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Determining the Tilt Direction of Spur Teeth

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Abstract

This paper presents the way of choosing the tilt direction of the wheels teeth on the intermediary shaft for a favorable loading of the intermediate bearing shaft for a two stages speed reducer.

Key words*: wheel, gear, shaft, teeth, strength, intermediate shaft*

General Considerations

Corresponding to the action of the nominal torques of the motors forces M_{t1} and resistant M_{t2} of the driving and driven wheels of the gear teeth on their engaged teeth, it develops the normal force of engagement F_n, considered concentrated and situated in the nominal plan, by the direction of the line of gear [1, 2].

To calculate the resistance of teeth and other machine parts: shafts, bearings, etc., nominal normal force F_n of gear on flanks decays in the normal plan into two components: $F_{t\,n}$ tangential resultant and radial F_r (fig. 1):

$$F_n = F_{t\,n} + F_r \ . \tag{1}$$

$F_{t\,n}$ tangential resultant component decays after two directions: tangential and radial, resulting:

$$F_{t\,n} = F_a + F_t \ , \tag{2}$$

where F_t is the tangential component at the level of the division circle, and F_a is the axial component (axial force). Relation (1) becomes [3, 4, 5]:

$$F_n = F_a + F_t + F_r \ . \tag{3}$$

The direction of the radial forces is always from the pole of engagement to the center of the wheel. In terms of direction, tangential forces depend on the rotation of the wheels, at the driving wheel F_{t1} it has the opposite direction of rotation, and at the driven wheel F_{t2} it has the same direction as the sense of rotation of the driven wheel.

The axial forces direction depends on the direction of rotation, the tilt direction and the role of the tooth in the gear wheel (driving or driven).

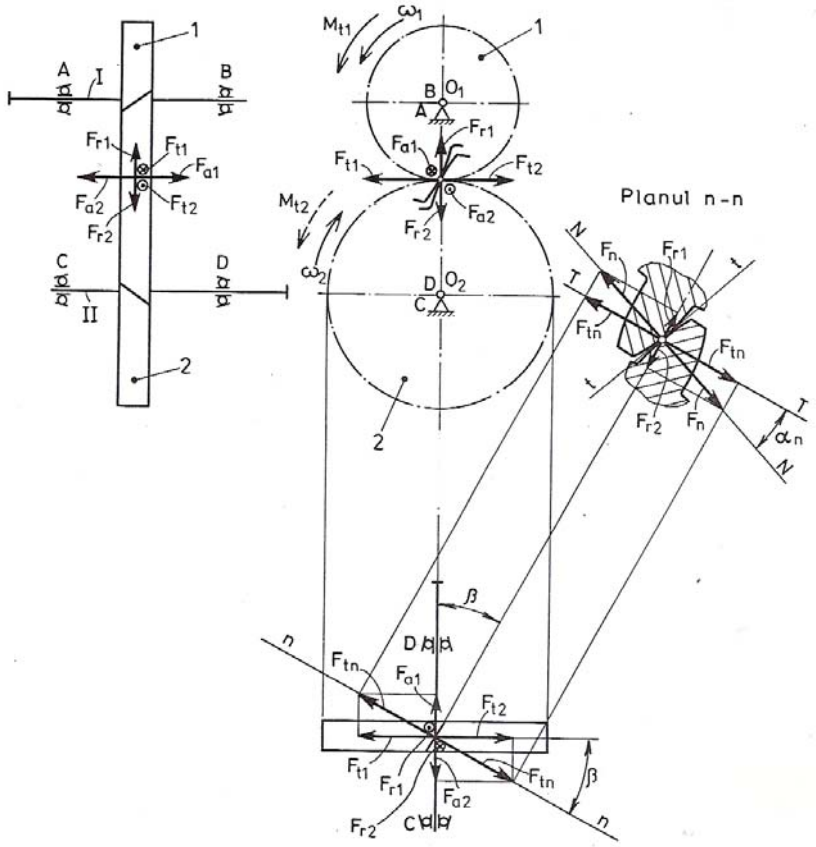

Fig. 1. Forces developed in the cylindrical gear with teeth inclined

Various Applications

In a two-stage speed reducer based on the above, it can be determined the forces developed in the two gears, in a global, centralized, unified view allowing the visualization of forces acting on the two gears, on shafts (I, II, III) and on the rolling bearings (bearings). Also, this representation allow to establish and discuss for the full reducer the tilt direction of the wheels' teeth for two wheels, choosing the rigorous solution that is convenient from the viewpoint of loading bearings.

It is found that the identification of active teeth flanks of driving wheels and driven in the cases analyzed has a very great importance.

In the case of a cylindrical, coaxial two stages speed reducer (fig. 2) bearing shaft I takes Fa_1 axial force, bearing shaft II takes axial force $Fa_2 - Fa_{2'}$ (Fa_2 and $Fa_{2'}$ have opposite directions), and bearing shaft III takes axial force Fa_3.

