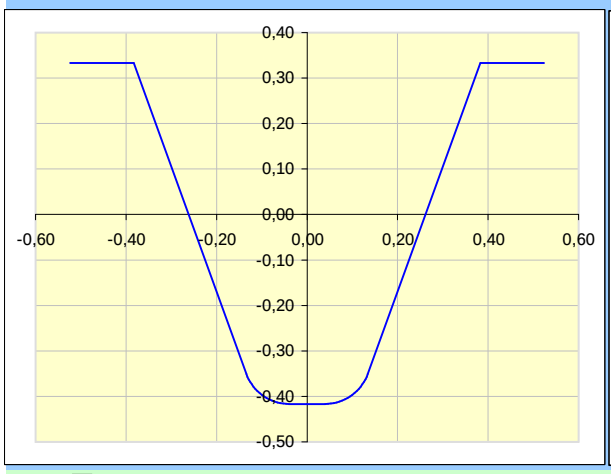
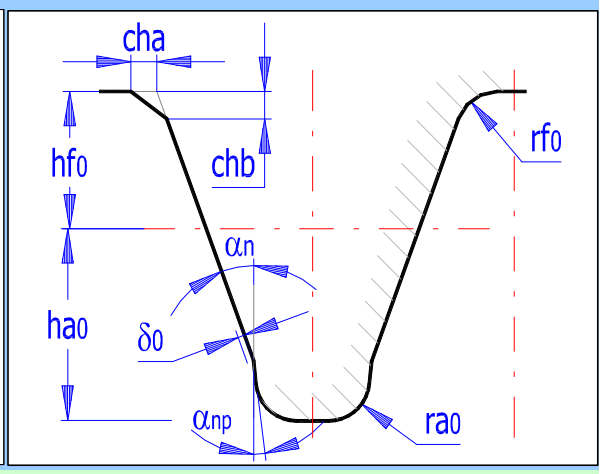
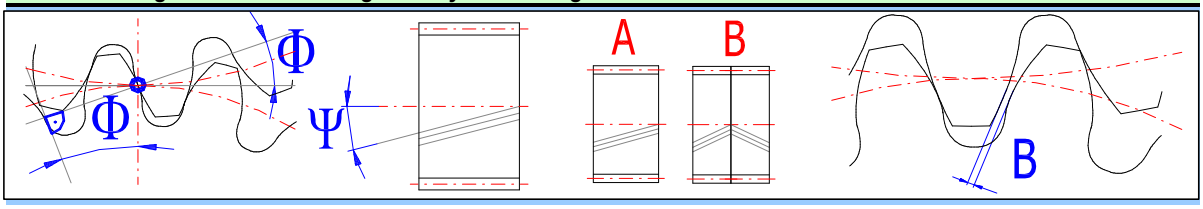
# Spur gearing, Helical gearing [in/AGMA]

