

Spur Gears Part 2: Learn how to Design and Calculate Spur Gears

This is the second in a set of two Skill Builders. In the first Skill builder, you learned how to design a spur gears connection based on known dimensions. In this second Skill Builder, you learn how to design and calculate spur gears for specific parameters (power, speed, and gears ratio).

These two Skill Builders are independent of each other. They show typical workflows for spur gears design and calculation. There is no need to complete the first Spur Gears Skill Builder before this one.

This Skill Builder consists of three parts:

- Geometry Design – we design the spur gears.
- Check Calculation – we check the calculated data.
- Material Design – we select the material for spur gears to see if it is suitable for the spur gears.

Expected completion time for this Skill Builder is 15 to 20 minutes.

This Skill Builder is intended for use with Autodesk Inventor 2009.

A. Geometry Design

Create a new metric assembly. Depending on your assembly units, the units in Spur Gears are used – metric or English.

Click the arrow in the Assembly panel bar and select Design Accelerator.

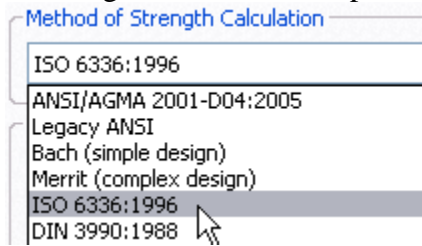
Click the Spur Gears tool. 


Note: Hold the CTRL key while clicking the Spur Gear command to load the Spur Gears Generator with the default installation data.

Spur Gears Component Generator opens on a Design tab, by default.

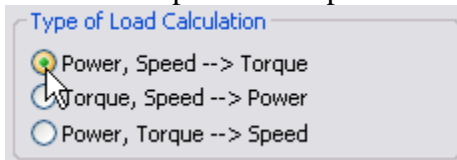
We want to design and calculate spur gears based on specific parameters. So, first switch to the Calculation tab.

We need to specify the method of performed calculation. Select **ISO 6336: 1996** in the Method of Strength Calculation drop-down menu.

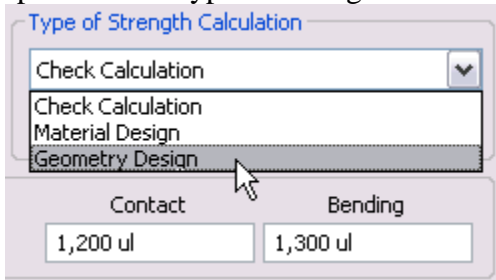


Click the **More options** command  in the right lower corner of the Calculation tab to display additional options for spur gears calculation.

In the Type of Calculation area select **Power, Speed > Torque** option. This means that we know the values of power and speed and torque will be the calculated value.



In this part of the Skill Builder we want to design our gears. So, select the **Geometry Design** option in the Type of Strength Calculation area of More options.



In the Loads area, enter value for Power to **3 kW** and for Speed to **1500 rpm**.

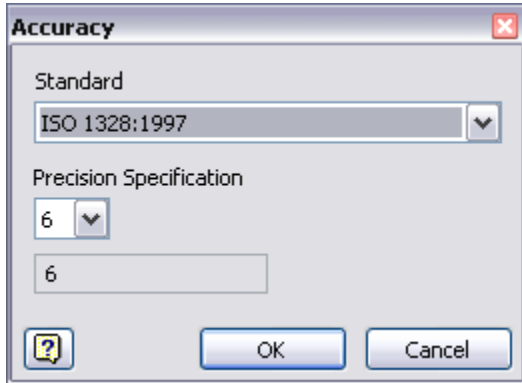
		Gear 1	Gear 2
Power	P	3,000 kW	0,980 kW
Speed	n	1500,00 rpm	403,51 rpm
Torque	T	9,549 N m	23,192 N m
Efficiency	η	0,980 ul	

Set Required Life to **15000 hr**.

