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New Friction Mechanical Transmission

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Abstract: *Creation of transmission gear and overcoming of drawbacks such as high cost of materials; design of instruments, tools and machines; precision control etc., can be achieved by using existing machine elements. Good results can be reached with some minor alterations in the construction, with suitable combination of the comprising elements and with the creation of efficient schemes. The aim of the present paper is to define the structure and to carry out computer analysis of friction gear with two successive comprising elements.*
Keywords: *friction mechanical transmission, computer analysis, creation of efficient schemes.*

I. Introduction

Efforts of experts in gear mechanisms have been focused mainly on minimization of overall dimensions, higher transmission ratio and gear load capacity. This is a complicated process associated with structural design, manufacturing control and operational tests. Achieving this would mean higher costs for materials, engineering design of new tools, accessories and machinery, precision test facilities, etc.

These disadvantages can be overcome through the use of prefabricated machine components. Reasonable results can be achieved through minor structural modifications and suitable combination of constituent components. One of the standard components is a roller bearing –Fig. 1.

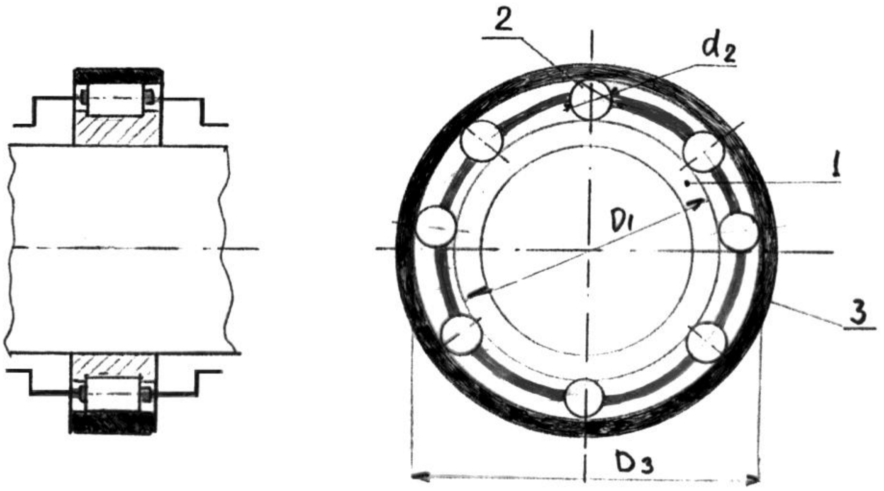


Figure 1. Roller bearing structure

In case of bearing balls or rolls being connected to a detail where the axis of rotation coincides with the axis of the bearing, when the bearing is in rotation, such detail entrained by the balls /rolls, would rotate i_1 times slower compared to the internal ring, and i_3 times slower compared to the external ring, supposing one of these rings is fixed. Under these conditions, the bearing is transformed into a mechanical reducer transmission with a gear ration of either i_1 or i_3. [1]

An advantage of bearing-based reducers is compact design and simple structure, low production costs and possibility for an extensive and flexible selection of transmission ratio value.

II. Kinematics Of Roller Bearing

Considering the kinematics of roller bearings (Fig. 2.), it can be found that both internal and external rings can rotate at different angular speed. More frequently in practice, there are cases where one of the rings (usually the external one) rotates. Roller bodies have angular speed around their respective axis of ω_g , while the separator rotates along with these around the bearing axis at angular speed of ω_0 [2].

