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ON VIRTUAL MODELLING OF A TRANSVERSAL COUPLING WITH LINKAGES

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***Abstract*—** Mechanical structures virtual modeling, as multibody systems with a minimal bodies number, in the real time simulation of product dynamic behavior, is a necessity. For a company, it saves time in product developing, reduces the number of physical prototypes and experiments, reduces the prices of product and increases the new developed product quality. In the paper there are presented some aspects regarding the modeling of a transversal coupling with linkages, as multibody system, using ADAMS. In the paper first part, there is presented the coupling, parts, geometry and virtual modeling. Then are defined the geometrical and kinematical restrictions between the coupling model parts. In the paper second part, there are presented aspects about the simulation and the results. In the paper final part, there are presented the conclusion.

***Keywords*—** Transversal coupling, linkages, parallelogram contour, multibody system, geometrical and kinematical constraints, virtual modeling, simulation.

I. INTRODUCTION

THE paper presents the virtual modeling and the kinematic simulation of a mobile transversal coupling with linkages, as multibody system, to obtain the relative motions in joints, using ADAMS. The relative motion in joints is useful in further design of the coupling.

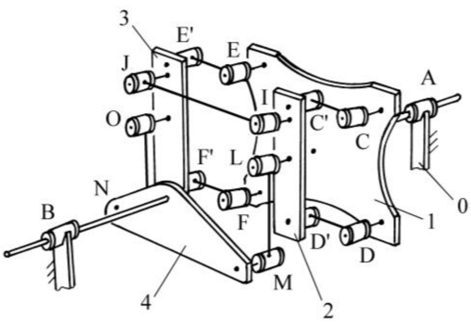


Fig. 1. Transversal mobile coupling structural scheme and the associated mechanism

The studied transversal coupling (Fig. 1) is a new structural solution, developed by authors in previous researches [4], to be used in movement and torque mechanical transmission, between two shafts with parallel axis [1], [5], [6], [9].

The shafts are connected by a kinematical linkage with the possibility to have translations in the transversal plane. These translations are named transversal movements. If the shafts are connected with joints to the basis, it will result the associated mechanism, which is a plane mechanism, see also Fig. 1 [1], [2], [7].

The most simple known linkages that may realise a translation between two elements (1 and 4, in Fig. 2, with the links 2 and 3) are the parallelogram linkage contour (Fig. 2, a,) and, also, the anti-parallelogram linkage contour [1], [2], [4].

For transversal couplings, is preferable to use the parallelogram linkage contours, which led to homo-kinetic couplings [1], [2].

The anti-parallelogram linkage contours are quasi homo-kinetic (in Fig. 2, b, for element 4 it appears the supplementary angle Δβ) and could led to quasi homo-kinetic couplings [1], [2]. The presented coupling has only parallelogram linkage contours.

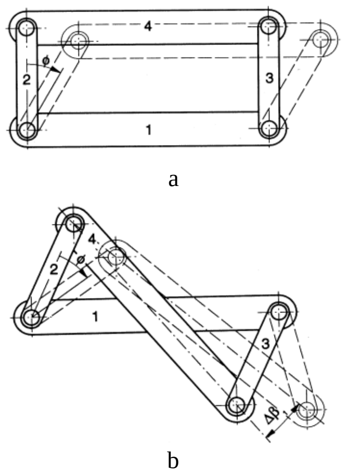


Fig. 2. Parallelogram and anti-parallelogram linkage contours

II. Parts Modelling

The coupling model main parts are (see also Fig.1): the semicouplings 1 and 4, the intermediary elements 2 and 3 and the links. As secondary parts, the coupling model contain also the spring rings. For the virtual model, all the parts are considered as rigid bodies, with masis and inertial properties. Each semicoupling and the intermediary element result as composite solids after few boolean operations with simple solids (Fig. 3, a, b, c). The same procedure will have as result the spring rings (Fig. 3, e). The model links will result after some simple boolean operations with solids, as links and cylinders (Fig. 3, d).

For all the mobile bodies, the soft calculating the masis, the inertial tensor, and masis center position.

The fixed body (ground, 0), without mass properties, is also created by the soft.