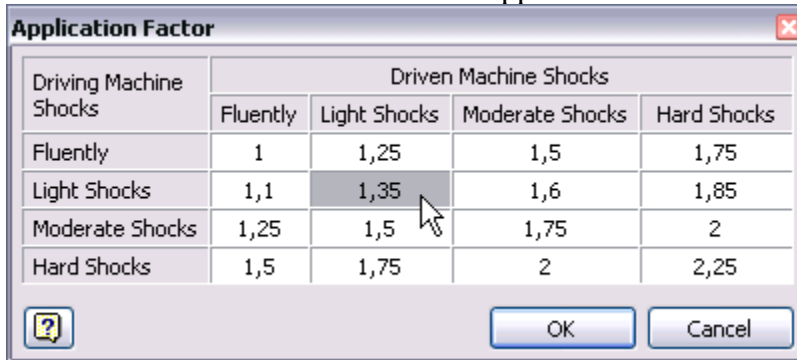
Required Life	L_h	15000 hr	>
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Note: Now, you can also select the expected type of spur gears material because it will affect the results of the spur gears design. In this Skill Builder we will perform the material design in the third part. So, at this moment we will not select any type of material.

Click the Accuracy button to display the Accuracy dialog. Make sure that **ISO 1328:1997** is selected the the Standard drop-down menu and **6** is entered in the Precision Specification drop-down menu. Click OK.



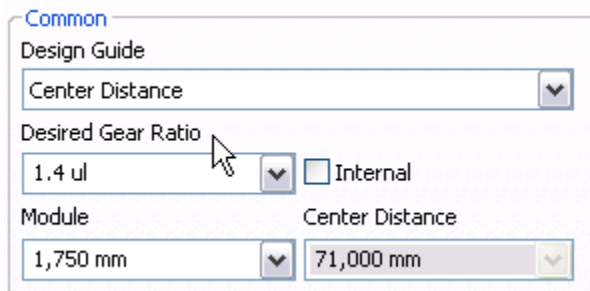
Click the Factors button to open the Factors dialog box. Click the arrow next to Application factor and click Factors to display the Application Factor dialog box. Select **1.35** and click OK. You can also enter the value into the Application factor edit field manually.



Click OK to close the Factors dialog box.

Switch to the Design tab.

Set Desired Gear Ratio value in the Common area to **1.4**.



Set Pressure Angle to **20**.

The screenshot shows a software interface with two input fields: "Pressure Angle" and "Helix Angle". Both are set to "20.0000 deg". Below these is a "Unit Corrections Guide" dropdown menu set to "With Comp. of Slips". At the bottom, there is a "Total Unit Correction" field showing "-1.2604 ul" and a "Preview..." button.

Set Helix Angle to **12**.

This screenshot is similar to the previous one, but the "Helix Angle" field is now set to "12.0000 deg". The "Pressure Angle" remains at "20.0000 deg".

Select **With Comp. of Slips** in the Unit Correction Guide drop-down menu.

The screenshot shows the "Unit Corrections Guide" dropdown menu expanded. The options are: "User", "In Gear Ratio", "In Reverse Ratio", "With Comp. of Slips" (which is highlighted by the mouse), and "According to Merrit".

Click Calculate. Calculation indicates design compliance. Inserted values are valid and it is possible to design spur gears based on inserted values.

You completed the preliminary spur gears design. In the next steps, you adjust the spur gears material and your own spur gears criteria.

B. Check calculation

Now, you can adjust designed geometry based on your own criteria and values.

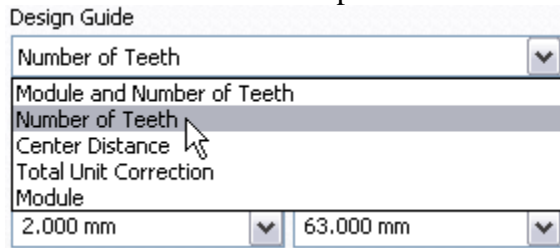
Switch to the Calculation tab. Select Check Calculation in the Type of Strength Calculation area of More options.

