CREATION AND EVALUATION OF PART ENVELOPES THROUGH AN AUTOMATED PROCESS

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(up to five)

ABSTRACT –
The creation of part envelopes is a common and useful study case for engineers. It lets them know the maximum volume that parts occupy during their movement. This paper focuses on the case of wheel envelopes during the kinematic movement of a suspension. The process is a combination of the Kinetics, Wrapping, Morphing and Scripting tools.

Through this process the user will create (load) a kinematic model of a suspension, define the Morphing boxes and parameters for the wheel and run the automation script. The script will move the suspension in various positions and save the wheel in every position. Then it will run the Wrapping tool that will provide the overall volume that the wheel occupies during its movement among all its positions and will apply a penetration check between the overall volume and the wheel arch. The script will continue with another loop, by parametrically increasing the width and/or the radius of the wheel. Finally, a report is given showing if any of the wheel sizes that have been checked interferes with the wheel arch.

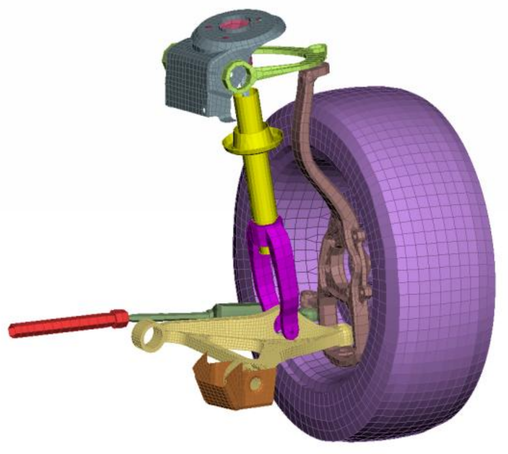
1. INTRODUCTION

The volume swept out by a part as it moves, represents the space that it occupies during its motion. This volume is also known as part envelope. Envelopes are often studied because of their importance during a CAD/CAE process. They let engineers know if a moving part interferes with any other objects as it moves which can be found very useful in case of kinematic simulations of mechanisms. Typical examples for the study of envelopes include the arms or parts of robotic mechanisms, the wheel of a moving suspension and many more. This paper demonstrates a simple process for the creation and study of wheel envelopes using the existing functionality and tools of ANSA.

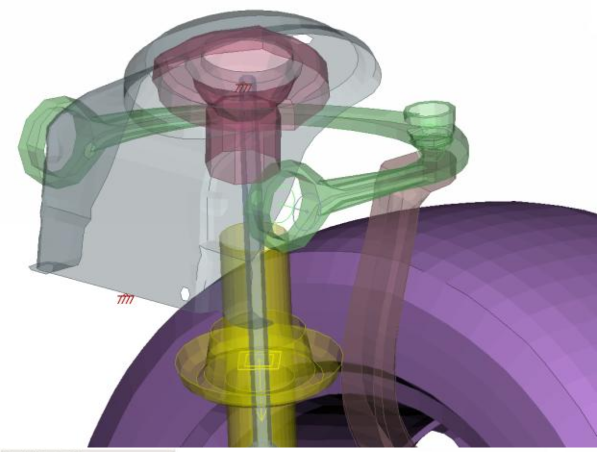
2. KINEMATIC SETUP OF THE SUSPENSION

As a first step of the process, the kinematic model of the suspension is created which allows any movements to be applied on it. The kinematic model is created

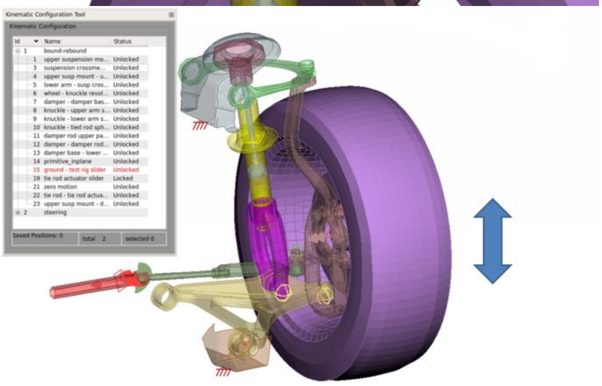
- by defining the kinematic rigid bodies of the suspension
- by defining the kinematic joints that interconnect the bodies together
- by defining the kinematic configurations that allow any movements to be applied to the suspension



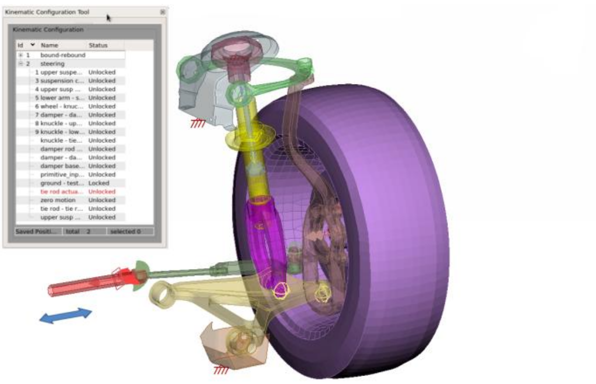
Each kinematic rigid body that is defined represents a specific part of the suspension and is shown in the picture with different colour.