For studied transversal coupling model, were chosen as main dimensional characteristics [3]:

1) input and output shaft diameter d = 32 mm;
2) the semi couplings diameter d_e = 60 mm;
3) diameter of the links bolts placement D = 100 mm;
4) semi couplings length l = 50 mm;
5) semi couplings flange exterior diameter D_e = 120 mm;
6) bolts diameter d_b = 8 mm;
7) flanges and intermediary element width g = 10 mm.

III. Restrictions Modelling

For the studied transversal coupling, all the joints are revolute joints. For each joint are detailed, in Table I, the adjacent bodies, the localisation and direction. Also, the spring rings are fixed on the each semicoupling bolts using the fixed joints. The model construction was made considering the transversal eccentricity e=0. But, as in reality, the model has to support some different values of the eccentricity. For this, the virtual model contain a supplementary body (cylinder). This cylinder has a revolute joint with the output semicoupling (B) and a translational joint with the basis (B').

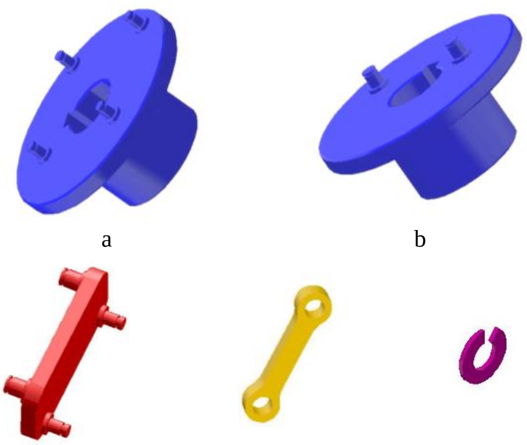


Fig. 3. Model parts

TABLE I
Joints Details.

Joint	Adjacent body	Localization	Direction
A	Semi coupling 1 + basis	Semi coupling axis	// z
B	Semi coupling 2 + supplementary cylinder	Semi coupling axis	// z
C, D, E, F	Semi coupling 1 + links	Links anchorage points	// z
C',D' E',F'	Links + intermediary element	Links anchorage points	// z
I, J	Intermediary element + intermediary element	Link anchorage points	// z
L, O	Intermediary elements + links	Links anchorage points	// z
M, N	Links + semi coupling 2	Links anchorage points	// z
B'	Supplementary cylinder + basis	Cylinder center	// y

The complete model of the coupling is presented, in Fig. 4, a, as opened view and, in Fig. 4, b, assembled.

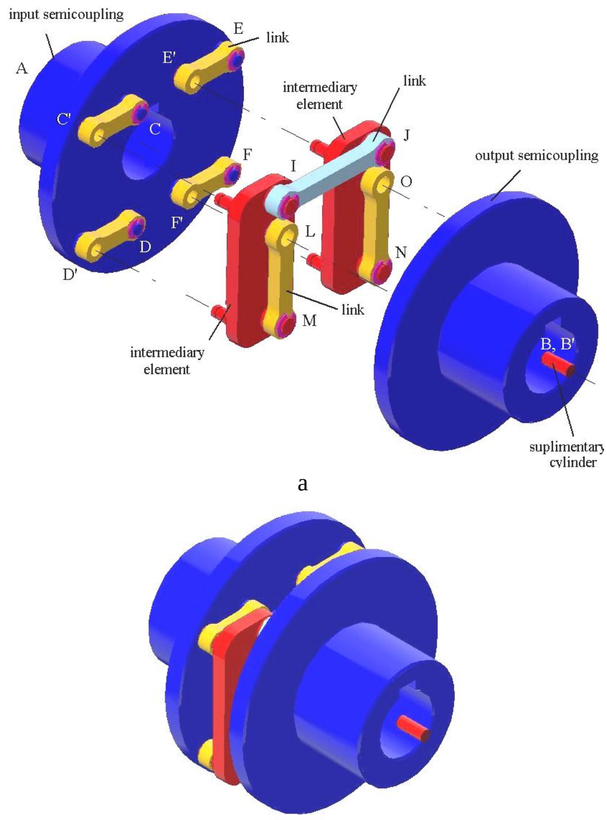


Fig. 4. Coupling virtual model

As kinematic restrictions, the model has two motions, as follows:

– at the input semicoupling, a rotation motion, given by relation

$$\varphi_1 = \omega \mathbf{t}, \tag{1}$$

where, for the studied case, ω=30 degree/s was considered;

– a translational motion between the supplementary cylinder and the basis; this motion may have different constant values, corresponding with the considered eccentricity values.

