BONNET BUCKLING FE OPTIMIZATION DUE TO NEW PEDESTRIAN REQUIREMENTS IN THE SEAT ATECA.

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ABSTRACT –

The new requirements in the EURO NCAP rating led to important optimizations in the frontal car area designs. Additional efforts were required to reduce the stiffness in some strategic locations, increasing the collapsibility and improving the energy management.

The bonnet in the SEAT Ateca had to face this new design challenge, finding new concepts that allow the designers to avoid local bucking problems, obtaining suitable acceleration curves for pedestrian head protection.

This FEM automation tool presented in this research has been proved to be essential in determining and analyzing a big number of the bonnet’s surface points. Less aggressive definitions for the pedestrian protection requirements were implemented in the project taking into account the possible buckling surface problems.

TECHNICAL PAPER -

1. INTRODUCTION - MOTIVATION

The pedestrian protection requirements have involved new structural designs in the bonnet and associated structures. This pedestrian optimized design based on the energy consumption during the impact could imply an instability problem in the surface in some dynamical load cases. A new analysis and methodology have been developed in order to find the points that can lead to buckling complications.

So far the technology being used only permitted checking a few test points. With the help of these newly developed tools, and using the capabilities and synergies from pedestrians head impact pre-processing and post-processing, an evaluation up to 200 test points in the bonnet is possible and effortlessly done.

2. BUCKLING FEM ANALYSIS: METHODOLOGY

A) POINTS DEFINITION

The strategy should start defining the test points to assess the local stiffness. This information can be provided by the Project manager or the test engineer. A typical hardware assembly to test the buckling candidates points is presented in Figure 1

Figure 1- Ateca Bonnet in an experimental analysis.

This list of points should be identified in the Finite element model and his labels must be renumbered suitably. A bonnet with different placements of the stamp to analyse the behaviour is presented in Figure 2

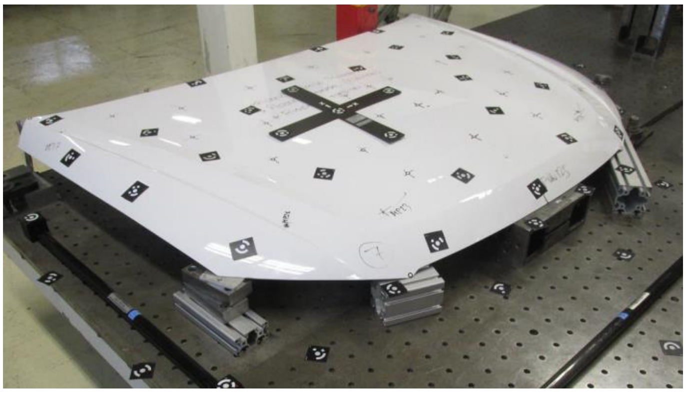

Figure 2- Test Points to buckling test in the SEAT Ateca.

Like a demonstration of the capabilities of the tools it is showed a first points test FEM definition in Figure 3, in this case 60 points were selected. The symmetry has not been taken into account in order to checking possible non-obvious differences.

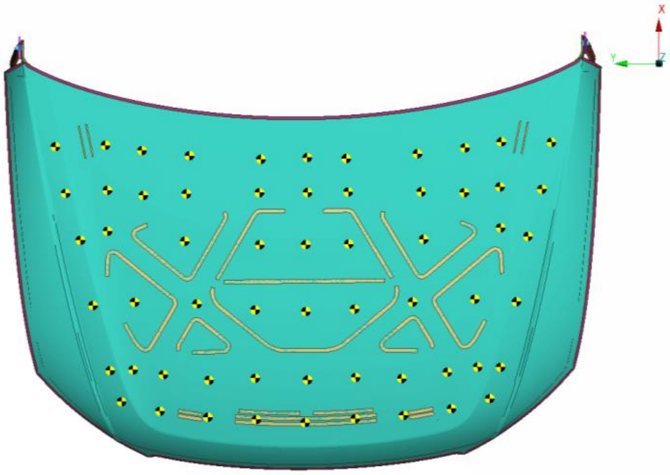

Figure 3- Example for test Points selected to buckling test in the SEAT Altea, FE model.