The screenshot shows the "Type of Strength Calculation" dropdown menu with "Check Calculation" selected. Below the menu are two input fields: "Contact" with the value "1,200 ul" and "Bending" with the value "1,300 ul".

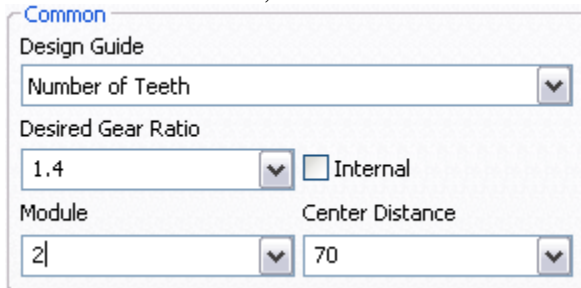
Switch to the Design tab.

In the Common area, select the Number of Teeth option from the Design Guide drop-down menu. The selected option indicates that the number of teeth is calculated based on center

distance and other known parameters.

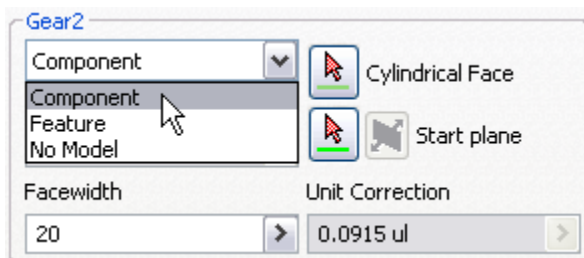
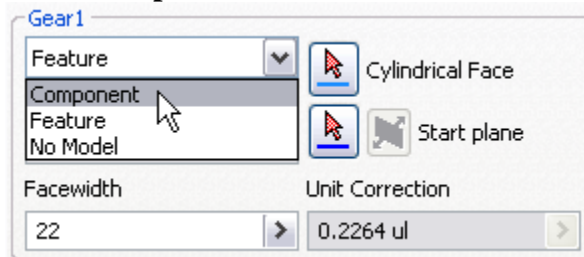


In the Common area, set Center Distance to **70** mm and Module to **2** mm.



Set Facewidth for Gear 1 to **22** mm and Facewidth for Gear 2 to **20** mm.

Select **Component** in the Gear 1 and Gear 2 drop-down menus.



Click Calculate.

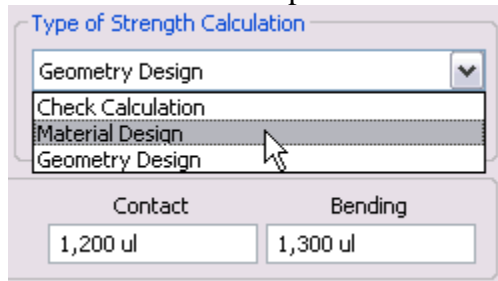
Check that the calculation still indicates design compliance.

Now let's calculate the minimal necessary material for the spur gears using the Material Design scenario.

C. Material Design

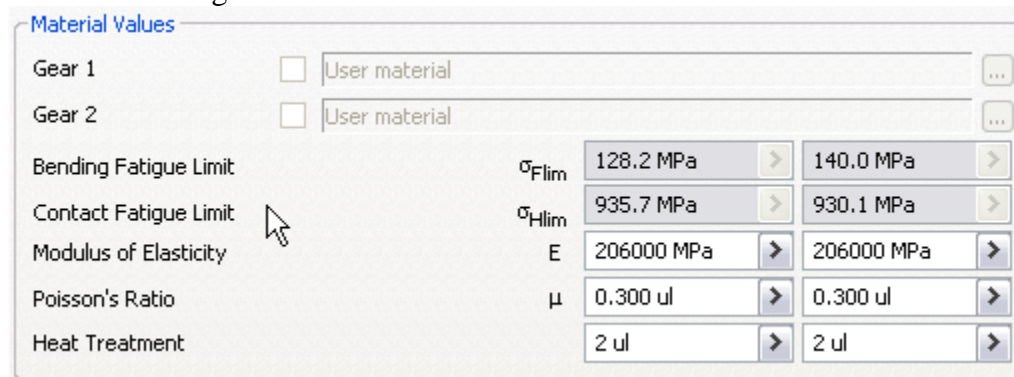
Switch to the Calculation tab. Select Material Design in the type of Strength Calculation drop-

down menu in More options.