IV. Simulation and Results

After the virtual model construction, is necessary to check the model, to identify possible errors that occurred: invalid joints, duplicates, redundant constraints. The degree of freedom (DOF) is calculated by the soft using the Gruebler relation

$$\mathbf{DOF} = \mathbf{6n} - \mathbf{r}, \tag{2}$$

where, n represent the number of the mobile bodies, and r is the number of the restrictions [3], [8], [9], [10].

If there are some redundant restrictions, there are automatically deleted by the software. For complicated virtual models, these redundant restrictions is useful to be eliminated by the user, for a correct results interpretation.

The model will be simulated for different values of eccentricity, from minimum eccentricity value, e = 0 mm, to the maximum eccentricity value for the studied model, e = 17 mm. The step size for eccentricity values is 1 mm.

After simulation, the angular velocity variation diagram in joints A, for input semicoupling, and respectively B, for output semicoupling, is presented in Fig. 5. In this diagram, the angular velocity variations are the same for both semicouplings, so, for the studied coupling, the model is homokinetic (the condition is $\varphi_1 = \varphi_4$, as is detailed in [1], [2], [4]).

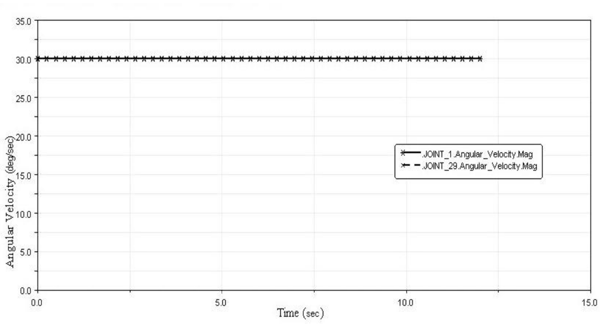
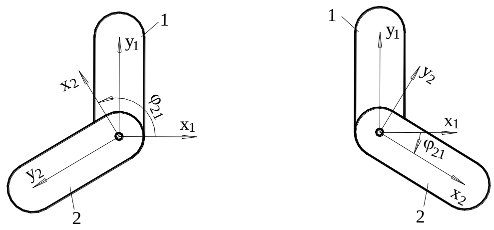


Fig. 5. Angular velocity in joints A and B

Other results of the model simulation are also the relative motion variations in each joint, depending of the values of eccentricity e, between the semicouplings, for one complete rotation.

In ADAMS, the relative motion in a revolute joint (in fact a relative rotation angle) is measured as the relative rotation angle between two markers attached to the joint adjacent elements, as is presented in Fig. 6. If the rotation angle is trigonometric measured, its value is positive (Fig. 6, a); otherwise, the value is negative (Fig. 6, b) [3], [10].



a. b.

Fig. 6. Joint relative rotation angle measurement

In Fig. 7...11 are presented the relative motion variation diagrams for each coupling rotation joint, for eccentricity values starting at minimum value, e = 0 mm, with the eccentricity step size 1 mm, to the maximum value of the eccentricity for the studied model, e = 17 mm.

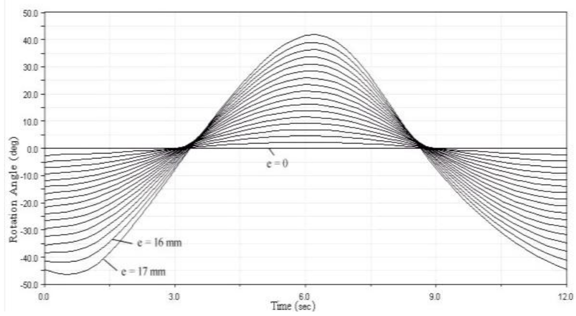


Fig. 7. Relative motion in joints C, D, E, F

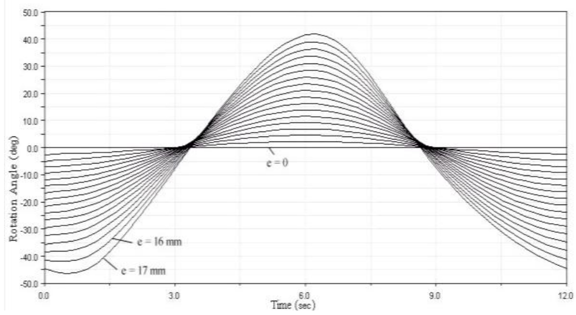


Fig. 8. Relative motion in joints C’, D’, E’, F’