Each joint that is defined allows specific movements between the two bodies that interconnects according to its type.



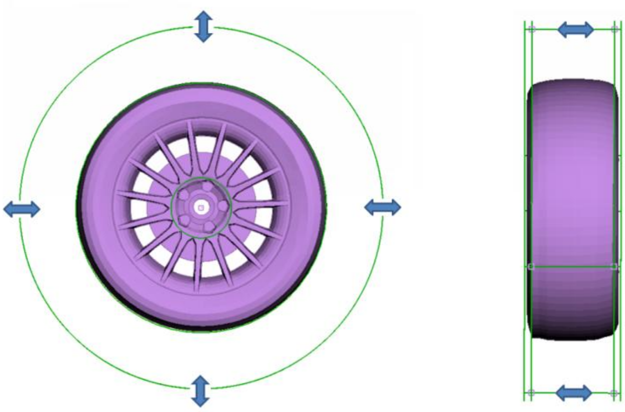
A kinematic configuration is defined from specific joints that the user selects. By articulating a configuration, the joints and the bodies that they refer will move accordingly. Two configurations are needed. One corresponds to the bound-rebound movements of the suspension.



The other one corresponds to the steering movements of the wheel.

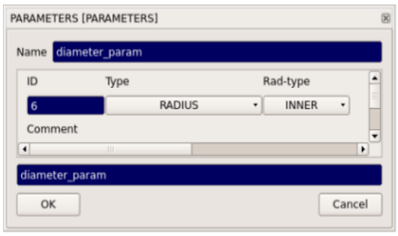
3. CREATION OF THE MORPHING BOXES OF THE WHEEL

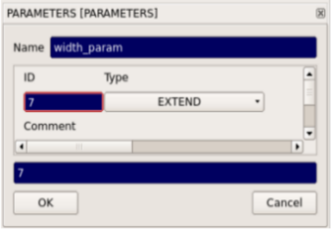
The second step of the process involves the creation of cylindrical morphing boxes around the wheel. These boxes will allow any modifications in the dimensions of the wheel. Additionally, with the aid of morphing parameters, the modifications can be applied parametrically.



A cylindrical morphing box is created around the wheel. The cylindrical morphing box will allow the modification of the diameter and the width of the wheel.

The initial diameter and width dimensions are 689mm and 215mm respectively.

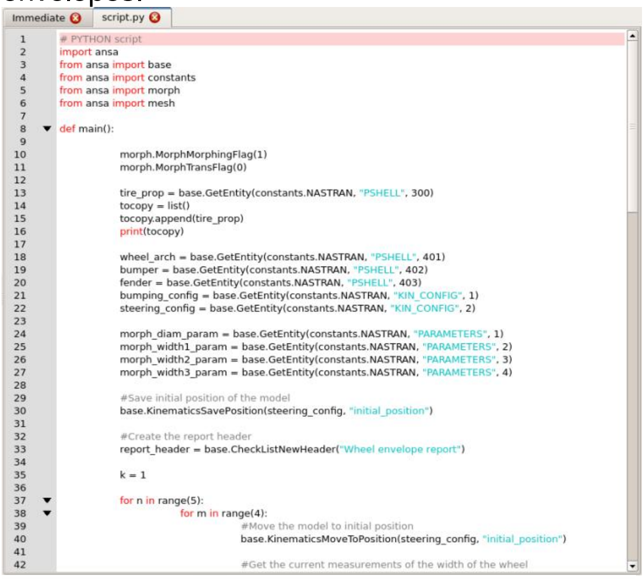




The morphing parameters are defined. One morphing parameter of type “RADIUS” will control the modification of the diameter of the wheel. Another parameter of type “EXTEND” will control the modification of the width of the wheel.

