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USE OF ARTIFICIAL INTELLIGENCE IN DESIGN CALCULATIONS OF MACHINE

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Abstract: This article describes the use of the ChatGPT tool in the field of construction and design of machine parts. When generating technical drawings, it turned out that this tool is not as reliable assistant as one might expect. The resulting visualizations often do not correspond exactly to the specified require-ments, which limits their practical use. In the field of technical calculations, the paid version of ChatGPT provides slightly better results. However, their accuracy cannot be guaranteed, and therefore it is always necessary to perform subsequent control and verification of the calculated values using standard methods or specialized software.

KEYWORDS: ChatGPT, gear wheel, artificial intelligence, design calculations

1 Introduction

Nowadays, students are used to using modern tools such as ChatGPT in their studies. Although such a tool can be useful for quickly finding information or explaining more complex concepts, it cannot be considered a completely reliable source. Artificial intelligence can sometimes provide inaccurate or unverified data.

This problem is especially noticeable in technical and construction fields, where it is important to accurately distinguish individual components, materials or technological processes. Artificial intelligence is not always able to correctly identify or describe specific construction elements, because its knowledge is based on general data, which may not be technically accurate. It also often fails to distinguish subtle diffe-rences between similar components or misinterprets technical terms. These shortcomings are due to the fact that the system is constantly developing and gradually improving, and therefore its answers cannot be trusted without reservation. Therefore, it is always better to rely on classic and verified study scripts, which were created on the basis of professional knowledge and many years of experience of teachers. Such materials represent a guarantee of the correctness and accuracy of information and are a reliable basis for quality preparation for exams and for a deeper understanding of the subject matter. For other articles dealing with similar issues, see papers [1, 2].

2 Gear wheels rendering

2.1 Projection of gear wheels

When ChatGPT is asked to draw a gear wheel, how it will look like? ChatGPT quickly displayed Figure 1 and wrote what it thought a gear wheel looked like.

Since we were not satisfied with this option, we requested a new image and asked ChatGPT to create a realistic gear wheel, which is shown in Figure 2.

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Both images were from the free version of ChatGPT. That's why we asked ChatGPT5 (the paid version) for the final approximation by writing it, "Make a realistic representation of the gear wheel." The result is shown in Figure 3.

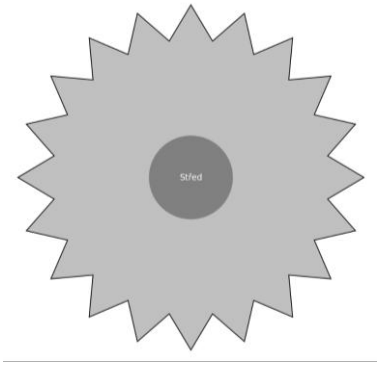


Fig. 1 Approximation of the sketch

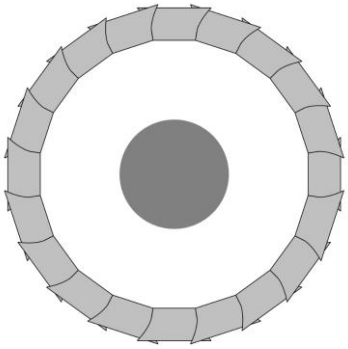


Fig. 2 Approximation of real gear wheel imaging

Fig. 3 Approximation, ChatGPT generated it itself, its own creation

When ChatGPT (the free version) was asked to display the gear again after two months, Figure 4 shows a more realistic gear.

Figure 5 shows the entire gear wheel with multiple teeth and involute profiles from the paid version of ChatGPT 5. Once again, it is not what was requested (expected).

The 3rd approximation after 2 months. We gave the ChatGPT the task of drawing one involute tooth and describing it with individual circles. The result is shown in Figure 6.

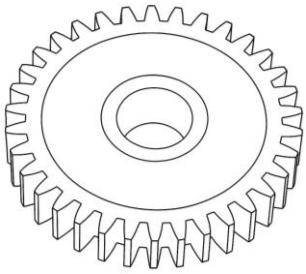


Fig. 4 Approximation of the sketch

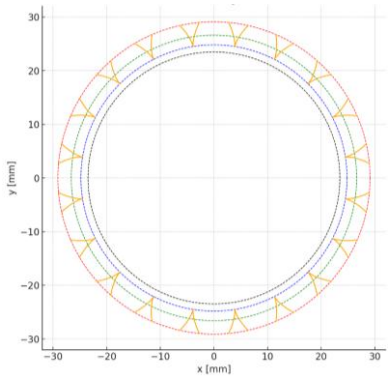


Fig. 5 Approximation Gear wheel with involute teeth (schematic visualization)

Again, as with the previous images, they do not correspond to the ideal state that one would expect.