| | | | Pinion | Gear | |
|---|---|---|---|---|---|
| i | Calculation without errors. | | | | |
| ii | ☐ Project information | | | | |
| ? | **Input section** | | | | |
| **1.0** | ☑ **Options of basic input parameters** | | | | |
| 1,1 | Transferred power | P | 100,000 | 98,860 | [HP] |
| 1,2 | Speed (Pinion / Gear) | n [/min] | 1000,0 | 552,6 | |
| 1,3 | Torsional moment (Pinion / Gear) | Torq [lb.in] | 6300,00 | 11270,02 | |
| 1,4 | Transmission ratio / from table | i | 1,80 | | |
| 1.5 | Actual transmission ratio / deviation | i | 1,81 | 0,53% | |
| **2.0** | ☑ **Options of material, loading conditions, operational and production parameters** | | | | |
| 2.1 | Material of the pinion : | | E...Alloy structural steel Gr.5135(ASTM A322) (S=228 Mpsi) nitro-case-hard. | | |
| 2.2 | Material of the gear : | | E...Alloy structural steel Gr.5135(ASTM A322) (S=228 Mpsi) nitro-case-hard. | | |
| 2.3 | Loading of the gearbox, driving machine - examples | | A...Continuous | | |
| 2.4 | Loading of gearbox, driven machine - examples | | A...Continuous | | |
| 2.5 | Type of gearing mounting | | D...Extra precision enclosed gearbox | | |
| | Type of gearing mounting | | A...Symmetric gearing support | | |
| 2.6 | Degree of accuracy (AGMA) \| Ra max \| min | Qv | 9 \| (Ra min.= 63 / max.= 63) | | |
| 2.7 | Failure probability (fewer than one failure in:) | FP | 10000 | | |
| 2.8 | Desired service life | Lh | 10000 | | [h] |
| 2.9 | Coefficient of safety (contact/bend) | SH / SF | 1,30 | 1,60 | |
| 2.10 | Automatic design | | | | |
| **3.0** | ☑ **Parameters of the cutting tool and tooth profile** | | | | |
| 3.1 | Standardized tool | | 3. ANSI B6.1 (a=20deg, ha0=1.25, hf0=1.0, ra0=0.3, d0=0deg, anp=0, ca=0.35) | | |
| 3.2 | Addendum of tool | ha0* | 1,2500 | 1,2500 | [1/P] |
| 3.3 | Dedendum of tool | hf0* | 1,0000 | 1,0000 | [1/P] |
| 3.4 | Fillet radius of tool | ra0* | 0,3000 | 0,3000 | [1/P] |
| 3.5 | Root fillet radius of tool | rf0* | 0,0000 | 0,0000 | [1/P] |
| 3.6 | Chamfer of root | cha* | 0,0000 | 0,0000 | [1/P] |
| 3.7 | Chamfer of root | chb* | 0,0000 | 0,0000 | [1/P] |
| 3.8 | Protuberance hight | δ0* | 0,0000 | 0,0000 | [1/P] |
| 3.9 | Protuberance angle | αnp | 0,0000 | 0,0000 | [°] |
| 3.10 | Min. unit head clearance | ca*min | 0,2500 | 0,2500 | [1/P] |
| 3.11 | Unit head clearance | ca* | 0,2500 | 0,2500 | [1/P] |
| 3.12 | Type of tooth shape | | Without modification | | |

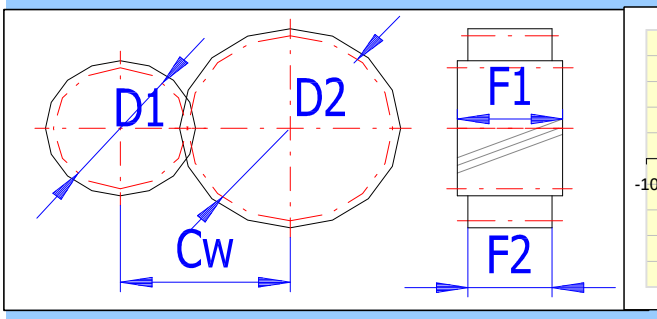


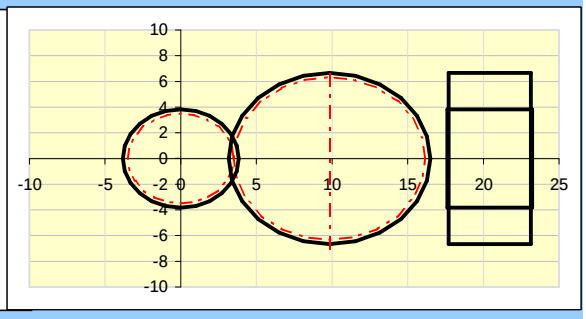




**4.0** ☑ **Design of a module and geometry of toothing**



| | | | | | | |
|---|---|---|---|---|---|---|
| 4.1 | Number of teeth Pinion / Gear | N | 21 | 38 | | |
| 4.2 | Normal pressure angle | Φ | 20 | | | [°] |
| 4.3 | Base helix angle | Ψ | 0 | | | [°] |
| 4.4 | Setting of the ratio of the width of the pinion to its diameter | | | | | |
| 4.5 | The ratio of the pinion width to its diameter | $\Psi_{d\,/\,max}$ | 1,05 | < 1,1 | | |
| 4.6 | Diametral Pitch | P | 3 | | | |
| | Circular Pitch / Module | CP/m | 1,047 | 0,333 | | [in] |
| 4.7 | Reference diameter Pinion / Gear | D1/D2 | 7,000 | 12,667 | | [in] |
| 4.8 | Recommended width of gearing | | 4,1 - 7,7 | | | [in] |
| 4.9 | Face width (Pinion / Gear) | F1/F2 | 5,600 | 5,430 | | [in] |
| 4.10 | Working face width | Fw | 5,430 | | ☑ | [in] |
| 4.11 | The ratio of the pinion width to its diameter | $\Psi_{d\,/\,max}$ | 0,80 | < 1,1 | | |
| 4.12 | Working center distance | Cw | 9,833 | | | [in] |
| 4.13 | Approximate weight of the gearing | m | 251,82 | | | [lb] |
| 4.14 | Minimum coefficient of safety | SH / SF | 1,79 | 16,49 | | |