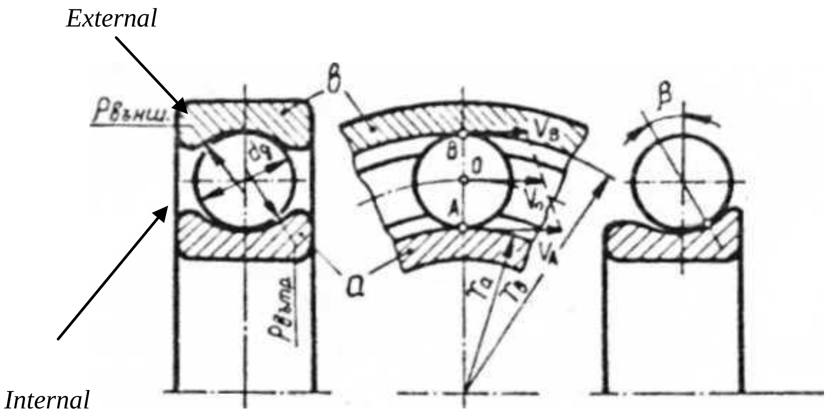


Figure 2. Roller bearing kinematics

The linear speed of the internal ring groove points *a* (point A) and the external ring *в* (point B) can be determined, as follows:

$$V_a = \frac{\pi.d_a.n_a}{60} \quad ; \quad V_b = \frac{\pi.d_b.n_b}{60} \qquad (1)$$

The linear speed of the separator (or of the centres of roller bodies around bearing axis) can be determined, as follows:

$$V_0 = \frac{V_a + V_b}{2} = \frac{\pi.d_m.n_0}{60} \qquad (2)$$

Using the geometric relations for roller bearing for radial clearance equal to zero:

$$d_a = d_m - d_g.\cos\beta; \;\; d_b = d_m + d_g.\cos\beta \qquad (3)$$

Following substitution in (1) and (2), the resulting separator speed is:

$$\omega_0 = 0.5.\omega_a(1 - \frac{d_g.\cos\beta}{d_m}) + 0.5.\omega_b(1 + \frac{d_g.\cos\beta}{d_m}) \qquad (4)$$

Separator speed relative to internal ring is:

$$\omega_{0(a)} = \omega_0 - \omega_a = 0{,}5(\omega_b - \omega_a)(1 + \frac{d_g.\cos\beta}{d_m}) \qquad (5)$$

Separator speed relative to external ring is:

$$\omega_{0(b)} = \omega_b - \omega_0 = 0{,}5(\omega_b - \omega_a)(1 - \frac{d_g.\cos\beta}{d_m}) \qquad (6)$$

The angular speed of the shot (roller) around its axis is:

$$\omega_g = 0{,}5.(\omega_a - \omega_b).(\frac{d_m^2 - d_g^2.\cos^2_\beta}{d_m.d_g}) \qquad (7)$$

III. Roller Bearing – A New Friction Mechanical Transmission

In the case of friction mechanical transmission design with one roller bearing, the kinematic diagram closely resembles the diagram of a planetary gear mechanism with two or more degrees of freedom, where external and internal rings, separator and rolling bodies are respectively the central gears *a* and *b*, driver *h* and satellite *g* (Fig. 3.). The analogy of motion performed by the individual units determines also the analogy of the names used for these units:

- internal and external ring ↔ central units (central gears);
- balls or rolls ↔ satellites (satellite gears);
- separator ↔ driver. [3]

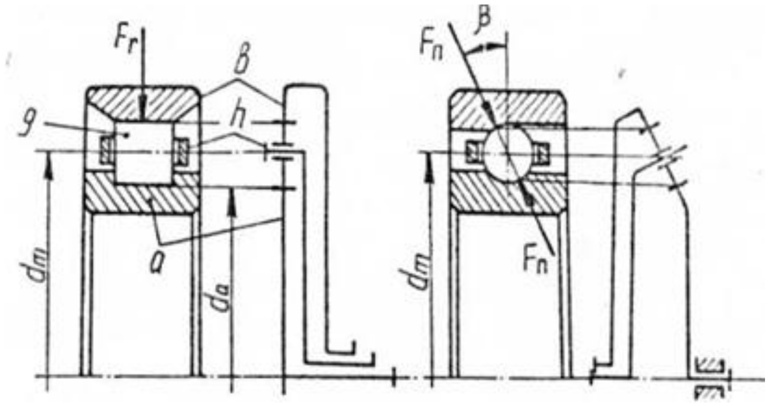


Figure 3. Roller bearing kinematic diagram

For the most common practical case of a rotating internal ring and a fixed external ring, we can determine:

$$i_{ha}^{b} = \frac{\omega_h - \omega_b}{\omega_a - \omega_b} = \frac{1}{1 - i_{ab}^{h}} = \frac{d_a}{d_a + d_b} = 0{,}5.(1 - \frac{d_g.\cos\beta}{d_m}) \qquad (8)$$