In the case of local analysis it is also possible to define a particular grid in the study area. This possibility can be seen in Figure 4.

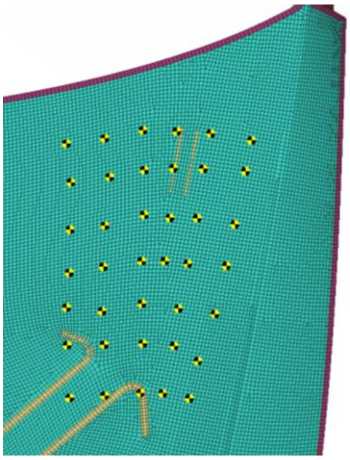

Figure 4 – Reduced area grid definition in the targets stamp points.

B) REPLICATION AND CREATION OF ALL THE MODELS FOR EACH TEST POINT

When has been decided the number of target points to be calculated, the next step would be to use the Beulertk tool. This tool that has been developed by SEAT, and calculates the different positions of the stamp for each given defined point. As an example one screenshot of the application it's showed in Figure 5.

Figure 5 –Beulertk tool interface.

The parameters defined in the tool are: the initial and last grid label nodes which are used to place the stamp, the distance between bonnet and stamp placed and, at last, an initial template pamcrash file to replicate the files with the different positions. The application generates one Pamcrash file for each test point.

In order to help the launching of all the .pc files a .mpc file has been created involving all the defined files with pc extension. Finally all .pc files are sent to the calculation server.

C) ANALYSIS OF THE RESULTS AND POST PROCESS.

Once the calculations are finished the procedure of the post process is started. PostHI SEAT tool it is able to manage a big amount of different calculations with different bonnets configurations and different projects in the same way.

In SEAT this automatic tool has been developed, that tool moves and manages the files taking in account the variant and the project of each .pc file and after run Meta sessions in each case generating Meta databases with all the results. An example of this display of this SEAT tool it is presented in Figure 6.

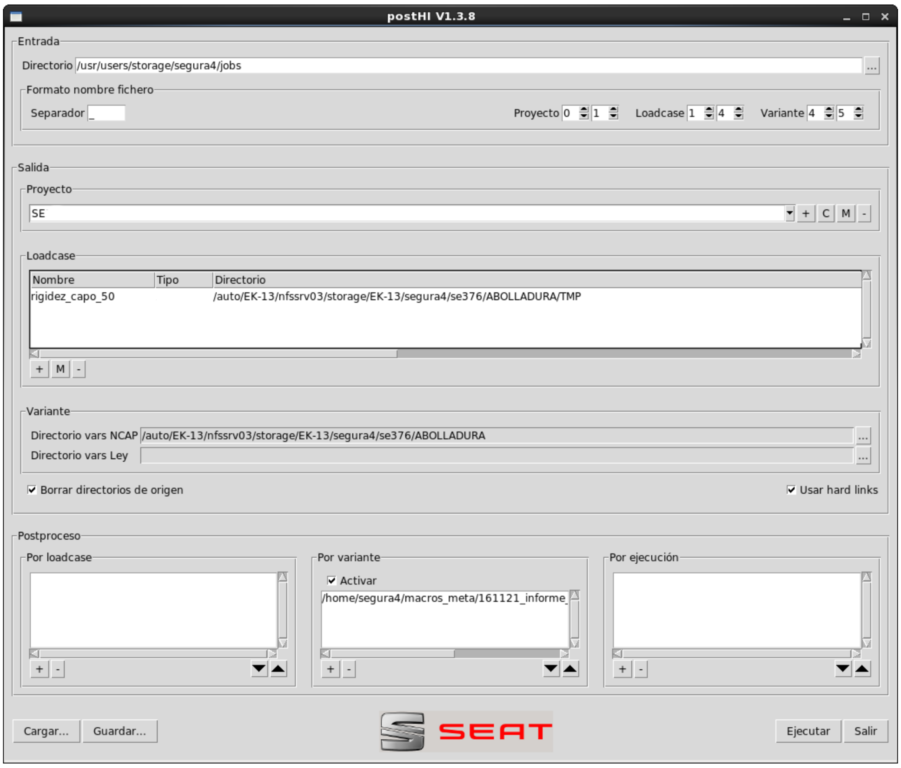

Figure 6 – SEAT PostHI tool

For each variant a map of stamps positions has been obtained, this map with the biggest permanent deformation in the bonnet and one analysis of the possibility of buckling problem using the curve Force vs Displacement in the stamp and in the node with more permanent deformations.