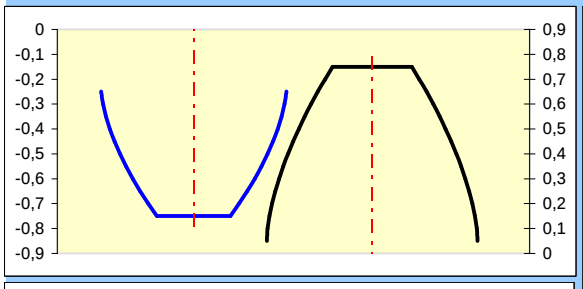


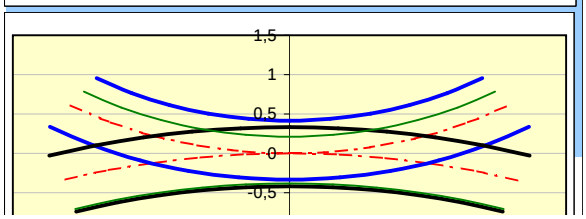



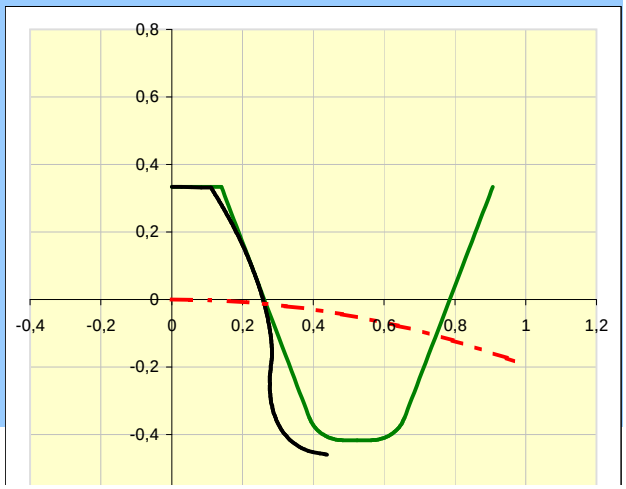

| | | | | | | |
|---|---|---|---|---|---|---|
| 4.15 | **Normal backlash** | | | | | |
| 4.16 | - Recommended min. \| max. value | B | 0,0037 | 0,0149 | | [in] |
| 4.17 | - Selected normal backlash | B | 0,0000 | | | [in] |

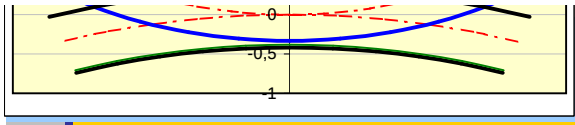
## 5.0 ☑ Correction of toothing (Addendum modification)

| | | | | | | |
|---|---|---|---|---|---|---|
| 5.1 | **Types** | | | | | |
| 5.2 | - Permissible undercutting of teeth (min. value) | | -0,286 | -0,605 | Σ= | -0,891 |
| 5.3 | - Preventing undercutting of teeth (min. value) | | -0,143 | -0,526 | Σ= | -0,669 |
| 5.4 | - Prevents tapering of teeth (min. value) | | 0,174 | -0,813 | Σ= | -0,639 |
| 5.5 | Pinion addendum modification coefficient setting | | | | ☑ | |
| 5.6 | Addendum modification coefficient Pinion / Gear | x | 0,0000 | 0,0000 | | [modul (1/P)] |
| 5.7 | Sum of addendum modification coefficients \| min. value | Σx | 0,0000 | > -1,208 | | [modul (1/P)] |
| 5.8 | Total contact ratio | εα/εγ | 1,6363 | 1,6363 | | |
| 5.9 | Unit tooth thickness on the tip diameter | sa* | 0,7007 | 0,7569 | | |
| 5.10 | Specific sliding on tooth root | ϑA1/ϑE2 | -3,6251 | -1,5559 | | |
| 5.11 | Specific sliding on tooth tip | ϑE1/ϑA2 | 0,6088 | 0,7838 | | |
| 5.12 | Sum of all specific slidings | Sum\|ϑ\| | 6,5736 | | | |
| 5.13 | Safety coefficient for surface durability | SH | 1,79 | 1,82 | | |
| 5.14 | Safety coefficient for bending durability | SF | 16,49 | 18,96 | | |
| 5.15 | Display of tooth and tool turn for: | Pinion | | 0 | | [°] |



