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A Software Model Proposed for the Contact Stress Calculation of Xylan 1052-coated Toothed Wheels

We are proposing a software simulation model that could be used for the contact stress determination in the case of a new type of Xylan 1052-coated cylindrical toothed wheel gearing. It shows the contact stress distribution and displacements into the Xylan 1052 fluoropolymer coating that was applied to the surfaces of tooth flank. It represents a necessity due to the fact that, as it's well known, the strength of plastic material is much less than the strength of steel material.

***Keywords**: contact stress, displacement, simulation model*

1. Introduction

In the last period on the software products market they have appeared a lot of programs generally and/or precisely dedicated to mechanical calculation.

Thus it can be identify one or two programs to implement an adequate simulation model. For the results accuracy improving, it is better if we chose to compare achieved results from at least two or three different experiments.

The program producers ensure the users about the accuracy and correctness of the results, so much time that the implementing of simulation model is doing with the strictly following of the program requires.

In Kissoft can be easily realize the gear components, the toothed wheels, in the case of right selection of the available standards the program corrects promptly and accurately any mistake.

In SolidWorks and ANSIS can be simulated the gearing of wheels after importing them from Kissoft or drawing them on the SolidWorks or ANSIS own platforms.

At this stage we appeal at SolidWorks, witch offer us the possibility to draw and simulate enough easily parts or the entirely gear order to achieve fast and accurate results by the finite element analysis.

So far have been simulated a pair of toothed wheels film coated with additional material having approximately features as the fluoropolymeric Xylan 1052.

For a correct simulation is necessary to get some features of material, such as: coefficient of elasticity, coefficient of friction, tensile strength etc.
The tests will be carried out on a small number of body parts, but with different loads and displacements.

2. The initial data for drawing and simulating.

Two wheels were built-up with the following geometrical dimensions. The reference profile / tolerance according to Din 967 / DIN 3967 – 25 CD

Characteristics	Pinion	Driven Wheel
Pressure angle (α)	20^o	20^o
Helix angle (β)	9^o	9^o
Centre distance (a)	125 (mm)	125 (mm)
Normal module (m_n)	4 (mm)	4 (mm)
Frontal module (m_t)	4.05 (mm)	4.05 (mm)
Tooth number ($z_{1/2}$)	17	43
Tip diameters ($d_{a\ 1/2}$)	80.04	185.28 (mm)
Pitch diameters ($d_{1/2}$)	68.85 (mm)	174.14 (mm)
Root diameters ($d_{f\ 1/2}$)	61.73 (mm)	166.9 (mm)
Base diameters ($d_{b\ 1/2}$)	64.601 (mm)	163.402 (mm)
Tooth heights ($h_{1/2}$)	9.156 (mm)	9.19 (mm)
Tip/root tooth heights ($h_{a\ 1/2}$ / $h_{f\ 1/2}$)	5.6 / 3.56 (mm)	5.57 / 3.62 (mm)
Tooth heights on cord ($h_{ny\ 1/2}$)	5.808 (mm)	5.649 (mm)
Tooth thickness on cord ($s_{ny\ 1/2}$)	7.679 (mm)	7.668 (mm)
Gear backlash ($j_{t\ 1/2}$)	0.15 / 0.27 (mm)	0.15 / 0.27 (mm)

The quality features according to DIN 3961-63 quality 8.

This pair of Teflon-coated wheels exists and it is currently mounted into a test gearbox on to the bench test.

The necessary features, to define the fluoropolymeric material mechanical properties, were considered by approximation because there are no precise data for now.

The producer given to us few properties for Xylan 1052-coating witch will be used for define the material. Admissible contact stress is about 343 (N/mm^2) and coefficient of friction 0,2. All the rest necessary mechanical and physical properties were taken with from other modified PTFEs.

Drawing in SolidWorks is not so difficult due to the easy access menu. A not so complicate part can be achieved in short time.

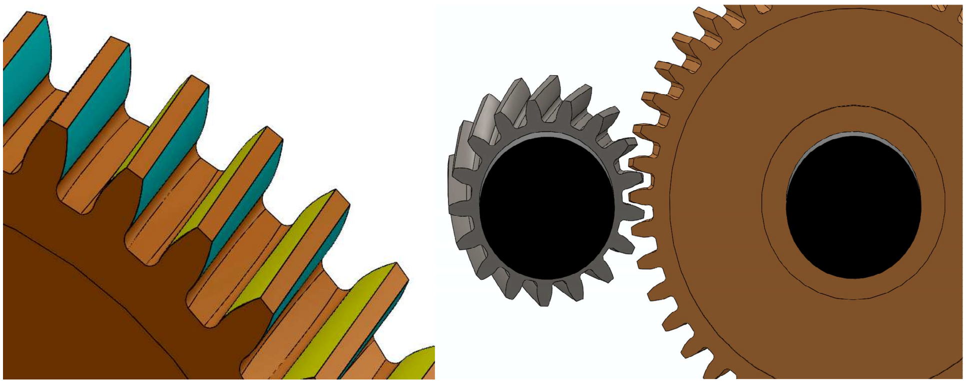

Figure 1. Xylan 1052 film applied on to the teeth flanks (left), gearing between pinion and driven wheel (right).