A version of the forces developed in a speed reducer is shown in Figure 3.

These cases presented in Figures 2 and 3 could be referred as cases with favorable loading of the shaft's bearing because the resultant axial force is the difference between axial forces Fa_2 and $Fa_{2'}$. If at the cinematic scheme of Figure 2 we change the tilt direction of the wheel 2', the forces developed in the cylindrical gear speed reducer with two coaxial stages are shown in Figure 4.

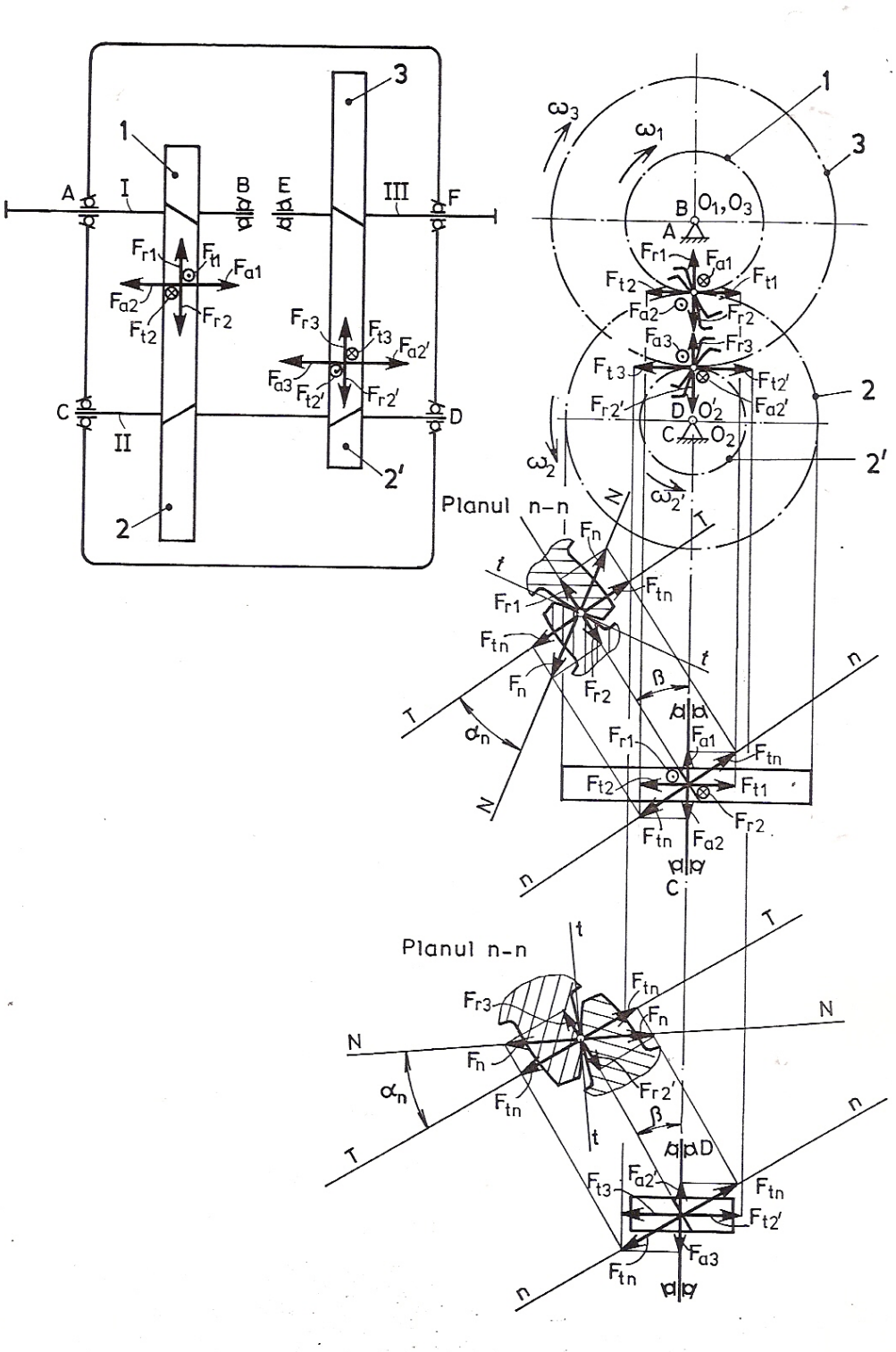

Fig. 2. Forces developed in a cylindrical and coaxial speed reducer with two stages

It is found in this case that at the second shaft the axial forces and Fa_2 and $Fa_{2'}$ the same direction, so on the bearing acts the resultant axial force ($Fa_2 + Fa_{2'}$).