Respectively

$$\omega_0 = \omega_h^b = 0{,}5.\omega_a(1 - \frac{d_g.\cos\beta}{d_m}) \leq 0{,}5.\omega_a \qquad (9)$$

For a fixed internal ring

$$i_{hb}^{a} = 0{,}5.(1 + \frac{d_g.\cos\beta}{d_m}) \qquad (10)$$

Respectively

$$\omega_0 = \omega_h^a = 0{,}5.\omega_b(1 + \frac{d_g.\cos\beta}{d_m}) \geq 0{,}5.\omega_b \qquad (11)$$

From the formulae 9 and 11 it can be inferred that when ω_a is equal to ω_b, the following inequality holds:

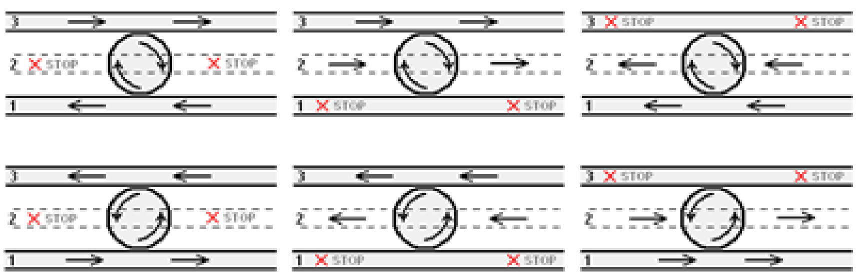
$\omega_h^a \geq \omega_h^b$,

therefore in the case of a fixed internal ring *a* (point load) the load frequency of the ring is higher and the number of cycles of variable pressures is higher.

It has been practically found that during bearing rotation, the least favourable load condition exist for the roller body, since rolling actions causes friction either against the separator, or ring grooves. The second highest frequency of load is found with the internal ring, and then comes the external ring.

IV. Design Schemes

Various transmission ratios can be achieved through several optional diagrams (Fig. 4). [4]



Fixed separator 2 Fixed ring 1 Fixed ring 3

Figure 4. Diagrams of driving and transmission

Two more sub-units can be derived from each of the diagrams depending on the bearing driver unit or the driven unit and the type of fixed unit (Fig. 5.).

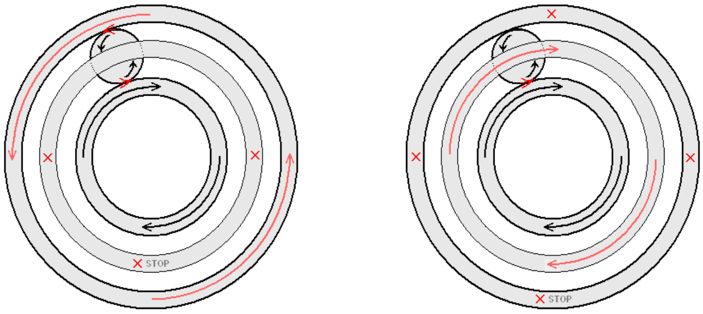


Diagram of a fixed separator Diagram of a fixed external ring

Figure 5. Diagrams of driving and transmission

In the case of one bearing integrated into another bearing, the result would be a friction transmission comprised of three components one placed inside the other, and having more degrees if freedom (Fig. 6). Interconnection or fixing of any of its units results in various mechanisms. [5]