4. RUNNING THE AUTOMATION SCRIPT

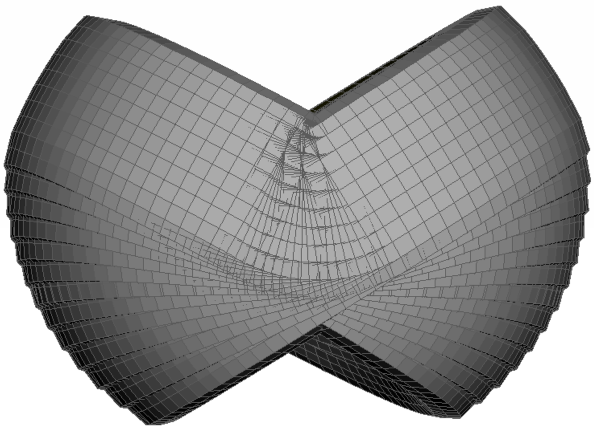
At this point no further interaction is needed from the user. The rest of the process is carried out by running an automation script that will create and evaluate the wheel envelopes.



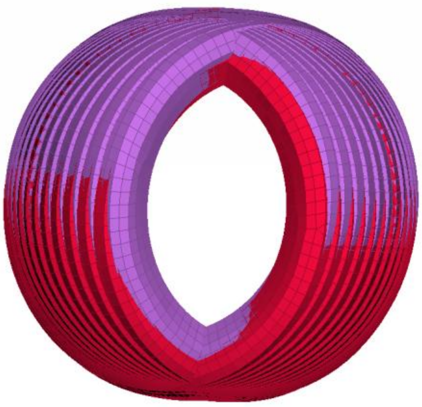
```
# PYTHON script
import ansa
from ansa import base
from ansa import constants
from ansa import morph
from ansa import mesh

def main():

        morph.MorphMorphingFlag(1)
        morph.MorphTransFlag(0)

        tire_prop = base.GetEntity(constants.NASTRAN, "PSHELL", 300)
        tocopy = list()
        tocopy.append(tire_prop)
        print(tocopy)

        wheel_arch = base.GetEntity(constants.NASTRAN, "PSHELL", 401)
        bumper = base.GetEntity(constants.NASTRAN, "PSHELL", 402)
        fender = base.GetEntity(constants.NASTRAN, "PSHELL", 403)
        bumping_config = base.GetEntity(constants.NASTRAN, "KIN_CONFIG", 1)
        steering_config = base.GetEntity(constants.NASTRAN, "KIN_CONFIG", 2)

        morph_diam_param = base.GetEntity(constants.NASTRAN, "PARAMETERS", 1)
        morph_width1_param = base.GetEntity(constants.NASTRAN, "PARAMETERS", 2)
        morph_width2_param = base.GetEntity(constants.NASTRAN, "PARAMETERS", 3)
        morph_width3_param = base.GetEntity(constants.NASTRAN, "PARAMETERS", 4)

        #Save initial position of the model
        base.KinematicsSavePosition(steering_config, "initial_position")

        #Create the report header
        report_header = base.CheckListNewHeader("Wheel envelope report")

        k = 1

        for n in range(5):
                for m in range(4):
                        #Move the model to initial position
                        base.KinematicsMoveToPosition(steering_config, "initial_position")

                        #Get the current measurements of the width of the wheel
```

The automation script was written using the Python language that ANSA already supports. This made the writing easy and clear that required no more than 100 lines.

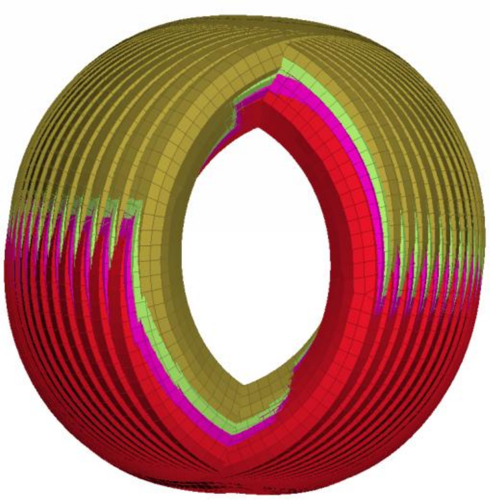
With the execution of the script a sequence of commands that are mentioned below will be run that will lead to the creation of the envelopes.



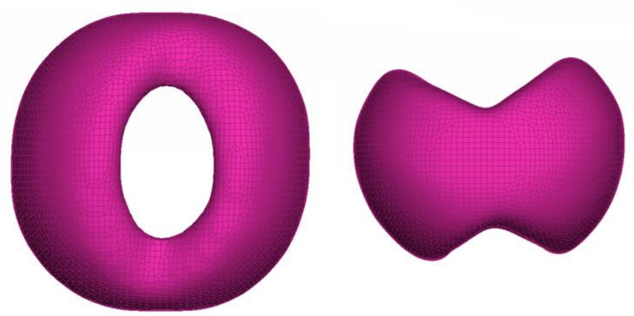
Initially, the steering kinematic configuration is articulated between the wheel’s steering limits by applying increment steps. At every steering step the wheel is copied.