We wanted it to create a schematic visualization of a gear with one tooth. Figure 7 shows how ChatGPT reworked it to follow the request.

2.2 Calculate gear wheel

ChatGPT was tasked with calculating the pitch circle, base circle, head circle, and root circle, given that the module $m = 2.5$ mm, the number of teeth $z = 20$, and the angle of pressure $\alpha = 20°$.

The calculation was performed using the ChatGPT tool. This tool performed the calculation correctly and the results are as expected.

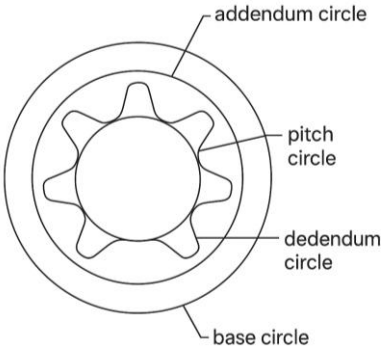


Fig. 6 Approximation, ChatGPT generated one involute tooth

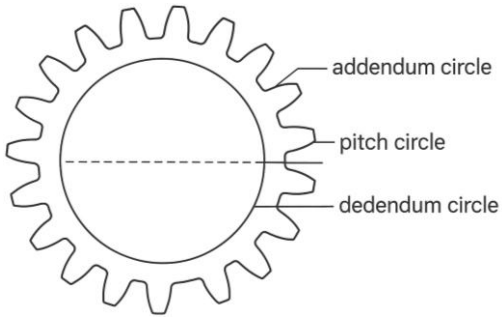


Fig. 7 Schematic visualization of a gear wheel with one tooth

The equation for calculating the pitch circle was written by ChatGPT completely correctly. ChatGPT attempted to generate the shape of an involute tooth, including the calculation from the previous example of individual circles, which is shown in Figure 8.

- **module** $m = 2.5\,\text{mm}$
- **number of teeth** $z = 20$
- **pressure angle** $\alpha = 20^\circ$

Basic Calculations of Gear Dimensions

1. **Pitch Diameter:**

$$d = m \cdot z = 2.5 \times 20 = 50\,\text{mm}$$

2. **Base Diameter:**

$$d_b = d \cdot \cos\alpha = 50 \times \cos 20^\circ \approx 50 \times 0.9397 = 46.985\,\text{mm}$$

3. **Addendum (Outside) Diameter (including addendum):**

$$d_a = m \cdot (z + 2) = 2.5 \times 22 = 55\,\text{mm}$$

4. **Dedendum (Root) Diameter:**

$$d_f = m \cdot (z - 2.5) = 2.5 \times 17.5 = 43.75\,\text{mm}$$

Additional Parameters (if needed):

- **Tooth height:** $h = h_a + h_f = 2.5m$ (usually)
- **Addendum:** $h_a = m$
- **Dedendum:** $h_f = 1.25m$

Fig. 8 Calculation for straight teeth using ChatGPT

The calculation was performed using the ChatGPT tool. This tool performed the calculation correctly and the results are as expected [3, 4].

It easily calculated this and was able to create a clear table for it, see Table 1.

Tab. 1 Calculation of gear wheel circles

Summary table (rounded)

Circle	Radius (mm)	Diameter (mm)
Pitch	25.000	50.000
Base	23.4923	46.9846
Addendum	27.500	55.000
Dedendum (root)	21.875	43.750

If the same problem is entered in the free version of ChatGPT, it is not entirely clear what is actually being calculated. It seems that the tangent modulus m_t is referred to in this version only as m and the normal modulus as m_n. In such a case, it is more difficult to determine exactly what the individual values refer to, see Figure 11. Better and clearer formulas are achieved in the paid version, as can be seen from the attached Figure 10.