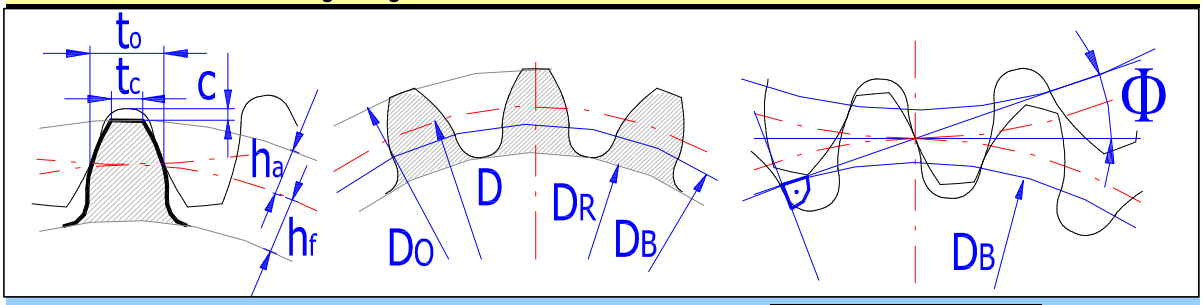







## Results section

### 6.0 ☑ Basic dimensions of gearing



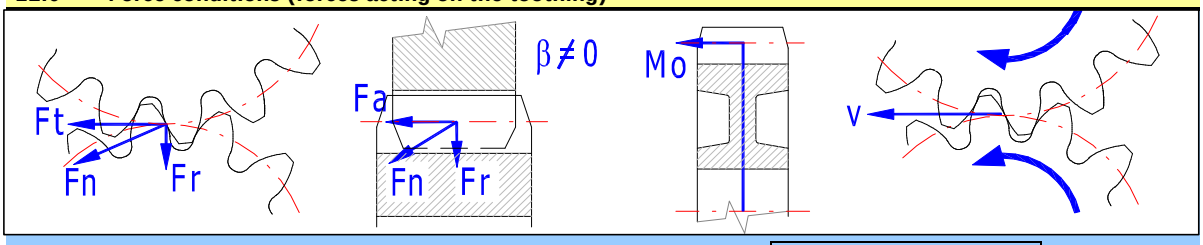

| | | | | | |
|---|---|---|---|---|---|
| 6.1 | Number of teeth Pinion / Gear | N | 21 | 38 | |
| 6.2 | Face width (Pinion / Gear) | F | 5,6000 | 5,4300 | [in] |
| 6.3 | Normal module | mn | 0,3333 | | [in] |
| 6.4 | Transverse module | mt | 0,3333 | | [in] |
| 6.5 | Diametral Pitch (normal) | Pn | 3,0000 | | |
| 6.6 | Diametral Pitch (transverse) | Pt | 3,0000 | | |
| 6.7 | Circular pitch | pn | 1,0472 | | [in] |
| 6.8 | Transverse circular pitch | pt | 1,0472 | | [in] |
| 6.9 | Base circular pitch | pN | 0,9840 | | [in] |
| 6.10 | Base circular pitch transverse | pT | 0,9840 | | [in] |
| 6.11 | Center distance (pitch) | C | 9,8333 | | [in] |
| 6.12 | Center distance (production) | Cm | 9,8333 | | [in] |
| 6.13 | Center distance (working) | Cw | 9,8333 | | [in] |
| 6.14 | Pressure angle | Φ | 20,0000 | | [°] |
| 6.15 | Transverse pressure angle | Φt | 20,0000 | | [°] |
| 6.16 | Pressure angle at the pitch cylinder | Φwn | 20,0000 | | [°] |
| 6.17 | Transverse pressure angle at the pitch cylinder | Φwt | 20,0000 | | [°] |
| 6.18 | Helix angle | Ψ | 0,0000 | | [°] |
| 6.19 | Base helix angle | Ψb | 0,0000 | | [°] |
| 6.20 | Tip diameter | DO | 7,6667 | 13,3333 | [in] |
| 6.21 | Reference diameter | D | 7,0000 | 12,6667 | [in] |
| 6.22 | Base diameter | DB | 6,5778 | 11,9028 | [in] |
| 6.23 | Root diameter | DR | 6,1667 | 11,8333 | [in] |
| 6.24 | Operating pitch diameter | DW | 7,0000 | 12,6667 | [in] |
| 6.25 | Addendum | ha | 0,3333 | 0,3333 | [in] |
| 6.26 | Dedendum | hf | 0,4167 | 0,4167 | [in] |
| 6.27 | Tooth thickness on the tip diameter | tno | 0,2336 | 0,2523 | [in] |
| 6.28 | Tooth thickness on the tip diameter (transverse) | tto | 0,2336 | 0,2523 | [in] |
| 6.29 | Tooth thickness on the pitch diameter | tnc | 0,5236 | 0,5236 | [in] |
| 6.30 | Tooth thickness on the pitch diameter (transverse) | ttc | 0,5236 | 0,5236 | [in] |
| 6.31 | Tooth thickness on the root diameter | tr | 0,5532 | 0,6655 | [in] |
| 6.32 | Unit tooth thickness on the tip diameter | to* | 0,7007 | 0,7569 | [modul (1/P)] |
| 6.33 | Unit correction | dY | 0,0000 | | [in] |
| 6.34 | Total unit correction | x1+x2 | 0,0000 | | [modul (1/P)] |
| 6.35 | Addendum modification coefficient | x | 0,0000 | 0,0000 | [in] |