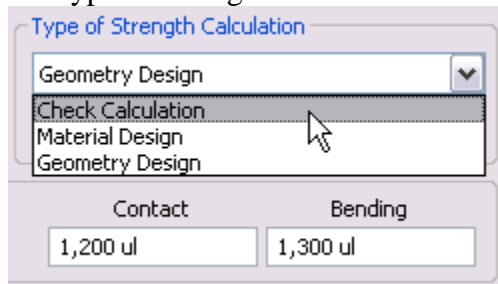


Click Calculate.

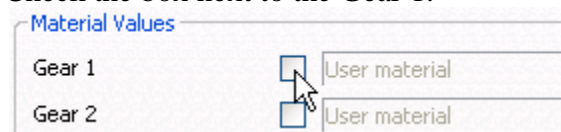
In the Material Values area, the values of Bending Fatigue Limit and Contact Fatigue Limit area are calculated. These values are minimum material values that satisfy the strength condition of the current strength calculation.



Select the optimal existing materials to reflect the calculated values. Select Check Calculation in the Type of Strength Calculation area of More options.



Check the box next to the Gear 1.



It lists all available materials for spur gears. Material database is editable so you can add your own material, delete selected material, and add new material based on existing material. For easier searching, use the "Enter text here" fields. For example, we want to insert an ISO material,

so type **ISO** into the field in the Standards column (Std).

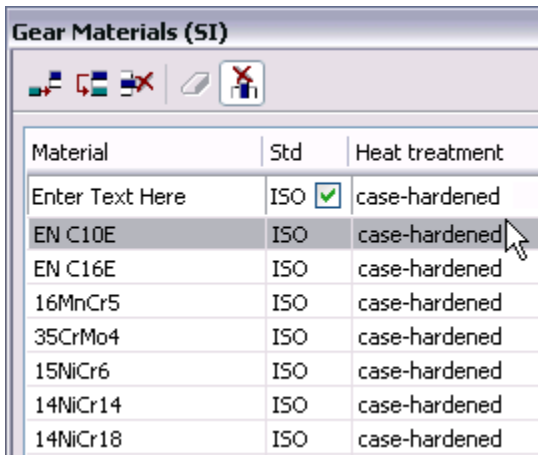


Material	Std	Heat treatment
Enter Text Here	ISO	Enter Text Here
Grey cast iron	ISO	
Grey cast iron	ISO	
Grey cast iron	ISO	
Nodular cast iron	ISO	
Nodular cast iron	ISO	
Nodular cast iron	ISO	heat treated
Malleable cast iron	ISO	normalized

Note: The text field is case-sensitive so you must type “ISO” not “iso” to the Enter Text Here field.

Note: Clear the checkmark from the box to cancel the narrowed search.

Let’s narrow the search even further and type **case-hardened** into the field in the Heat treatment column. A list of available materials is automatically displayed.



Material	Std	Heat treatment
Enter Text Here	ISO <input checked="" type="checkbox"/>	case-hardened
EN C10E	ISO	case-hardened
EN C16E	ISO	case-hardened
16MnCr5	ISO	case-hardened
35CrMo4	ISO	case-hardened
15NiCr6	ISO	case-hardened
14NiCr14	ISO	case-hardened
14NiCr18	ISO	case-hardened

Select material based on recommended values for Bending Fatigue Limit and Contact Fatigue Limit. Check the Bending Fatigue Limit and Contact Fatigue Limit columns in Material

Database.

