Self-Contact with Update of Wire Harness

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Summary:

Contact analysis is used as standard in structural analysis with finite elements. The correct load path between components of a group of components via contact has led to significantly improved predictability of the simulations. But, the demands on contact analysis are steadily increasing. Nowadays simulation software must not only meet short computing times and high accuracy, but also large relative movements of the contact partners, geometric non-linear behavior of the components and changing contact partners. Despite the increasing complexity, however, the definition of contact areas and properties should remain as simple as possible. A simple general definition and the efficient calculation execution seem to contradict each other in the objective.

By combining new high-performance contact solution algorithms with efficient definition methods, PERMAS fulfills all requirements for modern simulation software for contact analysis. It could be prevented multiple definitions by the cross-component use of self-contact, resulting in a convenient solution. Despite the simplicity of the contact definition, even contact pairings that are not apparent in the initial configuration are safely found and taken into account. Large relative movements and large rotations are additionally taken into account.

Keywords:

Self-Contact, Contact Update, Contact Analysis, Large Rotations, Wire Harness, Non-linear, Large Relative Movements, Changing Contact Partners

1 Introduction

Wire harness are standard components in cars. The focus of this investigation is on the wire harness connection inside a flexible bellow between the body of a car and the door. Opening and closing the door takes place very often during operating life of a car. So, wire break is a well-known failure of such a junction. Today this issue is enhanced by more cables for more functionality like heat able mirrors, electrical mirror adjustment, electrical fold in mirrors, window lifters, window lifters control, speaker, electrical seat adjustment and door lighting. For some of this functionalities in addition the required power followed by the corresponding cable diameter is growing.

To improve the mechanical behavior of the cable harness and bellow to prevent cable break findings of simulation are very important, because the equivalent long-time experiments are very expensive.

2 Wire Harness – Model Overview

The investigated wire harness model has 13 wires and one bellow. The upper ends of wires and bellow are fixed by a bracket. The lower ends of both describe a rotation of 70 degree that is given by the door, respectively the lower bracket. The rotation takes place around the red line in dotdash style (see Fig. 1). The movement is described by an MPC for the FE-analysis. The wires have three different diameter: 1.4mm, 1.8mm and 2.1mm. The inner diameter of the bellow is 16mm the outer is 24mm. The wires are modeled by solid elements, the bellow by shell elements with thickness of 1mm.

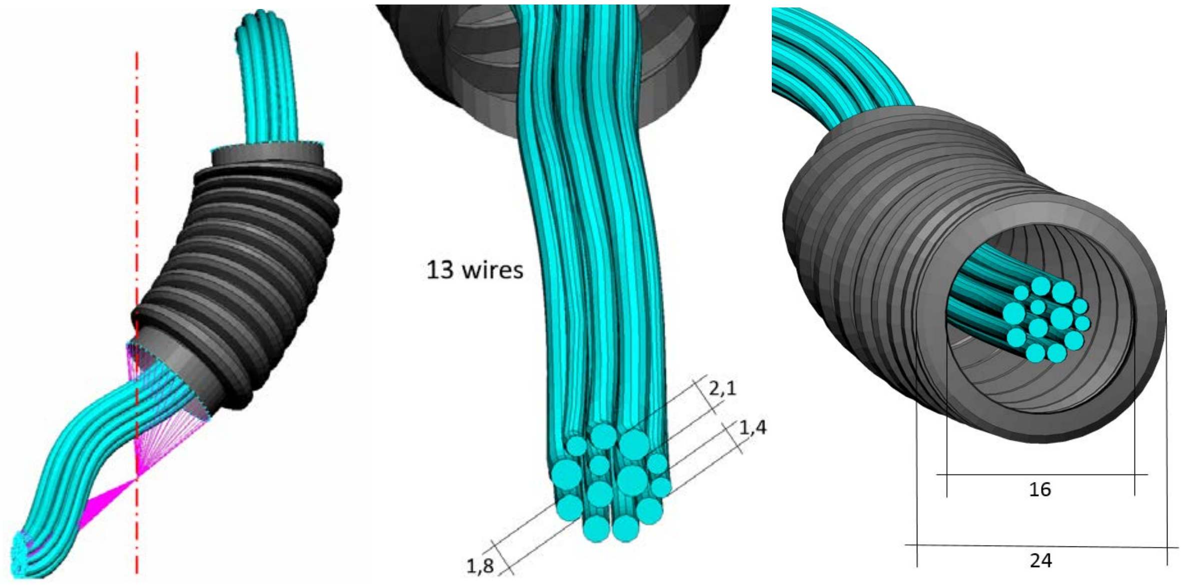

Fig. 1: Wire harness with bellow, axis of rotation, cable diameter, bellow diameter

All together the model consists of 34,134 nodes, 21,444 hexahedron elements and 3,690 square shell elements.