### 7.0 ☑ Supplemental parameters of gearing

| | | | | | |
|---|---|---|---|---|---|
| 7.1 | Number of teeth | z | 21 | 38 | |
| 7.2 | Virtual number of teeth of a helical gear | zn | 21,000 | 38,000 | |
| | **Minimum number of teeth:** | | | | |
| 7.3 | - Permissible undercutting | zmin1 | 15 | 15 | |
| 7.4 | - Without undercutting | zmin2 | 18 | 18 | |
| 7.5 | - Without tapering | zmin3 | 24 | 24 | |

### 8.0 ☑ Qualitative indices of gearing

| | | | | | |
|---|---|---|---|---|---|
| 8.1 | Transverse contact ratio / overlap ratio | $\varepsilon_\alpha \mid \varepsilon_\beta$ | 1,6363 | 0,0000 | |
| 8.2 | Total contact ratio | $\varepsilon\gamma$ | 1,6363 | | |
| 8.3 | Coefficient of gear unloading | Cdi/df | 0,00 | 0,00 | |
| 8.4 | Resonance speed | nE1 | 6917,45 | | [ /min] |
| 8.5 | Resonance ratio | N | 0,14 | | |
| 8.6 | Approximate weight of the gearing | m | 251,8206 | | [lb] |
| 8.7 | Efficiency of the gearing | μ | 98,86% | | |
| 8.8 | Recomended lubricant viscosity | v50 | 0,28 | | [in2/sec] |
| **9.0** | ☑ **Coefficients for safety calculation** | | | | |
| 9.1 | **Common for the gearing** | | | | |
| 9.2 | Overloading correction coefficient | Ko | 1,00 | | |
| 9.3 | Dynamic coefficient | Kv | 1,26 | | |
| 9.4 | Loading distribution coefficient | Km | 1,20 | | |
| 9.5 | Temperature coefficient | Kt | 1,00 | | |
| 9.6 | Reliability coefficient | Kr | 1,50 | | |
| 9.7 | Number of cycles | NK | 6,00E+08 | 3,32E+08 | |
| 9.8 | **For bending safety calculation** | | | | |
| 9.9 | Geometry coefficient (bending) | J | 0,3415 | 0,3852 | |
| 9.10 | Thickness of rim | tr | 10 | 10 | [in] |
| 9.11 | Rim thickness coefficient | Kb | 1,00 | 1,00 | |
| 9.12 | Size coefficient | Ks | 0,87 | | |
| 9.13 | Stress cycle coefficient for bending strength | YN | 0,88 | 0,89 | |
| 9.14 | **For pitting safety calculation** | | | | |
| 9.15 | Geometry coefficient (surface durability) | I | 0,0935 | | |
| 9.16 | Elasticity coefficient | CP | 2285,93 | | |
| 9.17 | Surface condition coefficient | Cf | 1,00 | 1,00 | |
| 9.18 | Hardness ratio coefficient | CH | 1,00 | 1,00 | |
| 9.19 | Stress cycle coefficient for pitting resistance | ZN | 0,91 | 0,92 | |
| **10.0** | ☑ **Safety coefficients** | | | | |
| 10.1 | Bending stress | St | 3,80 | 3,37 | [kpsi] |
| 10.2 | Permissible bending stress | Sat | 62,69 | 63,90 | [kpsi] |
| 10.3 | Contact stress | Sc | 63,20 | 63,20 | [kpsi] |
| 10.4 | Permissible contact stress | Sac | 113,35 | 114,90 | [kpsi] |
| 10.5 | Safety coefficient for bending durability | SF | 16,49 | 18,96 | |
| 10.6 | Safety coefficient for surface durability | SH | 1,79 | 1,82 | |
| **11.0** | ☑ **Check dimensions of gearing** | | | | |
| 11.1 | Number of measured teeth | zw | 3 | 5 | |
| 11.2 | Number of measured teeth | zw | 3 | 5 | ☑ |
| 11.3 | Chordal dimension | W | 2,5581 | 4,6056 | [in] |
| 11.4 | Pin/Ball diameter | dt | 0,6000 | 0,6000 | [in] |
| 11.5 | Pin/Ball diameter | dt | 0,6000 | 0,6000 | ☑ [in] |
| 11.6 | Dimension over pins/balls | M | 7,8583 | 13,5588 | [in] |
| **12.0** | ☑ **Force conditions (forces acting on the toothing)** | | | | |