Unlike the situation presented above, it shows that favorable loading of the bearing shaft II occurs under the wheel 2 (wheel driven in gear 1-2) and 2'(wheel driving in gear 2'-3) have the same direction of inclination of the teeth.

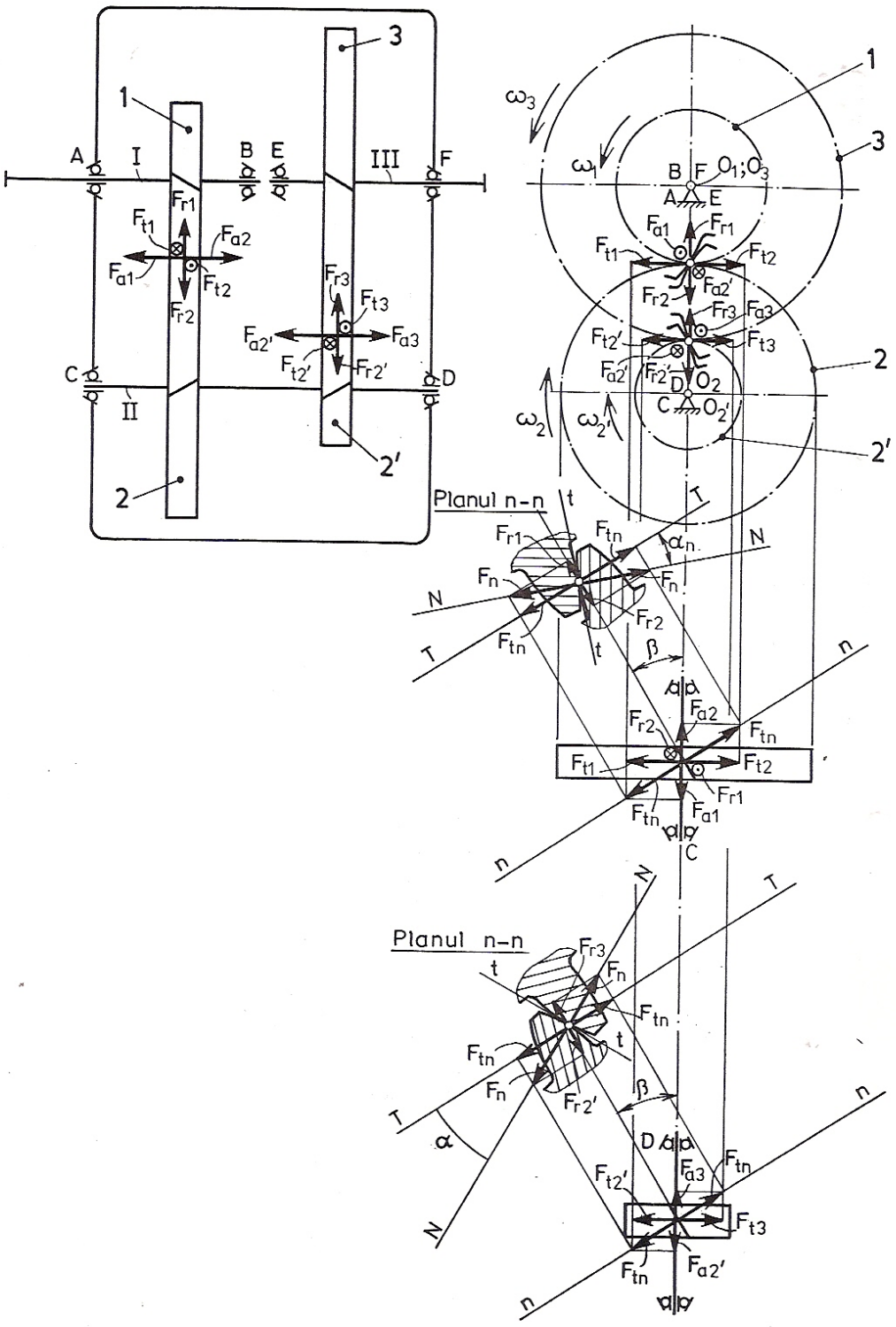

Fig. 3. Forces developed in a cylindrical and coaxial speed reducer with two stages – example