In Figure 7 an example is presented, using red labels to identify the points that have permanent deformations bigger than the objective, the points with green colour imply that the permanent deformation is below the target. The grey points imply that these points have numerical convergence problems and have not finished correctly. Finally, the points with a white frame are associated to the detection of a possible buckling effect and this will be the points where the optimization geometry will be targeted.

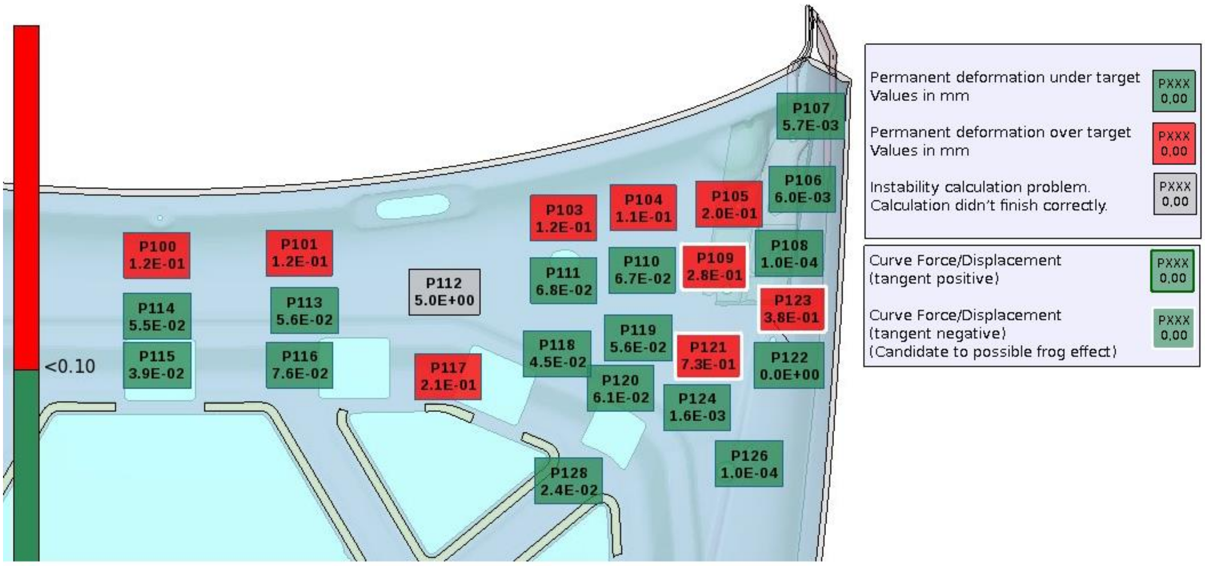

Figure 7 – Example Variant Status after PostHI postprocessing

D) CRITERIA TO DEFINE A POSSIBLE BUCKLING RESULT

The criterion to define a buckling effect experimentally uses a curve for each point. This curve uses the force applied by the stamp versus the measured displacement. In case of detecting a large change of the tangent of the curve that would mean the structure has no reaction and there would be a possible buckling effect. In fact that means a very large no-linearity. This effect can be seen on and it is defined in Figure 8, in some cases a value of 15N measured in the curve is enough to analyze in depth this point.