Figure 1 represents the gearing between two toothed wheels described geometrically above. In the right side, on the tooth flanks of driven wheel are applied layers from Xylan 1052 different colored for each flank of the tooth.

3. Study properties.

Beginning with the name of study, we shall continue establishing, the type of analysis, mesh type, solver type, thermal effect, units, friction and doing active ignore clearance for surface contact.

Applying typical or advanced restraints we will define the degree of freedom for each parts and entire assemble, as well.

The nature of connection between bodies is very important, there are define some typical contacts and also is available the possibility to define advanced contacts.

Also, if it is necessary, a part can be considered as rigid – nondeformable.

In our case the contact stress and displacement is requested only for Xylan 1052-coating. So, it is easier to adopt other parts as rigid.

4. Mesh Information

For meshing we need to define: mesh type, mesher used, surface type, jacobian check point, tolerance and quality.

Once the mesh is done, we can proceed to run simulation. In this case, meshing the Xylan 1052 film was difficult due to its small thickness, it is practically invisible.

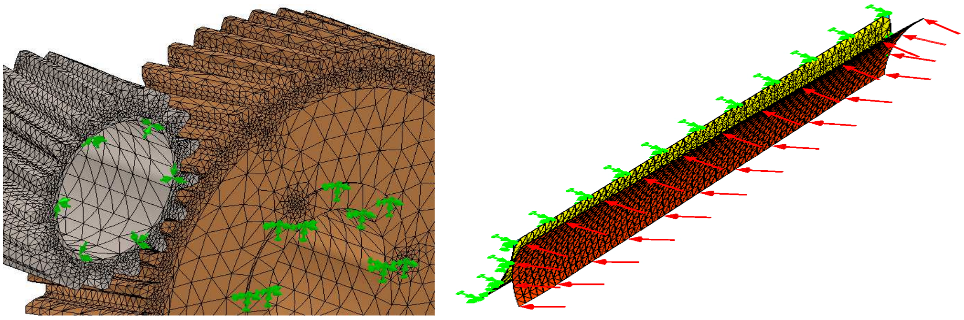

Figure 2. Gearing (left) and homologous flanks (right) meshing.

In that case we considered three steps for simulation.

In the beginning, we adopted a sphere sector, normally pushed on the surface of Xylan film, having a pressure type load added to the flat face. The pressure value was chose in order to have the requested pressure at contact and find-out the displacement.

For the second step, it was checked the ideal contact surface between two homologous flanks, considering two cylinders having the radius equal with the minimum curvature radius of tooth involute. In order to make evident the difference between static and dynamic simulation, they both had been done.

The contact surface of helical wheels is different than the contact surface between cylindrical faces. Therefore, we cut-out two homologous flanks of small thickness for study.

5. Study Results

In the following some of the results obtained by simulation in SolidWorks will be presented.

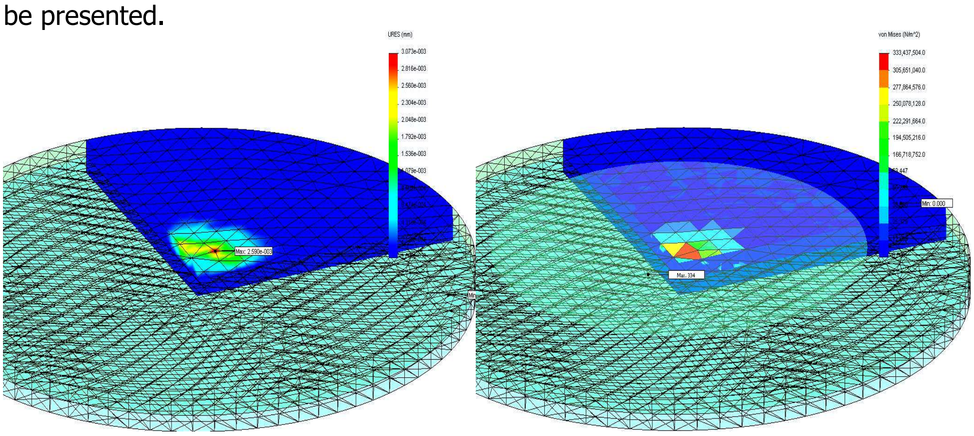

Figure 4. Static determination of contact stress (right) and displacement (left).