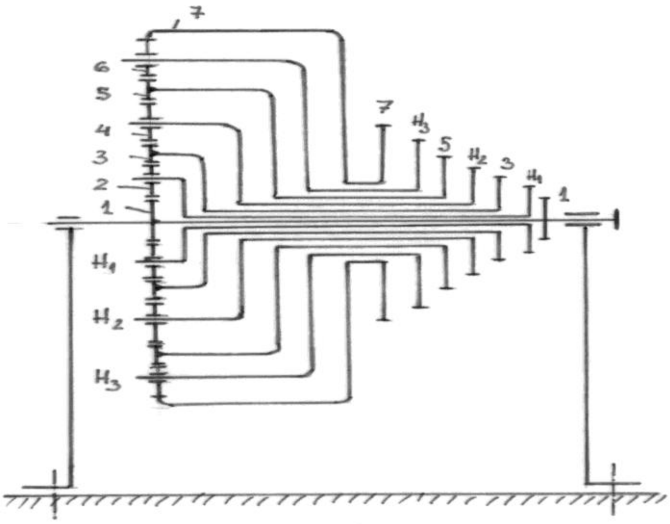


Figure 6. Kinematic diagram of a friction mechanical transmission with three components, one of them inserted in the other

V. Structural Design

The structural design of a friction mechanical transmission with two components, one of them inserted in the other, is demonstrated on Fig. 7.

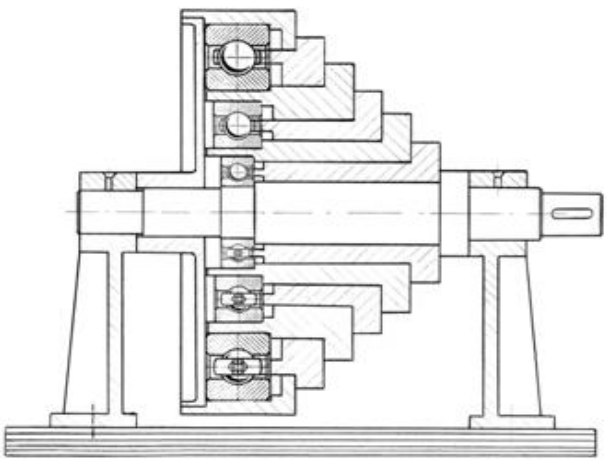


Figure 6. Structural design of the kinematic diagram, shown in Fig. 6.

The software used for the design and the simulation of transmission gears is NX UNIGRAPHICS. This CAD based software product is in a complete line of succession to the CAM systems by way of installing an additional module. It helps create 3D objects and enables the implementation of various simulations. These demonstrate hidden defects of during the design stage of future articles, and enable structural modifications, removal or addition of components, dimensional changes of an article, design changes, etc.

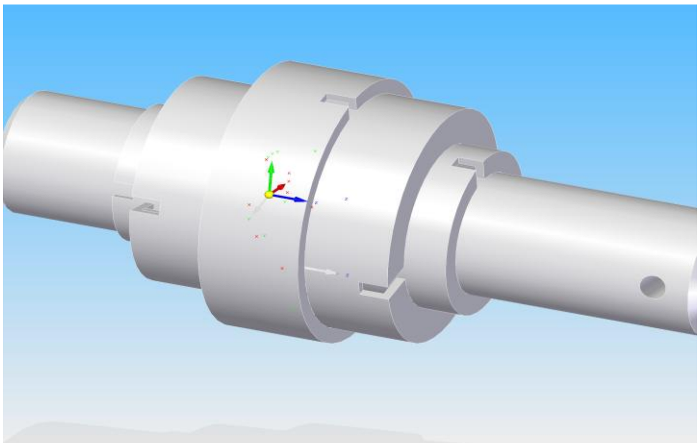


Figure 8. Computer model of the mechanical friction gear with two one in the other components

V. Conclusion

- Analogy between planetary and differential gear mechanisms enables segmentation of the resultant mechanisms and sample classification of a friction transmission.
- This will enable exact analysis, prompt calculation and correct application of the design/diagram/ friction gear used.
- This will enable proper and financially viable design of friction gears.
- Using computer modelling (Fig. 8 and Fig. 9), one can choose correct solutions, quickly and precisely, for experiments needed to arrive at a structural design that is most advantageous from the technical and engineering perspective.

Figure 9. Practical implementation of the model of Fig. 8

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