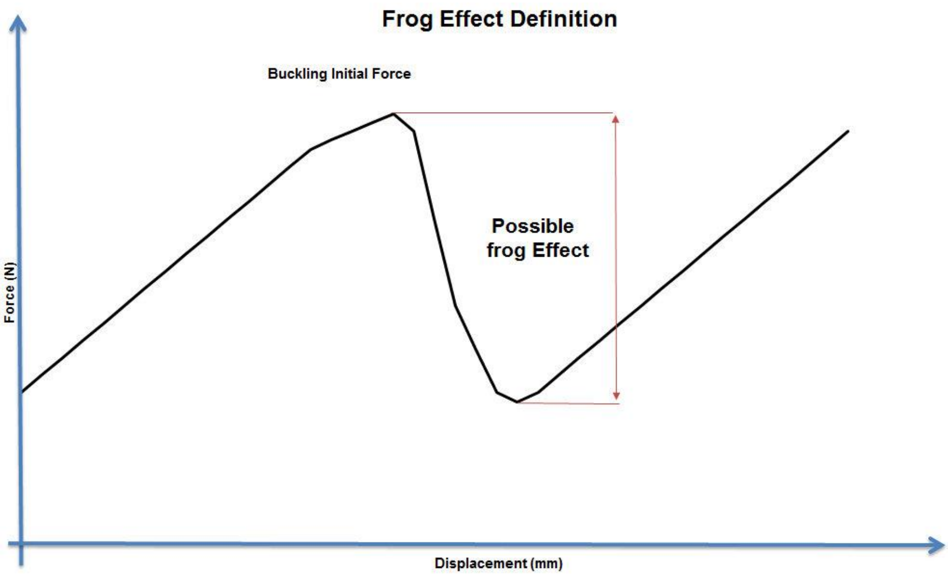

Figure 8 - Experimental Definition of a buckling effect.

In the Meta session an algorithm has been implemented to check the tangent of the curve force versus the displacement and it has been adjusted with experimental results, in order to assign it to this result if there is a probability to a buckling effect or not. At this point the implementation of a python script in the session has been implemented to obtain a good identification of the behaviour at this point.

The methodology to implement this data has been using a comma separated text values CSV format with the next following information in each point: Name of the file, Label of the node with the largest permanent deformation of the model, Label of the stamper, Coordinates X, Y, Z Stamper, Coordinates of the point with largest deformation X, Y, Z. Label of buckling NO/0 YES/1, Last state calculated.

All of this information was used to generate the final report for each variant.
The field Last state calculated has been used to check if the simulation ends. If the calculation has an error and doesn't arrive to the last state, automatically the colour of the annotation will be grey and indicating that something went wrong. In the example of Figure 7 it can be observed that point P112 didn't end properly.

3 APPLICATION OF THE METHODOLOGY

A) INITIAL STATUS BONNET ANALYSIS.

As an example on the application of this methodology a different cases were presented.
In the first model of the SEAT ATECA's bonnet the goal was to identify some candidates to this problem and some variants were implemented and analyzed in order to correct this effect. In Figure 9 the first values of permanent deformation and the analysis of those curves force/displacement analysis obtained for every point are represented.

