

## DEFINING THE TOP LAND THICKNESS OF INVOLUTE GEARS

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### 1. INTRODUCTION

In case of an involute gear there are two different types of interferences:

Production interference: can be described when during the machining of the involute external gear the tool during its cutting movement harms the normal geometry of the tooth profile (undercut is created) [1], [2].

Operational interference: belongs to a pair of gears, it means that one gear requires a kind of profile what cannot be produced or it wasn't produced.

During the design of simple planetary gear drives it can happen the case, when the value of the top land thickness of the external gear in the inadequately designed planetary gear drive will be lower than expected or practically defined the lowest value [1], [2]. The verification of this value has to be made, because a thin top land can cause tooth breakage near the tip circle. As the top land thickness belongs to a pair of gears thus its analyses belongs to the concept of operational interference.

Instead of the general approximation found in literature [3]-[6], we examine in details the effects of the designed geometry on the dimensions of the external gear. We shall define the conditions of the interference occurrence, and propose how to choose the parameters to avoid this phenomena.

### 2. INVESTIGATION OF TOP LAND THICKNESS OF INVOLUTE SPURGEAR

During the analyses of the top land thickness, we shall determine the top land for the external gear is not thinner than the values which can be found in the literatures and determined by calculations or estimations. Typically, here we calculate the thickness referred to the module of the gear and we give it as a percentage of the module. The top land thickness is considered as correct, if:

$$s'_{a2} \geq s'_{a2min}, \quad (1)$$

where  $s'_{a2}$  is the ratio of tooth thickness on tip circle and the module

$s'_{a3min}$  is suggested in the literature between 0,2 ... 0,4 depending on the material and heat treatment of gear.

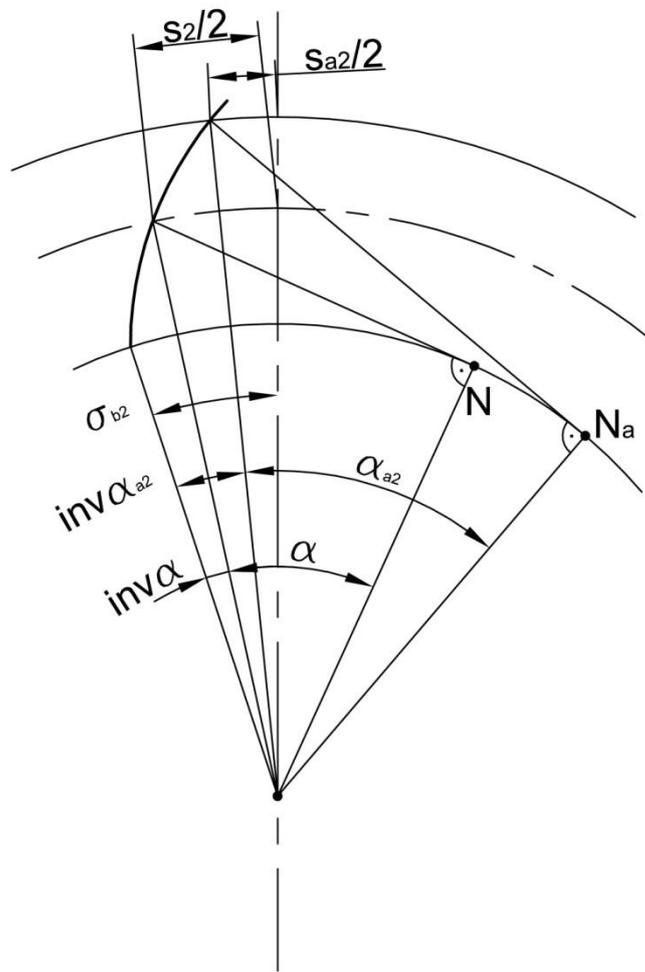


Figure 1.

As it is well known from the literature [2],[8] that we can give the tooth thickness of a spur gear on the pitch circle, as

$$s_2 = \frac{p}{2} + 2x_2 m \tan\alpha, \quad (2)$$

where  $p$  is the pitch on the reference circle,  
 $m$  is the module,  
 $\alpha$  is the pressure angle,  
 $x_2$  is the profile shift coefficient of aspur gear.

According to Fig. 1, the profile angle  $\sigma_{a2}$  can be determined by the equation as follows

$$\sigma_{b2} = \frac{s_2}{2r_2} + \text{inv } \alpha = \frac{s_{a2}}{2r_{a2}} + \text{inv } \alpha_{a2}, \quad (3)$$

where  $s_2$  is the tooth thickness of the profile on pitch circle,

$r_2$  is the radius of pitch circle,

$s_{a2}$  is the tooth thickness on the tip circle,

$r_{a2}$  is the radius of tip circle.

From this equation we can give the thickness on tip circle as

$$s_{a2} = 2r_{a2} \left( \frac{s_2}{2r_2} + \text{inv } \alpha - \text{inv } \alpha_{a2} \right) \quad (4)$$

where  $\alpha_{a2}$  is the profile angle on tip circle.

