.0722

c23 = 0.0722





Program **Profile_shift_2** based on Appendix A of AGMA 901-A92. Use this program when tooth thicknesses sn1 a sn2 are unknown. Profile shift x1 is a design decision and must be known. If x1 is unknown, try iterating x1 until t diameters agree with known values.

Input data

$x1 := 0.2727$	Pinion profile shift
$z1 := 23$	Number of teeth in pinion
$z2 := 54$	Number of teeth in gear (negative for internal gear)
$mn := 0.16666666666666667$	Normal module (mm) Enter mn for metric units Enter 1/Pn for inch units
$\alpha n := 20$	Normal pressure angle (deg)
$\beta := 32.698$	Reference helix angle (deg)
$aw := 7.69$	Operating center distance (mm)
$\Delta sn1 := 0.024$ $\Delta sn2 := 0.024$	Tooth thinning for backlash (normalized)
$hao1 := 1.4$	hob addendum for pinion (normalized
$hao2 := 1.4$	hob addendum for gear (normalized)

Calculations

$\alpha n := \alpha n \cdot \frac{\pi}{180}$ $\beta := \beta \cdot \frac{\pi}{180}$ converts angles to radians

$s := \frac{|z2|}{z2}$ s = +1 for external gearset, -1 for internal gearset

$u := \frac{z2}{z1}$	Gear ratio	$u = 2.34783$
$r1 := \frac{z1 \cdot mn}{2 \cdot \cos(\beta)}$	Pinion reference radius (mm)	$r1 = 2.2776$
$r2 := r1 \cdot \lvert u \rvert$	Wheel reference radius (mm)	$r2 = 5.34741$
$a := r2 + s \cdot r1$	Reference center distance (mm)	$a = 7.625003763$
$rw1 := \frac{aw}{\lvert u \rvert + s}$	Pinion operating radius (mm)	$rw1 = 2.29701$
$rw2 := rw1 \cdot \lvert u \rvert$	Wheel operating radius (mm)	$rw2 = 5.39299$
$\alpha t := \operatorname{atan}\left(\frac{\tan(\alpha n)}{\cos(\beta)}\right)$	Transverse reference pressure angle (rad)	$\alpha t = 0.4082147$
$rb1 := r1 \cdot \cos(\alpha t)$	Pinion base radius (mm)	$rb1 = 2.09045$
$rb2 := rb1 \cdot \lvert u \rvert$	Wheel base radius (mm)	$rb2 = 4.90801$
$\alpha wt := \operatorname{acos}\left[\frac{(rb2 + s \cdot rb1)}{aw}\right]$	Transverse operating pressure angle (rad)	$\alpha wt = 0.42733508$

Begin AGMA 901-A92 algorithm for profile shift

$invαt := \tan(αt) - αt$	Involute function for $αt$ (rad)	$invαt = 0.024295597$
$invαwt := \tan(αwt) - αwt$	Involute function for $αwt$ (rad)	$invαwt = 0.028064432$
$Σx := a \cdot \frac{(invαwt - invαt)}{mn \cdot \tan(αt)}$	Sum of profile shift coeffs	$Σx = 0.39866$
$Δa := aw - a$	Center distance change (mm)	$Δa = 0.064996237$
$ks := Σx - \frac{Δa}{mn}$	Tip shortening coefficient	$ks = 8.681927573 \times 10^{-3}$
$x2 := Σx - s \cdot x1$	Wheel profile shift coefficient	$x2 = 0.125959351$
$ha11 := (1 + x1) \cdot mn$	Pinion addendum full length (mm)	$ha11 = 0.2121$
$ha21 := (1 + x2) \cdot mn$	Wheel addendum full length (mm)	$ha21 = 0.1877$
$ha12 := \left(1 + x1 - \frac{ks}{2}\right) \cdot mn$	Pinion addendum std working depth (mm)	$ha12 = 0.2114$
$ha22 := \left(1 + x2 - \frac{ks}{2}\right) \cdot mn$	Wheel addendum std working depth (mm)	$ha22 = 0.1869$
$ha13 := (1 + x1 - ks) \cdot mn$	Pinion addendum std tip-to-root clearance (mm)	$ha13 = 0.2107$
$ha23 := (1 + x2 - ks) \cdot mn$	Wheel addendum std tip-to-root clearance (mm)	$ha23 = 0.1862$
$ra11 := r1 + ha11$	Pinion tip radius full length teeth (mm)	$ra11 = 2.4897$
$ra21 := r2 + s \cdot ha21$	Wheel tip radius full length teeth (mm)	$ra21 = 5.5351$
$ra12 := r1 + ha12$	Pinion tip radius std working depth (mm)	$ra12 = 2.489$
$ra22 := r2 + s \cdot ha22$	Wheel tip radius std working depth (mm)	$ra22 = 5.5343$
$ra13 := r1 + ha13$	Pinion tip radius std tip-to-root clearance (mm)	$ra13 = 2.4883$
$ra23 := r2 + s \cdot ha23$	Wheel tip radius std tip-to-root clearance (mm)	$ra23 = 5.5336$