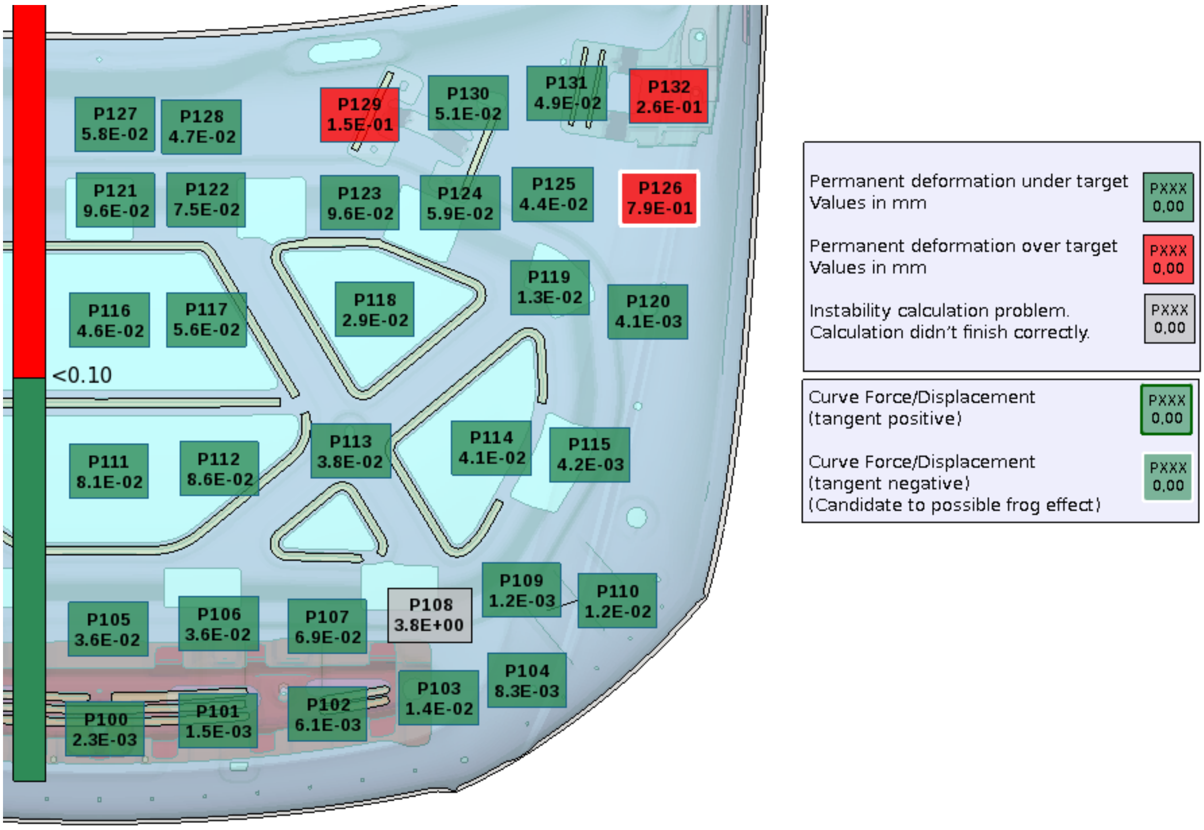

Figure 9 – Initial analyzed model

There are two points (P129 & P132) with a permanent deformation over the range but those curves are not identified like a frog candidate. In Figures 10-11 the results can be displayed using Meta Software capabilities. There are two curves showed in each graphical display: the red one display the values measured in a control grid in the Stamp and the blue one follows the node with largest residual displacements measured. Point P132 would be a candidate but the curve obtained doesn't follow the frog definition as it can be demonstrated in Figure 10. On the left side of the image it can be seen the permanent deformation after the stamp is retired of the structure and its values measured.