| | | | | | |
|---|---|---|---|---|---|
| 12.1 | Tangential force | Ft | 1800,86 | | [lb] |
| 12.2 | Normal force | Fn | 1916,44 | | [lb] |
| 12.3 | Axial force | Fa | 0,00 | | [lb] |
| 12.4 | Radial force | Fr | 655,46 | | [lb] |
| 12.5 | Bending moment | Mo | 0,00 | 0,00 | [lb.in] |
| 12.6 | Peripheral speed on the pitch diameter | V \| Vmax | 1832,60 | 6868,899878 | [ft/min] |
| **13.0** | ☑ **Parameters of the chosen material** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 13.1 | Density | p | 491,3 | 491,3 | [lb/ft^3] |
| 13.2 | Young's Modulus (Modulus of Elasticity) | E | 29,9 | 29,9 | [psi*1e9] |
| 13.3 | Tensile Strength, Ultimate | Rm | 227,7 | 227,7 | [psi*1e6] |
| 13.4 | Tensile Strength, Yield | Rp0.2 | 195,8 | 195,8 | [psi*1e6] |
| 13.5 | Poison's Ratio | | 0,3 | 0,3 | |
| 13.6 | Contact Fatigue Limit | SHlim | 186,8 | 186,8 | [psi*1e6] |
| 13.7 | Bending Fatigue Limit | SFlim | 107,3 | 107,3 | [psi*1e6] |
| 13.8 | Tooth Hardness - Side | HB | 540 | 540 | [HB] |
| 13.9 | Tooth Hardness - Core | HB | 453 | 453 | [HB] |
| 13.10 | Base Number of Load Cycles in Contact | NHlim | 1,00E+08 | 1,00E+08 | |
| 13.11 | Wohler Curve Exponent for Contact | qH | 10 | 10 | |
| 13.12 | Base Number of Load Cycles in Bend | NFlim | 3,00E+06 | 3,00E+06 | |
| 13.13 | Wohler Curve Exponent for Bend | qF | 9 | 9 | |

