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WINDSHIELD WIPER MECHANISM DYNAMIC SIMULATION IN AUTOMOTIVES

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ABSTRACT: For monospaced automotives (MPV), windshield surface is large, which requires that for a good visibility, the "cleaned" windshield surface to be as large as possible, meaning the driven components trajectory (windscreen wiper arms) of the wiper mechanism to be well adapted to the windscreen surface. This paper presents component and functioning of the windshield wiper on Renault Scenic automotive. Analysis and dynamic simulation was achieved in 3D Autodesk Inventor Professional modeling and design, considering that the mechanism is a multibody system (mbs). At the same time it was made finite element method analysis to the mechanism main rod, by isolating her from the rest of the mechanism in a moment of time where the loading mechanism is maxim.
KEYWORDS: windshield wiper, mechanism, dynamic simulation, connecting road

INTRODUCTION

For monospaced automotives (MPV), windshield surface is large ($\approx$ 1,4 m^2), which requires that for a good visibility, the "cleaned" windshield surface to be as large as possible, meaning the driven components trajectory (windscreen wiper arms) of the wiper mechanism to be well adapted to the windscreen surface.

Windshield wiper mechanism arrangement from road vehicles is shown in figure 1.

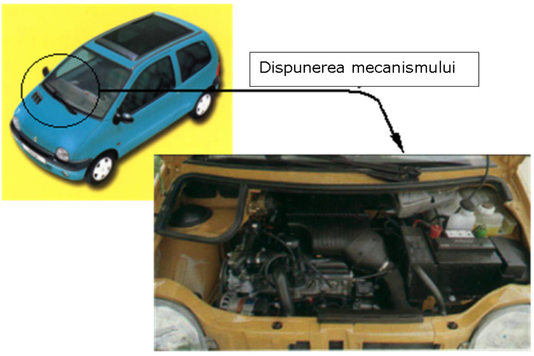


Figure 1. Windshield wiper mechanism arrangement

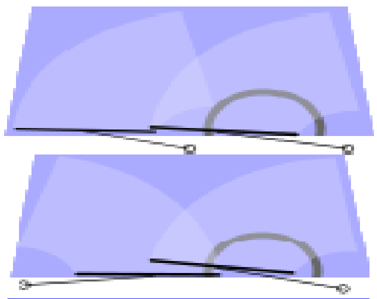


Figure 2. Constructive solutions to the windshield wiper mechanisms

In practice there are a wide variety of constructive solutions for windshield wiper mechanisms on road vehicles, the most common being based on articulated parallelogram or anti articulated parallelogram mechanisms as shown in figure 2.

Windshield wiper mechanism studied (from road vehicles Renault Scenic type), modeled 3D using Autodesk Inventor Professional is presented in figure 3. Move and power transmission kinematic chain consists of three parts:

a. - Primary transmission: It consists of crank drive, primary rod and crank element. Wiper arm from the driver is completely bound by the crank element. Primary transmission is similar to a connecting rod-crank mechanism and transforms gearbox output shaft continuous rotation motion in crank element alternative (oscillating) rotation motion, necessary for wiper arms go-back motion.
b. - Intermediary transmission: This element sends crank element motion to passenger windshield wiper arm. Her parts are: secondary rod and intermediary hand crank.
c. - Secondary transmission: This transmission move passenger windshield wiper arm. It is an articulated quadrilateral mechanism, who its parts are: tubular frame, secondary leverage, crane „passenger" fixed on passenger windshield wiper and primary leverage (into fixed bond with axis and intermediary hand crank).

WINDSHIELD WIPER MECHANISM DYNAMIC SIMULATION AND ANALYSIS CONSIDERING THAT THE MECHANISM IS A MULTIBODY SYSTEM

Windshield wiper from Renault Scenic road vehicle (figure 3) may be considered articulated quadrilateral mechanism, in witch crank drive rotational motion is transmitted through the three transmissions on two windshields wipers considered cross beam kinematic elements.

For analysis and dynamic simulation that took into account a simplified geometric model of the mechanism (figure 4), type crank handle-beam, 3D parametric modeled in Autodesk Inventor by applying properly assembly constraints.

Kinematic couplers of the kinematic model studied are modeled by automatic conversion of the assembly constraints (considering that they were geometrically defined correctly). All mechanism kinematic couplers are rotation V class, for example is the link conversion between crank handle 2 and the frame (exit from speed reducer), as shown in figure 5.