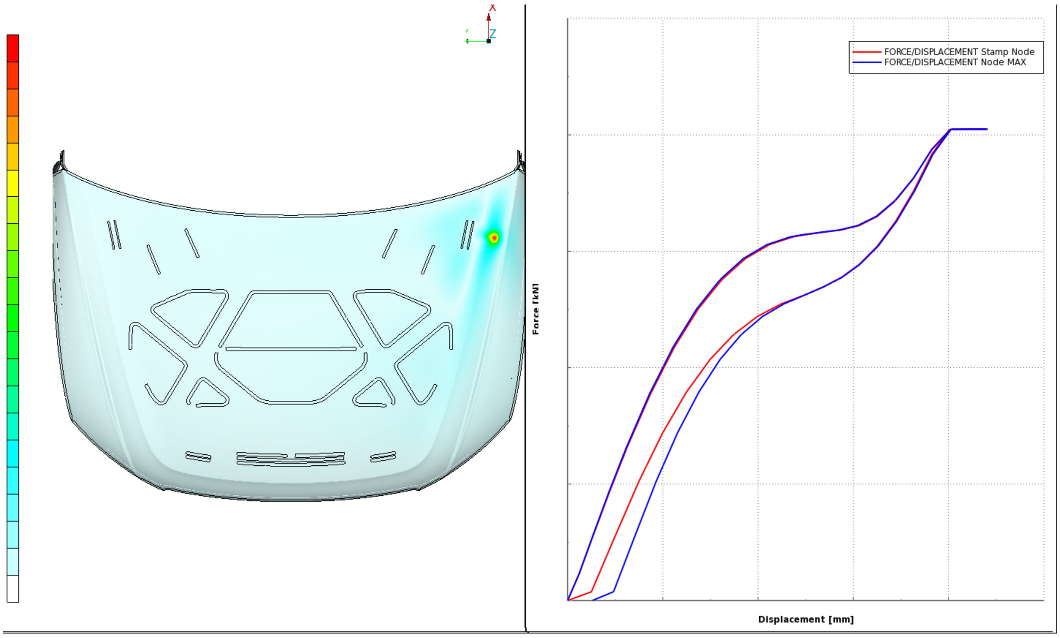

Figure 10 – P132 Results

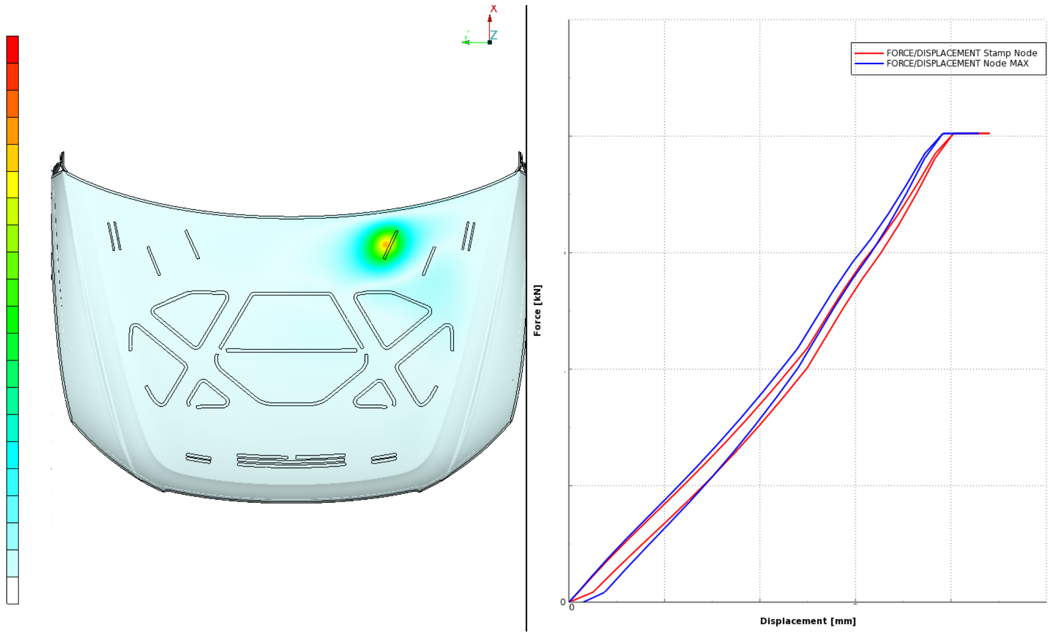

Figure 11 – P129 Results

The result for the point P108 was not displayed due to a model convergence problem. *"line search not converged, maximum iteration reached".* It could be solved creating a particular grid around the point and checking the deformation. Several examples of how to solve this particular case will be analyzed along the paper.

Test point P126 has been detected as a candidate for frog effect. In Figure 12 the Force versus displacement curve can be seen to analyze its behaviour. Comparing the curve topology with the pattern it is clear that in this position a frog effect could be appearing in the bonnet. An analysis in depth was necessary with geometric updated changes and a new reinforcement.