## Additions section

### 14.0 ☑ Calculation of gearing for the given axis distance

| | | | | | |
|---|---|---|---|---|---|
| 14.1 | Required axis distance / Current | Cw | 12,5000 | 9,8333 | [in] |
| 14.2 | **List of solutions** | | ID. NP NG i Ψ Sum X | | |
| 14.3 | Combination of the teeth number | | 5. \| 26 \| 48 \| 1,846 \| 9,367 \| 0,5244 | | |
| 14.4 | Number of teeth Pinion / Gear | z1/z2 | 26 | 48 | |
| 14.5 | Transmission ratio / Deviation | i | 1,8462 | 2,50% | |
| 14.6 | **A. Change of the addendum modification** | | | | |
| 14.7 | Base helix angle | Ψ | 0,0000 | | [°] |
| 14.8 | Total unit correction | Sum x | 0,52438 | | [modul] |
| 14.9 | Distribution of correction | | In reverse transmission ratio | | |
| 14.10 | Type of distribution of corrections to the pinion and gear | x | 0,1842 | 0,3401 | [modul] |
| 14.11 | Press the button for transmitting values in to calculation | | | | |
| 14.12 | **B. By a change of the helix angle** | | | | |
| 14.13 | Base helix angle | Ψ | 9,3668 | | [°] |
| 14.14 | Total unit correction | Sum x | 0,00 | | [modul] |
| 14.15 | Press the button for transmitting values in to calculation | | | | |

### 15.0 ☑ Power, warming-up, gearbox surface

| | | | | |
|---|---|---|---|---|
| 15.1 | Ambient air temperature | 70,00 | | [°F] |
| 15.2 | Maximum oil temperature | 140,00 | | [°F] |
| 15.3 | Coefficient of heat dissipation | 2,00 | | [BTU/ft2/h/° |
| 15.4 | Power losses | 1,14 | | [HP] |
| 15.5 | Gearbox surface (min.) | 20,72 | | [ft2] |

### 16.0 ☑ Preliminary design of shaft diameters (steel)

**Recommended shaft diameter for:**

| | | | | | |
|---|---|---|---|---|---|
| 16.1 | - Main power-transmitting shafts | DA | 4,30 | 5,22 | [in] |
| 16.2 | - Small, short shafts | DB | 3,34 | 4,05 | [in] |

### 17.0 ☑ Approximate module calculation from the existing gear

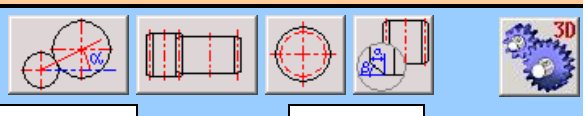
| | | | | | |
|---|---|---|---|---|---|
| 17.1 | Number of teeth | N | 21 | | |
| 17.2 | Tip diameter | DO | 33,50 | | [in] |
| 17.3 | Distance between teeth edges | u | 0,00 | | [in] |
| 17.4 | Helix angle | β | 10,00 | | [°] |
| 17.5 | Diametral Pitch | DP | 0,70 | | |

### 18.0 ☑ Auxiliary calculations

| | | | | | |
|---|---|---|---|---|---|
| 18.1 | Transmission ratio calculation using the number of teeth | NP,NG = i | 21 | 35 | = 1,6667 |
| 18.2 | Transmission ratio calculation using the speed | nP,nG = i | 1450,0 | 800,0 | = 1,8125 |
| 18.3 | Power calculation using the pinion speed and torque mom | Torq,nP=P | 1000,0 | 500,0 | = 7,9365 |

### 19.0 ☑ Graphical output, CAD systems

| | | | | | |
|---|---|---|---|---|---|
| 19.1 | 2D drawing output to: | DXF File | | | |
| 19.2 | 2D Drawing scale | Automatic | | | |
| 19.3 | Detail: | Pinion | | | |
| | | α [°]... | 30 | β [°]... | 30 |
| 19.4 | **Detailed drawing of tooth and wheel** | | | a [modul]... | 1 |
| 19.5 | Number of drawn teeth | | 3 | | |




| | | | |
|---|---|---|---|
| 19.6 | Number of points of tooth tip | 5 | |
| 19.7 | Number of points of tooth flank | 30 | |
| 19.8 | Rolling (turning) of a tool between the bite | 0,5 | [°] ☐ Drawing without axes |
| 19.9 | Number of tooth copies in the picture of engagement chec | 20 | |
| 19.10 | **Text description (Information for BOM)** | **Pinion** | |
| | Row 1 (BOM attribute 1) | Spur gear - Pinion | ☑ |
| | Row 2 (BOM attribute 2) | N1=21, P=3, beta=0 | |
| | Row 3 (BOM attribute 3) | Material: Gr.5135(ASTM A322) | |
| | | **Gear** | |
| | Row 1 (BOM attribute 1) | Spur gear - Gear | ☑ |
| | Row 2 (BOM attribute 2) | N2=38, P=3, beta=0 | |
| | Row 3 (BOM attribute 3) | Material: Gr.5135(ASTM A322) | |
| 19.11 | Table of parameters | Table of pinion parameters | |