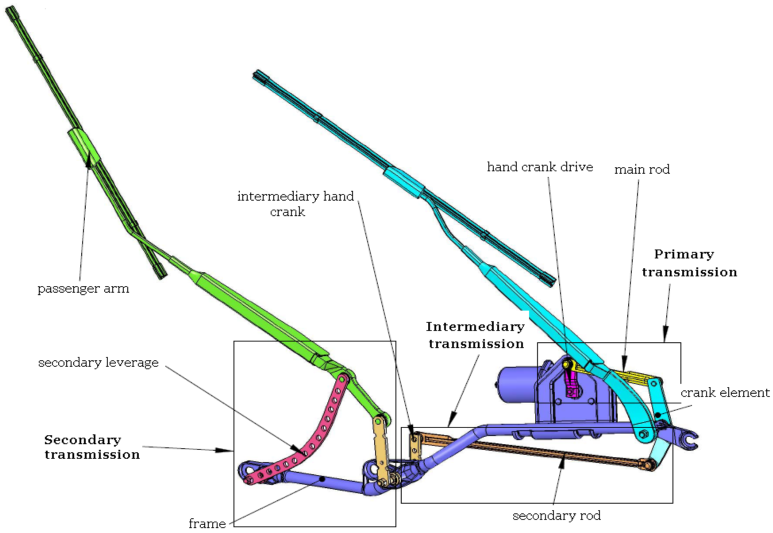


Figure 3. Mechanism part

Mechanism drive motion is defined in kinematic couple between motional crank handle-frame, such a rotational motion with constant speed, as shown in figure 6.

Figure 4. Windshield wipes mechanism with two arms

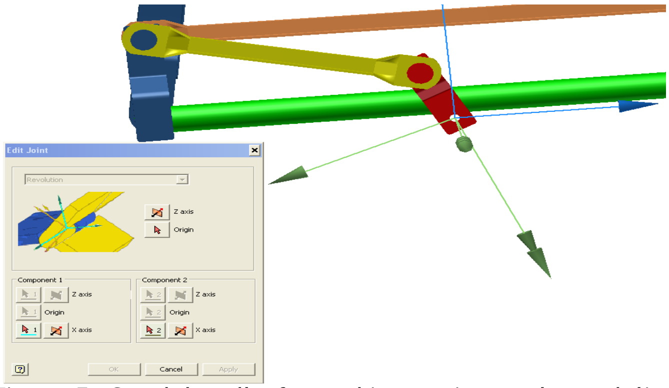


Figure 5. Crank handle-frame kinematic couple modeling

External loads consist of pressure force on the windshield wiper blade on the windscreen surface defined in figure 7, and the friction force between the wiper blade and windshield area defined in figure 8. Because changing the direction of motion friction force is not defined as a constant, but is defined as a variable determined by a curve in this meaning.

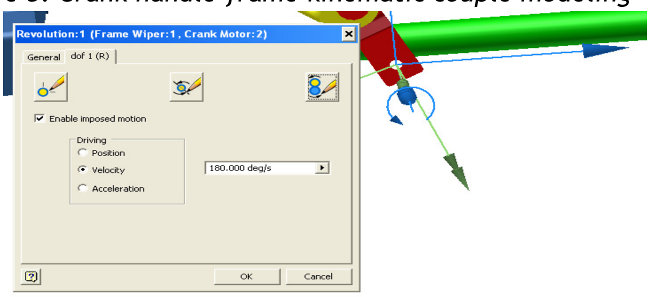


Figure 6. Motion engage defining

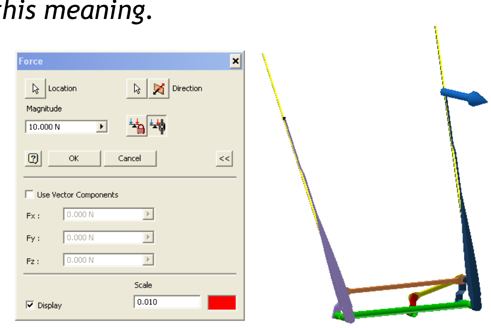


Figure 7. External loads

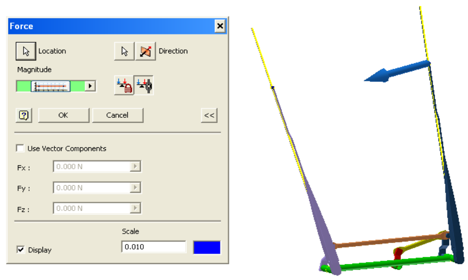
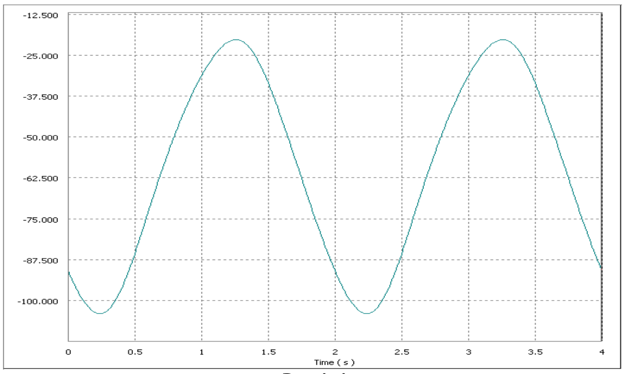
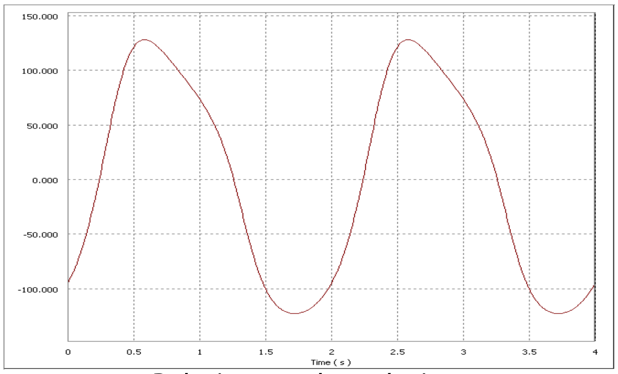