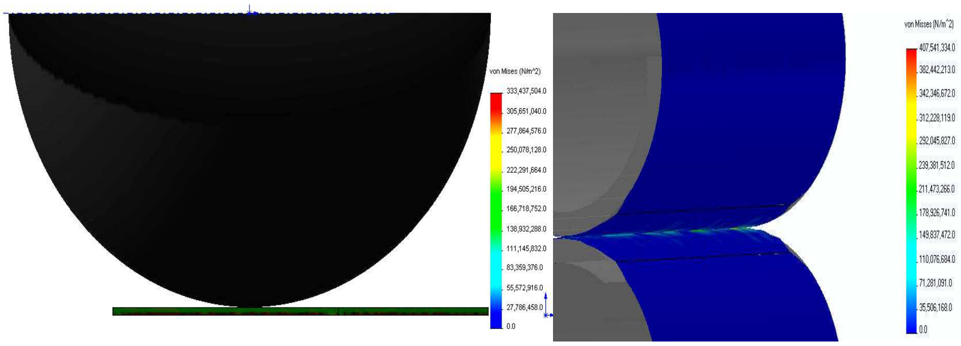

Figure 5. Contact stress evolution for the step one and two.

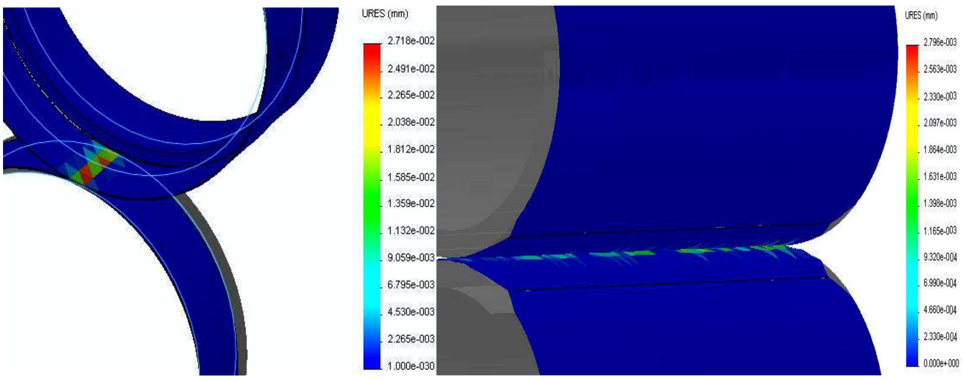

Figure 6. Static (left) and dynamic (right) displacement.

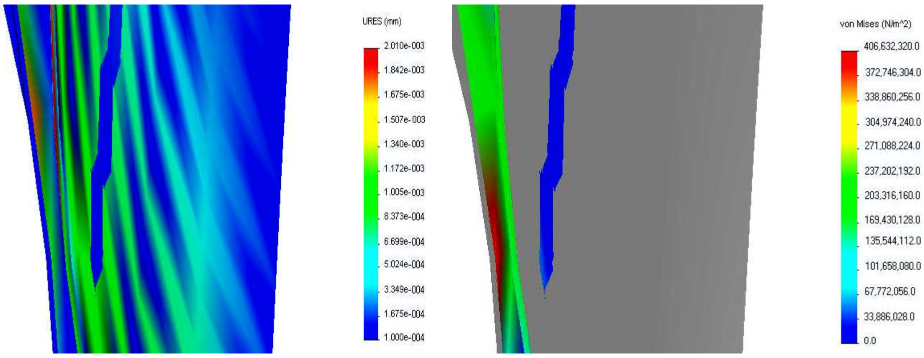

Figure 7. Dynamic contact stress (right) and displacement (left) between two homologous flanks.

They are visible some differences between static and dynamic simulation. Also, it is easy to see the contact stress and displacement differences, related to the both, cylindrical and involute profile.

6. Conclusion.

Validation of simulation model will be made by comparing the results obtained by practice experimentation on to the bench test with.

Once validated, the software model will become easy to use, for all those who would like to test the Teflon-coated toothed wheels, and the simulation limit can be expanded. Numerical simulation, by finite elements, is preferred towards, the practical simulation, thanks to its lower costs and short time for carrying out the experiments.

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