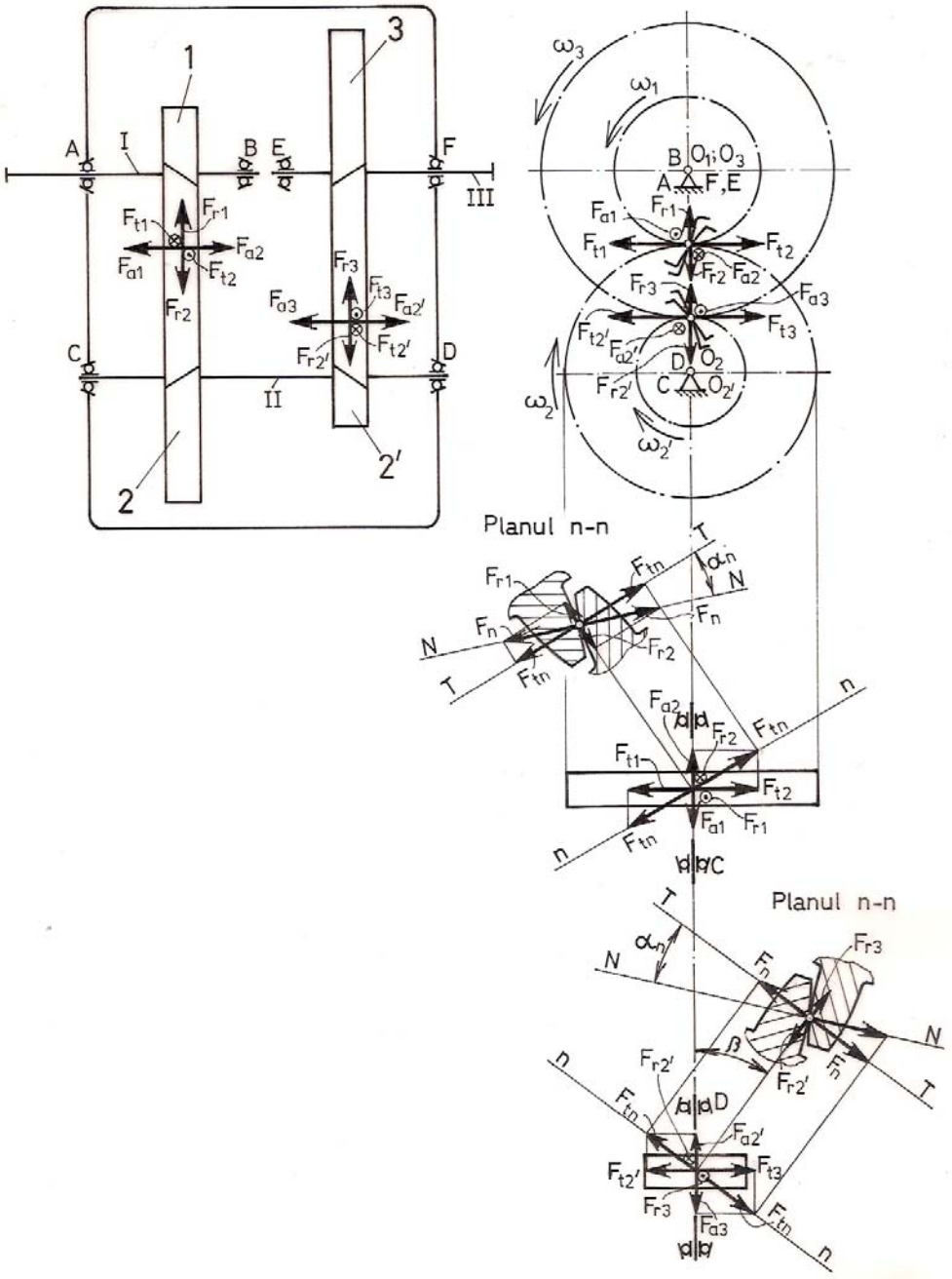

Fig. 4. Forces developed in the gears of a cylindrical, coaxial speed reducer with two stages, bad option

Conclusions

This paper presents the way of choosing the tilt direction of the wheels' teeth on the intermediary shaft for a favorable loading of the intermediate bearing shaft for a two stages speed reducer.

Forces developed in the two gears are presented in a comprehensive, centralized, unified view allowing the forces to act on the two gears, on the three shafts, on the rolling bearings, etc.

Please note that the favorable loading of the bearing of the intermediate shaft occurs when the wheels 2 and 2' have the same direction (tilt) of the teeth.

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Asupra determinării sensului de înclinare a danturii roţilor dinţate cilindrice

Rezumat

Lucrarea prezintă modul de alegere a sensului de înclinare al dinţilor roţilor de pe arborele intermediar pentru o incărcare favorabilă a lagărelor arborelui intermediar de la un reductor de turaţie. Forţele dezvoltate intr-un reductor de turaţie in doua trepte se prezintă intr-un mod global, centralizat, unitar, permiţând vizualizarea forţelor care acţionează asupra angrenajelor, asupra celor trei arbori, asupra lagărelor cu rostogolire etc. Se prezintă mai multe exemple de alegere a sensurilor de înclinare a danturii roţilor dinţate cilindrice atât pentru o incărcare favorabilă a lagărelor cu rostogolire, cât şi pentru o încărcare nefavorabilă a lagărelor cu implicaţii directe în activitatea de proiectare a sistemelor mecanice de transmitere a puterii.