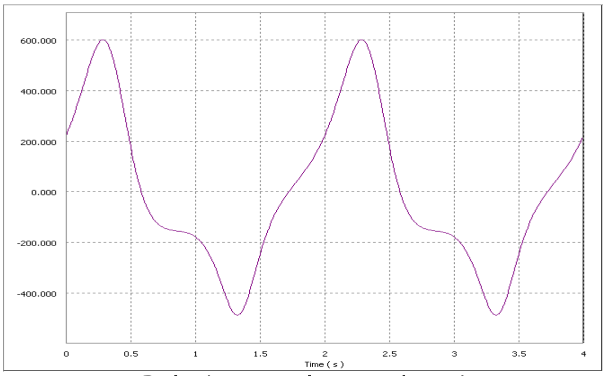
Figure 8. The friction force



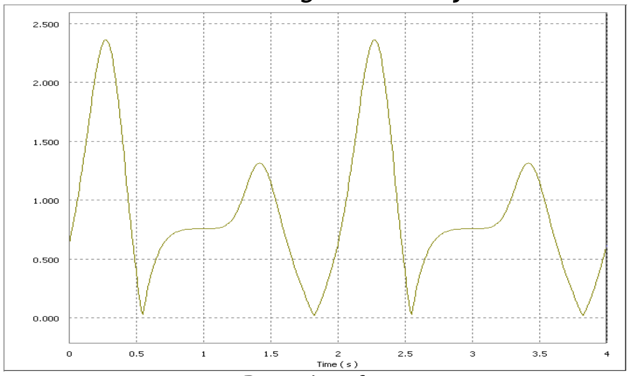
Position



Relative angular velocity



Relative angular acceleration



Reaction force

Figure 9. Graphics kinematic and kinetostatic quantities variation

Kinematic model processing was performed using Dynamic Simulation Module (Autodesk Inventor), which formulates itself and solve kinematic equations of motion (geometric constrained analytical equations and kinematic constrained equation). Kinematic analysis parameters includes: analyze type, duration, number of steps which is divided the length of time respectively tolerances for solving the equations.

After model analyzing (processing) is determined windshield wiper mechanism kinematic behavior, whose evaluation is performed in the next step post-processing (processing) of results. This consists of drawing the variation diagrams versus time or another parameter, for kinematic quantities of interest (positions, velocities, and accelerations), virtual model graphic animation, results reports.

In figure 9 is presented as graphics kinematic and kinetostatic quantities variation (position, angular velocity and relative angular acceleration respectively reaction force) corresponding coupling between group of training arm - rubber blade support 2 and mechanism connecting rod.

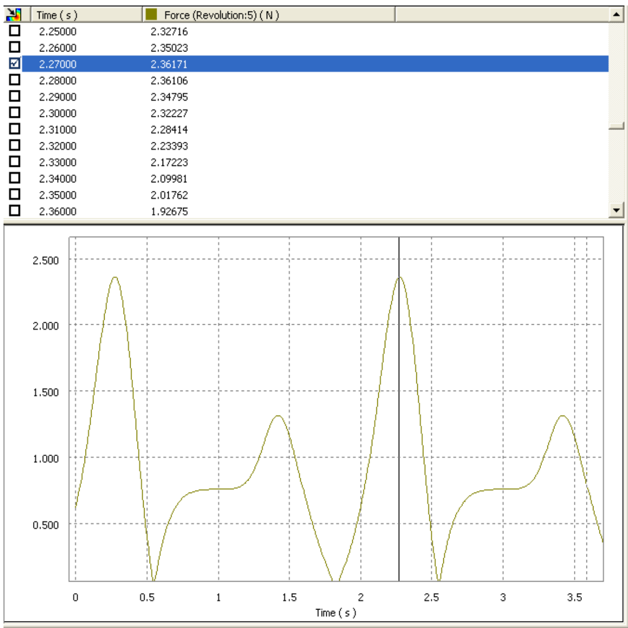
Windshield wiper mechanism finite element analysis

Because the windshield wiper mechanism analysis (dynamic simulation) was made with Autodesk Inventor Professional program, finite element analysis has been made with the same program, with Dynamic simulation and Stress analysis modules. The advantage of this option compared to using other softwares, is the existence of the geometric mechanism model, respectively constraints (kinematic couplings) and external loads, as well as kinematic and kinetostatic results, on which (maximum values at some moment on kinematic cycle) can be analyzed by finite element method.