$d1 := 2 \cdot r1$ $\quad αt := αt \cdot \frac{180}{\pi}$ $\quad αwt := αwt \cdot \frac{180}{\pi}$

$d2 := 2 \cdot r2$

$dw1 := 2 \cdot rw1$ $\quad db1 := 2 \cdot rb1$

$dw2 := 2 \cdot rw2$ $\quad db2 := 2 \cdot rb2$

$da11 := 2 \cdot ra11$ $\quad da12 := 2 \cdot ra12$ $\quad da13 := 2 \cdot ra13$

$da21 := 2 \cdot ra21$ $\quad da22 := 2 \cdot ra22$ $\quad da23 := 2 \cdot ra23$

$xg1 := x1 - \left(\frac{\Delta sn1}{2 \cdot \tan(\alpha n)}\right)$ Pinion generating rack shift coeff. $xg1 = 0.2397$

$xg2 := x2 - s \cdot \left(\frac{\Delta sn2}{2 \cdot \tan(\alpha n)}\right)$ Wheel generating rack shift coeff. $xg2 = 0.093$

$\Sigma xg := xg2 + s \cdot xg1$ Sum of generating rack shift coeffs $\Sigma xg = 0.3327$

$sn1 := \left[\left(\frac{\pi}{2}\right) + 2 \cdot xg1 \cdot \tan(\alpha n)\right] \cdot mn$ Pinion tooth thinning for backlash $sn1 = 0.2909$

$sn2 := \left[\left(\frac{\pi}{2}\right) + s \cdot 2 \cdot xg2 \cdot \tan(\alpha n)\right] \cdot mn$ Wheel tooth thinning for backlash $sn2 = 0.2731$

$jwn := mn \cdot (\Delta sn1 + \Delta sn2) \cdot \left(\frac{aw}{a}\right)$ Normal circular operating backlash (mm) $jwn = 0.0081$

$rf1 := r1 - (hao1 - xg1) \cdot mn$ $rf1 = 2.0842$

$rf2 := r2 - s \cdot (hao2 - s \cdot xg2) \cdot mn$ $rf2 = 5.1296$

$c11 := s \cdot (aw - rf2) - ra11$ $c11 = 0.0707$

$c21 := s \cdot (aw - ra21) - rf1$ $c21 = 0.0707$

$c12 := s \cdot (aw - rf2) - ra12$ $c12 = 0.0714$

$c22 := s \cdot (aw - ra22) - rf1$ $c22 = 0.0714$

$c13 := s \cdot (aw - rf2) - ra13$ $c13 = 0.0722$

$c23 := s \cdot (aw - ra23) - rf1$ $c23 = 0.0722$

$df1 := 2 \cdot rf1$ $df1 = 4.1684$

$df2 := 2 \cdot rf2$ $df2 = 10.2591$

Output data

Reference diameters

$d1 = 4.5552$

$d2 = 10.6948$

Operating pitch diameters

$dw1 = 4.594$

$dw2 = 10.786$

Base diameters

db1 = 4.1809

db2 = 9.816

Root diameters

df1 = 4.1684

df2 = 10.2591

Transverse pressure angles

αt = 23.388979434

αwt = 24.484496538

Profile shift coefficients

x1 = 0.2727

x2 = 0.126

Σx = 0.3987

Tip shortening coefficient

ks = 0.0087

Generating rack shift coefficients

xg1 = 0.2397

xg2 = 0.093

Σxg = 0.3327

Normal circular tooth thickness

sn1 = 0.2909

sn2 = 0.2731

Normal circular operating backlash

jwn = 0.0081

Tip diameters for full length teeth

da11 = 4.9794

da21 = 11.0701

Tip diameters for standard working depth

da12 = 4.978

da22 = 11.0687

Tip diameters for standard tip-to-root clearance

da13 = 4.9765

da23 = 11.0672

Tip clearance for full length teeth

c11 = 0.0707

c21 = 0.0707

Tip clearance for standard working depth

c12 = 0.0714

c22 = 0.0714

Tip clearance for standard tip-to-root clearance

c13 = 0.0722

c23 = 0.0722