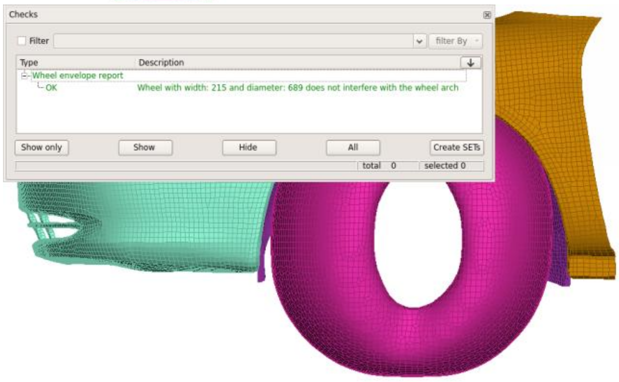
Then, the bound-rebound kinematic configuration is articulated until the wheel’s upper limit by applying vertical increment steps. At every vertical step the steering configuration is articulated as well and the wheel is copied at every steering and vertical step.



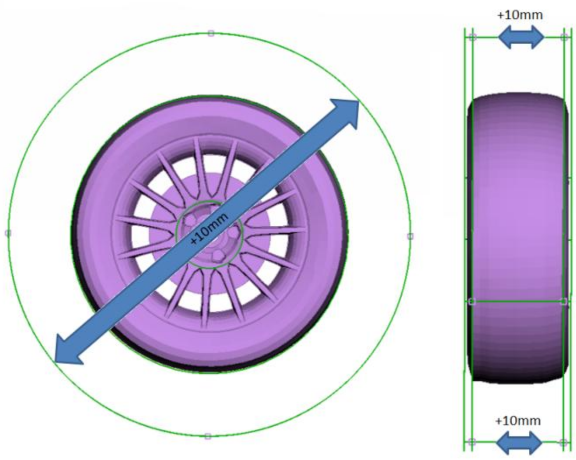
The combination of the articulations of those two configurations shows the limits where the wheel can move.



Having the wheel copied in various positions along its movement, the script runs the Wrapping command that provides a closed surface wrap mesh. This closed surface mesh actually represents the wheel's envelope.

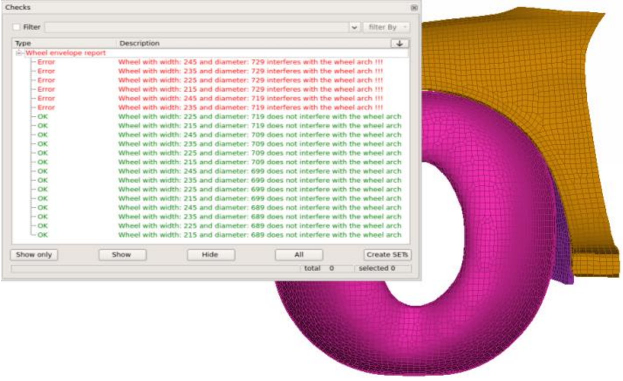


After the creation of the wheel's envelope, the script continues with the evaluation by checking for intersections between the wheel's envelope and the parts of the wheel's arch. This check determines if the current size of the wheel is acceptable and has no interference with the wheel arch during its movements. The result is displayed on a Checks Report table.



The script continues with another loop, by increasing the wheel's size and running the same sequence of commands. The increase of the wheel size is achieved by applying the morphing parameters that can modify the diameter and width dimensions of the wheel. In this particular study, the script has been written to increase both dimensions by 10mm at every loop with maximum allowed values of 729mm for the diameter and 245mm for the width. Eventually, a wheel envelope will be created and evaluated for every wheel size of the table.

		width			
		215	225	235	245
diameter	689	x	x	x	x
	699	x	x	x	x
	709	x	x	x	x
	719	x	x	x	x
	729	x	x	x	x



While the script has finished running, the Checks Report will show an overview of which sizes were acceptable that caused no interference with the wheel arch and which sizes were not.

5. CONCLUSION

This paper has presented how wheel envelopes can be created and evaluated in an automated process with the aid of Kinetics, Morphing and Wrapping tools. A similar process could be applied for suspension arms, dummy limbs or any other parts. This process might appear quite simple for some users while for some others too complex. However, the functionality and versatility of ANSA give the opportunity to setup an automated process according to everyone's needs. The existence of the Kinetics brings a multibody dynamics experience to the users within ANSA. It expands the capabilities of ANSA and in combination with other ANSA tools, it can increase productivity considerably.