For finite element analysis was chosen connecting rod element at the kinematic cycle time step t=2,36s, where according to the graphics from figure 10 reaction force from one of the connecting rod couplings is maximum.

Next, finite element analysis is performed by following the next steps:

- ☐ *Connecting rod element isolation (figure 11).*
- ☐ *Kinematic couplings identification, by which connecting rod is connected to the rest of*



Time (s)	Force (Revolution:5) (N)
2.25000	2.32716
2.26000	2.35023
2.27000	2.36171
2.28000	2.36106
2.29000	2.34795
2.30000	2.32227
2.31000	2.28414
2.32000	2.23393
2.33000	2.17223
2.34000	2.09981
2.35000	2.01762
2.36000	1.92675

Figure 10. Choosing the time step for analysis

the mechanism (figure 12).

- *Choosing how to perform the analysis - by taking kinematic and kinetostatic quantities defined on dynamic simulation, Motion Load option, in this case no need to redefine them.*
- *Defining the mechanism elements materials.*
- *Finite element analyze run (simulation).*
- *Analyze report generation.*

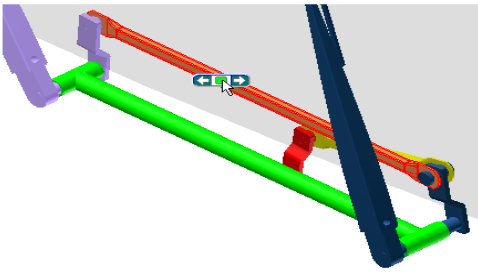


Figure 11. Connecting rod element isolation

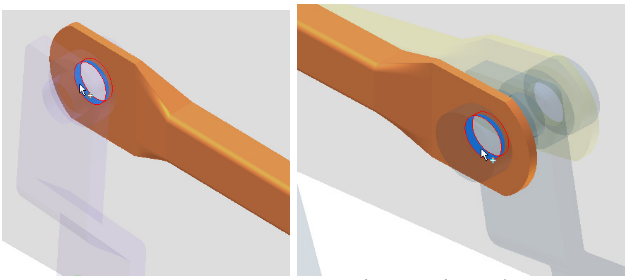


Figure 12. Kinematic couplings identification

Analyze report contains some information on the obtained results in table form (minimum and maximum values) of different quantities, or graphical form. For example, in figure 13 is shown the Von Misses stress distribution in the main connecting rod, for the chosen time moment.

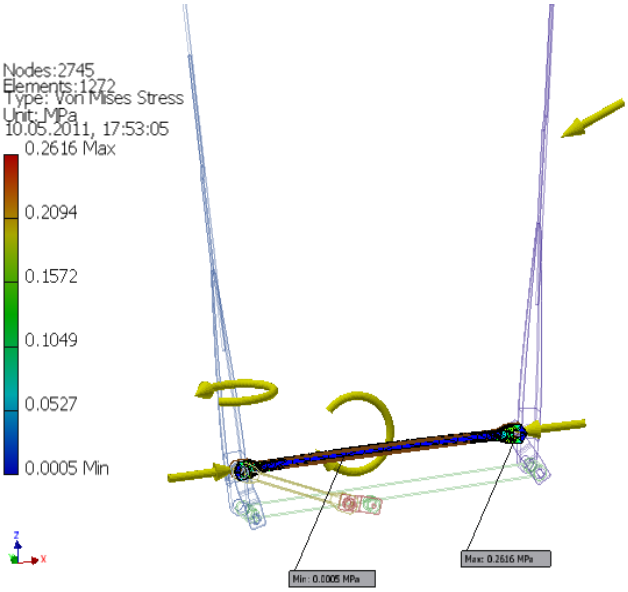


Figure 13. Stress distribution in the main connecting rod

CONCLUSIONS

Windshield wiper analyze and dynamic simulation, considered multibody system using a specialized software (Autodesk Inventor Professional) allows to obtain kinematic and kinetostatic quantities numerical or graphical form corresponding to the elements and kinematic couplers in any time moment on kinematic cycle. Also it can observe mechanism behavior by its movement simulation during kinematic cycle.

After mechanism dynamic analysis, by taking the quantities corresponding movement, respectively external loads, it can made finite element analysis, separately for each kinematic element, analysis that is useful to shape design and dimensioning these.

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