3 Contact Definition

Contact definition has several targets to hit. The physical contact properties, geometry, possible contact partner and partner search distances are the most important definitions. The geometry was changed by meshing from CAD geometry entities to element facets. For contact analysis the original geometry should be recycled as good as possible by smoothing technology. In left part of Fig. 2 a cut through the wires shows the facets of the finite elements. For contact analysis the smoothed surface is used as marked at one cable by a blue circle. At the bellow there are areas where the smoothing also should be used and edges, e.g. between the blue and gray areas, where the kinks should remain as kinks without smoothing.

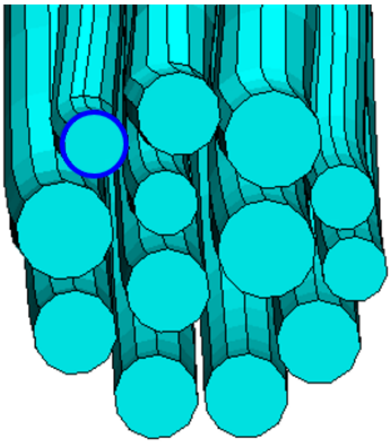

Fig. 2: Kinks from element facets, for contact original geometry should be recovered

Contact partner search distances have influence on the run time. Bigger distances lead to bigger search regions and longer run times. But the search distance must always be big enough to cover the relative movement of the contact partners in one step.

3.1 Self Contact

Classic contact definitions with two contact partners are for some configurations not convenient. The contact between the wires is such a configuration. Classic partner configuration requires many contact definitions to cover contact from each wire to every other wire. And all possible combinations are required, because the order of the wires may change during the rotation of the door. Much easier is one singele self-contact definition that contents all surfaces of all wires. Another advantage is, that double definitions are prevented by this strategy.

3.2 Contact Update

Since the cable configuration may change during the complete door opening, contact update is required. Contact update also cover changed contact partners and changed contact directions.

4 Contact Results

Pictures of results from processes show only a small part of the complete movements. Typically, only a movie can cover the complete results. For contact pressure results of several bodies, like in a wire harshness, additional visualization setting options are necessary, because the contact areas are inside and hide each other.

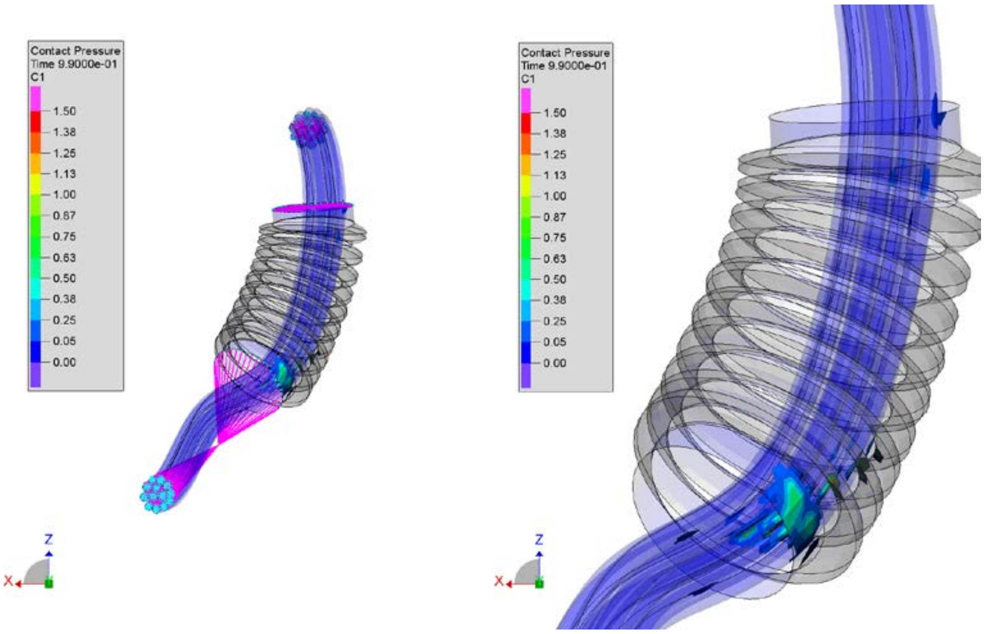

Fig. 3: Contact pressure at 70° door opening

The most important option is the transparency setting. This must be available for the visualization of the structure and for the result colors, too. Fig. 3 shows the contact pressure result with color table. Result colors are transparent under the level of 0.25. By this clever option it is possible to see high contact pressures directly, because other areas with low contact pressure do not hide them. Cumbersome hide and show of parts can be skipped, the important results are directly visible.

5 Conclusion

Implicit contact solution delivers today very accurate results. Those contact analysis methods are today capable of very complex analysis with many parts with changing contact partner. In addition, large geometric nonlinearities, like large translations and rotations are possible. By clever usage of the high-speed contact algorithms of PERMAS the runtime of those analysis is now acceptable for industrial usage. At the same time the accuracy fulfills the requirements from Industry, too.