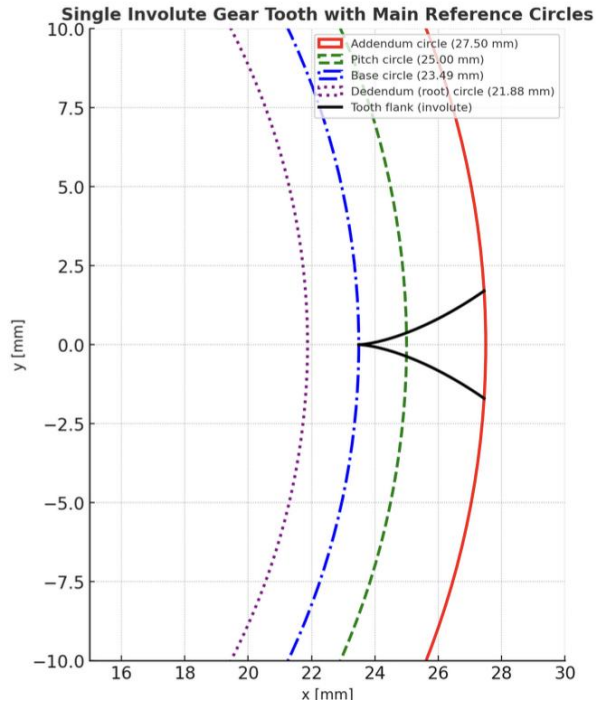


Fig. 9 The shape of the involute tooth

Let us consider a **helical gear**, where the **normal module** is $m_n = 2.5\,\text{mm}$, the **normal pressure angle** is $\alpha_n = 20°$, and the **helix angle** is $\beta = 20°$.
(Standard ISO/DIN: $h_a = m_n,\ h_f = 1.25m_n$)

Conversion to the transverse direction:

$$m_t = \frac{m_n}{\cos\beta}$$

$$\tan\alpha_t = \frac{\tan\alpha_n}{\cos\beta}$$

Then:

- **Pitch diameter:**

$$d = m_t\, z = \frac{m_n}{\cos\beta} z$$

- **Base diameter:**

$$d_b = d\cos\alpha_t$$

- **Addendum (outside) diameter:**

$$d_a = d + 2m_n$$

- **Dedendum (root) diameter:**

$$d_f = d - 2\times 1.25m_n$$

Substitution (for $m_n = 2.5\,\text{mm},\ z = 20,\ \beta = 20°,\ \alpha_n = 20°$):

$$m_t \approx 2.6604\,\text{mm},\quad \alpha_t \approx 21.173°$$

$$d \approx 53.21\,\text{mm}$$

$$d_b \approx 49.62\,\text{mm}$$

$$d_a \approx 58.21\,\text{mm}$$

$$d_f \approx 46.96\,\text{mm}$$

Fig. 10 Calculation for oblique teeth using ChatGPT5 (the paid version) (correct)

3 Showing the connection of the hub to the shaft using a key

I asked ChatGPT in the paid version to show the connection of the hub with the shaft using a key. To do this, in cross-section, Figure 10 on the left and in longitudinal section, Figure 10 on the right. ChatGPT described it with the following words: "Here you have a drawing with sections: on the left – cross-section of the shaft: the gray circle represents the cross-section of the shaft, the red rectangle is the key in the groove. On the right – longitudinal section of the shaft: the gray rectangle shows the shaft in section, the red element is the key along the entire length."

Sure, if you mean the **helix angle (β)** or the **angle of helical gearing** $\beta = 20°$, that means we are dealing with **helical gearing** (a screw gear) with an angle of 20°.

What this means for the dimensions:

- **Module in the direction of the gear axis (axial module)** is

$$m_n = m \cdot \cos\beta = 2.5 \times \cos 20° \approx 2.5 \times 0.9397 = 2.35\,\text{mm}$$

- The **number of teeth** z remains the same.
- The **pressure angle** in the axial direction must be recalculated. However, if you have a standard pressure angle $\alpha = 20°$ in a plane perpendicular to the gear axis, then:

$$\alpha_n = \arctan(\tan\alpha \cdot \cos\beta)$$

For $\alpha = 20°$, $\beta = 20°$:

$$\tan\alpha_n = \tan 20° \times \cos 20° \Rightarrow \alpha_n \approx \arctan(0.3640 \times 0.9397) \approx \arctan(0.3418) \approx 18.9°$$

Summary:

- **Normal module** (module in the plane perpendicular to the teeth): $m_n = 2.35\,\text{mm}$
- **Normal pressure angle:** approx. $18.9°$
- **Number of teeth:** the same, but the effective number in the axis direction is $z/\cos\beta$

Fig. 11 Calculation for oblique teeth using ChatGPT

The display result was not the best. In this regard, we do not recommend using ChatGPT to generate mechanical drawings. Figure 13 correctly shows the connection using feather key, [5].