One can rewrite it in the form

$$s_{a2} = d_{a2} \left( \frac{s_2}{2r_2} + \text{inv } \alpha - \text{inv } \alpha_{a2} \right). \quad (5)$$

By substituting the tooth thickness on the pitch circle and the profile angle for the tip circle we get

$$s_{a2} = d_{a2} \left\{ \frac{\pi}{2z_2} + \frac{2x_2}{z_2} \tan \alpha + \text{inv } \alpha - \text{inv} \left[ \arccos \left( \frac{z_2 m}{d_{a2}} \cos \alpha \right) \right] \right\}. \quad (6)$$

Using equation (6) and (1) we get the conditional inequality

$$s'_{a2} \geq \frac{d_{a2}}{m} \left\{ \frac{\pi}{2z_2} + \frac{2x_2}{z_2} \tan \alpha + \text{inv } \alpha - \text{inv} \left[ \arccos \left( \frac{z_2 m}{d_{a2}} \cos \alpha \right) \right] \right\}. \quad (7)$$

### 3. INVESTIGATION OF TOP LAND THICKNESS OF INVOLUTE INTERNAL GEAR

During the analysis of the top land thickness, we intend to determine the top land for the internal gears not thinner than the values which can be found in the literatures and determined by calculations or estimations. Typically here we calculate the thickness referred to the module of the gear and we give as a percentage of the module. The head thickness is considered as correct, if:

$$s'_{a3} \geq s'_{a3min} \tag{8}$$

where  $s'_{a3}$  is the ratio of the module and the tooth thickness of gear on tip circle

$s'_{a3min}$  is suggested in the literature between 0,2 ... 0,4 depending on material and heat treatment of gear.

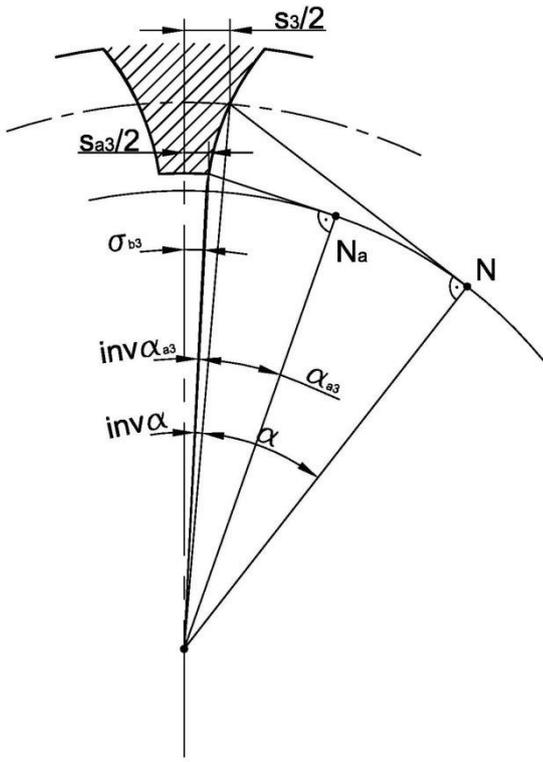


Figure 2.

As shown in Fig. 2, the tooth thickness on the pitch circle can be given as follows:

$$s_3 = \frac{p}{2} - 2x_3 m \tan \alpha, \quad (9)$$

where  $x_3$  denotes the profile shift coefficient of the internal gear.

The profile angle  $\sigma_{b3}$  can be determined by the equation

$$\sigma_{b3} = \frac{s_3}{2r_3} - \text{inv} \alpha = \frac{s_{a3}}{2r_{a3}} - \text{inv} \alpha_{a3}, \quad (10)$$

where  $s_3$  is the tooth thickness on the pitch circle,  
 $r_3$  is the radius of pitch circle,  
 $r_{a3}$  is the radius of tip circle.

From this equation we can give the thickness on tip circle

$$s_{a3} = 2r_{a3} \left( \frac{s_3}{2r_3} - \text{inv} \alpha + \text{inv} \alpha_{a3} \right), \quad (11)$$

where  $\alpha_{a3}$  denotes the profile angle on the tip circle.

Substituting the thickness on the pitch circle and the profile angle for the tip circle into equation (11), we get

$$s_{a3} = d_{a3} \left\{ \frac{\pi}{2z_3} - \frac{2x_3}{z_3} \tan \alpha - \text{inv} \alpha + \text{inv} \left[ \arccos \left( \frac{z_3 m}{d_{a3}} \cos \alpha \right) \right] \right\}. \quad (12)$$

By substituting the equation (12) into the inequality (8) we get the conditional inequality

$$s'_{a3} \geq \frac{d_{a3}}{m} \left\{ \frac{\pi}{2z_3} - \frac{2x_3}{z_3} \tan \alpha - \text{inv} \alpha + \text{inv} \left[ \arccos \left( \frac{z_3 m}{d_{a3}} \cos \alpha \right) \right] \right\}. \quad (13)$$

#### 4. CONCLUSIONS

According to the calculations we see that two different type of interferences can appear.

The production interference is the type of interference, where the problem is made by the tooling instrument.

The operational interference is the type of interference, where the problem is made by the mating gear.

The examination of the interferences must be carried out via systematic analyses instead of a random one.

## 5. REFERENCES

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