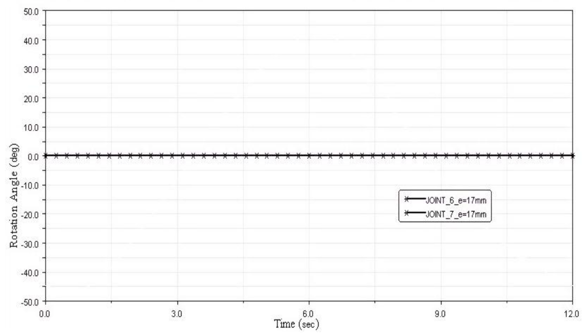


Fig. 9. Relative motion in joint I, J

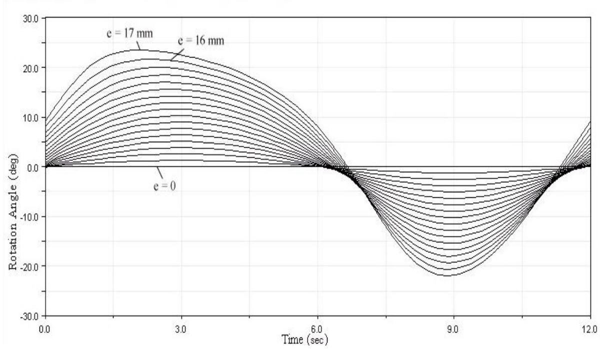


Fig. 10. Relative motion in joints L, O

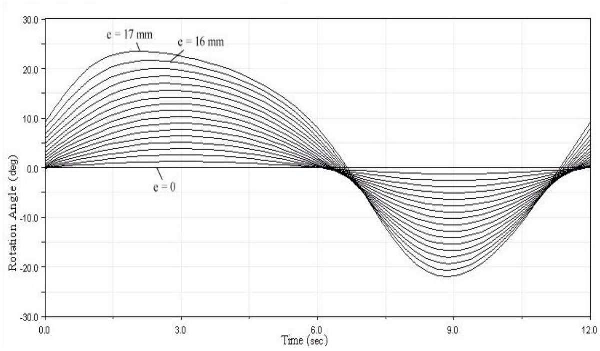


Fig. 11. Relative motion in joints M, N

V. CONCLUSION

Following the virtual model simulation and diagrams drawing, can be concluded that, if the coupling eccentricity e = 0, the relative motion in joints is also zero. The joints relative motion increase with the values of eccentricity, and is maximum for the maximum value of the eccentricity for the studied model, e = 17 mm. Over this value of the maximum eccentricity, the coupling will block itself.

The diagrams, from Fig. 7 and 8, corresponding to the joints C, D, E, F, and, respectively C', D', E', F' are the same variation, because the links between the bodies are placed as parallelogram configurations, with the same dimensions.

In the diagram from Fig. 9, corresponding to the joints I and J, is presented a particular situation, where, for different eccentricity values, the relative motion is zero, because all the corresponding links between the bodies are placed as parallelogram configurations. But, in the real case, in these joints could appear some relative motion, because of the real imperfections caused by the coupling manufacturing. In this case, to simplify the coupling construction, the adjacent intermediary elements and the link can be replaced with an equivalent elastic intermediary element.

The diagrams, from Fig. 10 and 11, corresponding to the joints L and O, respectively M and N have similar variation, because of the links parallelogram configurations between the bodies, also with the same dimensions.

Generally, the presented diagrams are useful for choosing of the coupling design different construction variants. So, for reduced relative motion in joints during the functioning, the elements and links can be replaced with a simplified elastic intermediary element with optimal design; if the joints relative motion is high, to avoid coupling parts wear, in the joints can be placed different types of bearings, to replace the sliding friction with rolling friction.

As future researches, the coupling virtual model is useful also for FEM analysis.

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