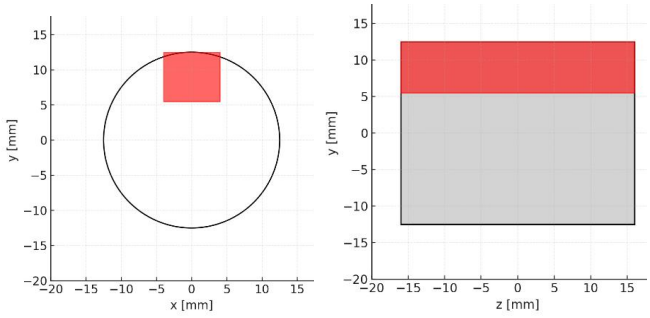


Fig. 12 Connection using feather key (ChatGPT paid version)

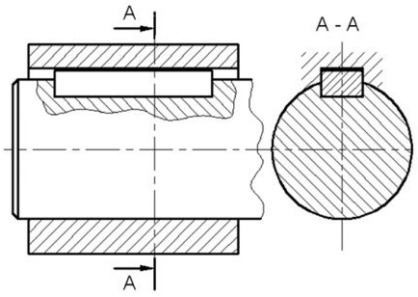


Fig. 13 Connection using feather key (correct) [3]

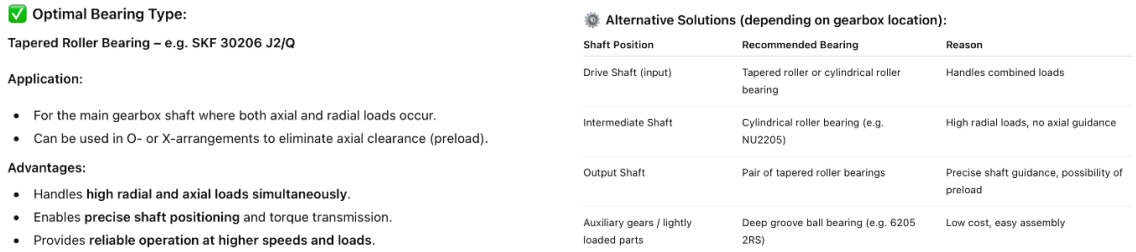
4 Bearing design for a single-stage gearbox

We entered a calculation of bearings for a single-stage gearbox, but the model did not recognize that it was a single-stage transmission, and began to consider the parameters corresponding to a two-stage gear-box, as can be seen in Figure 14. ChatGPT writes the calculation procedure, but it is not able to safely decide on the structural arrangement, in this case, whether it is single-stage or multi-stage. If we had entered a more detailed description, that only two shafts are entered. Maybe it would have calculated. Therefore, when using ChatGPT for design and control calculations, we recommend using other engineering software that is made for calculations.

CONCLUSION

The article dealt with the use of ChatGPT in the visualization and design of machine parts. This tool can be very useful assistant, especially for users who can work effectively with this tool and have sufficient technical knowledge. ChatGPT can, for example, suggest basic

concepts, check the logic of the design or advise on design optimization options. However, it is important to emphasize that this tool is not flawless - the generated designs may contain errors or inaccuracies that only an experienced expert can detect. Without this expertise, the user risks accepting a design that may not work in practice or could even be dangerous.



✅ **Optimal Bearing Type:**

Tapered Roller Bearing – e.g. SKF 30206 J2/Q

Application:

- For the main gearbox shaft where both axial and radial loads occur.
- Can be used in O- or X-arrangements to eliminate axial clearance (preload).

Advantages:

- Handles **high radial and axial loads simultaneously**.
- Enables **precise shaft positioning** and torque transmission.
- Provides **reliable operation at higher speeds and loads**.

⚙️ **Alternative Solutions (depending on gearbox location):**

Shaft Position	Recommended Bearing	Reason
Drive Shaft (input)	Tapered roller or cylindrical roller bearing	Handles combined loads
Intermediate Shaft	Cylindrical roller bearing (e.g. NU2205)	High radial loads, no axial guidance
Output Shaft	Pair of tapered roller bearings	Precise shaft guidance, possibility of preload
Auxiliary gears / lightly loaded parts	Deep groove ball bearing (e.g. 6205 2RS)	Low cost, easy assembly

Fig. 14 Design of a single-stage gearbox bearing

When it comes to visualization or accurate display of machine parts, ChatGPT does not yet reach the necessary quality. Especially in the free version, it cannot accurately distinguish individual parts or reproduce their actual appearance or spatial arrangement. This means that it is still necessary to use specialized CAD software for detailed designs and technical drawings. ChatGPT therefore complements the design process rather than fully replacing it.

Overall, ChatGPT is an interesting and promising tool for mechanical engineers that can speed up some parts of the design process and inspire new solutions. However, its outputs still need to be carefully verified and checked using classical methods. It should be kept in mind that the designed machine component must be safe, functional, and accurate.

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