VHV [ul]	sHlim [MPa]	sFlim [MPa]	NHlim [ul]
Enter Text...	Enter Text Here	Enter Text Here	Enter Text Here
650	1210	500	100000000
650	1210	500	100000000
650	1270	700	100000000
650	1270	700	100000000
650	1270	700	100000000
650	1270	700	100000000
650	1330	740	100000000

For Gear 1, the smallest recommended value for Bending Fatigue Limit is 352 MPa and for Contact Fatigue Limit it is 1140 MPa. Select Material **EN C10E** with the value of Bending Fatigue Limit of 500 MPa and with the value of Contact Fatigue Limit of 1210.

Gear Materials (SI)

Material	Std	Heat treatment	R _m [MPa]
Enter Text Here	ISO <input checked="" type="checkbox"/>	case <input checked="" type="checkbox"/>	Enter Text Here
EN C10E	ISO	case-hardened	440
EN C16E	ISO	case-hardened	495
37Cr4	ISO	nitro-case-hard.	1570
16MnCr5	ISO	case-hardened	785
35CrMo4	ISO	case-hardened	880
15NiCr6	ISO	case-hardened	880
14NiCr14	ISO	case-hardened	932
14NiCr18	ISO	case-hardened	1130

Click the row with the material and click OK.

Let's specify the material for Gear 2. In the Material Values area check the box next to Gear 2.

Material Values

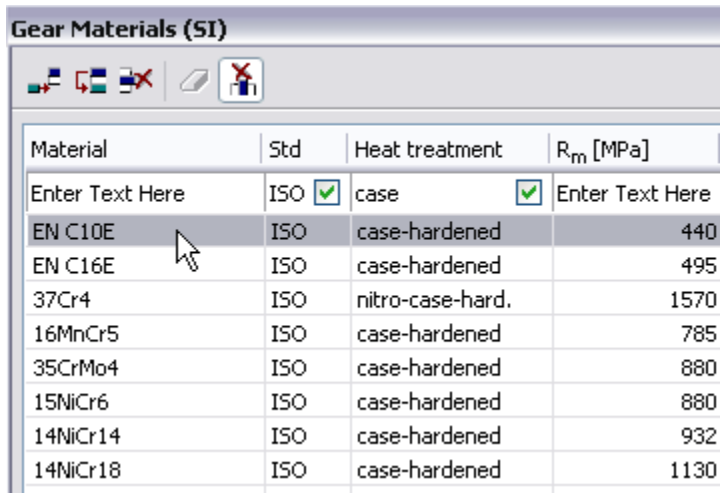
Gear 1 EN C10E

Gear 2 User material

Bending Fatigue Limit σ_{Flim} 500.0 MPa > 140.0 MPa >

The Material database opens with the last set criteria so the list of ISO and case-hardened materials is displayed. Select the **EN C10E** material and click OK. Material values are inserted

to the Calculation tab.



Material	Std	Heat treatment	R _m [MPa]
Enter Text Here	ISO <input checked="" type="checkbox"/>	case <input checked="" type="checkbox"/>	Enter Text Here
EN C10E	ISO	case-hardened	440
EN C16E	ISO	case-hardened	495
37Cr4	ISO	nitro-case-hard.	1570
16MnCr5	ISO	case-hardened	785
35CrMo4	ISO	case-hardened	880
15NiCr6	ISO	case-hardened	880
14NiCr14	ISO	case-hardened	932
14NiCr18	ISO	case-hardened	1130

Click Calculate.

Selected materials can be used for our spur gears design because the calculation did not fail.

Now, your design is complete.

Save the assembly. This is the end of this Skill Builder.

In this Skill Builder you learned how to:

- Design spur gears based on specified criteria necessary for your design.
- Check calculation and adjust spur gears design to other necessary parameters.
- Select material for spur gears based on calculated values. Material suitable for designed spur gears with specified criteria.