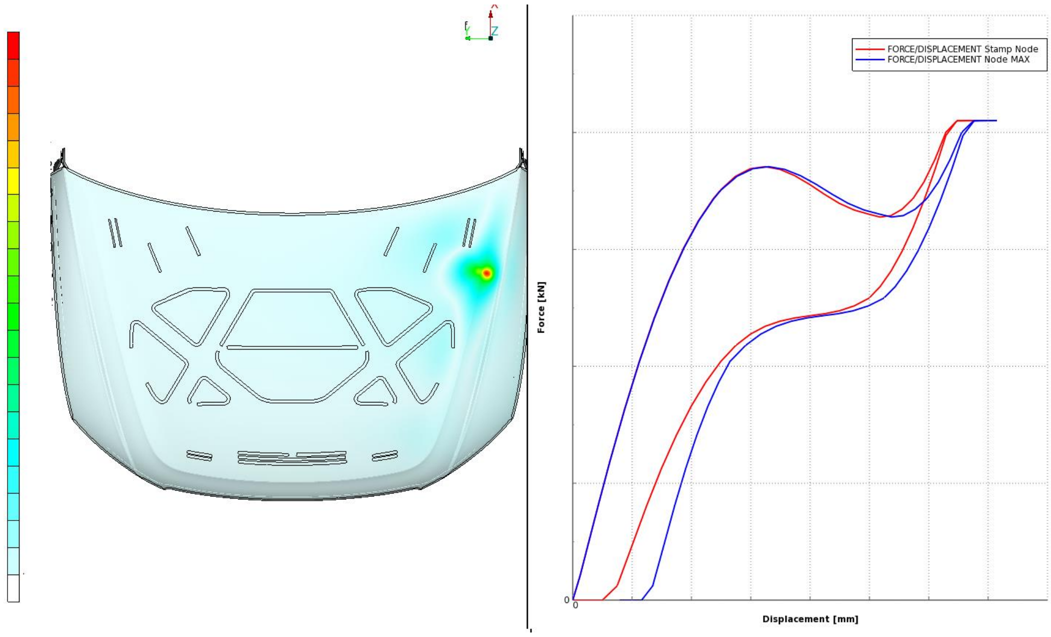

Figure 12 – P126 Results

B) STRUCTURAL BONNET OPTIMIZATION

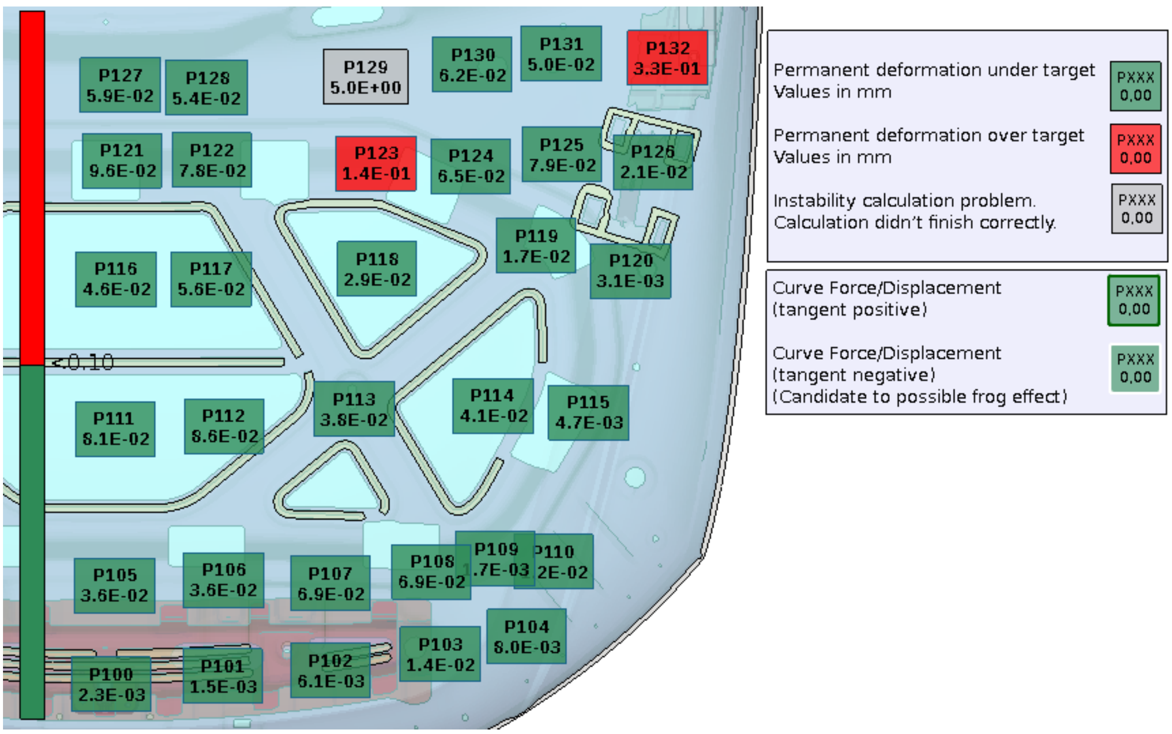

Figure 13 – Model improved.

The reinforcement was redesigned and placed to match the previous status results. The design line in the outer surface played a very significant role in the dynamical behaviour. The amount of glue and the orientation also was modified. In Figure 14 the differences between the 2 designed elements can be seen.

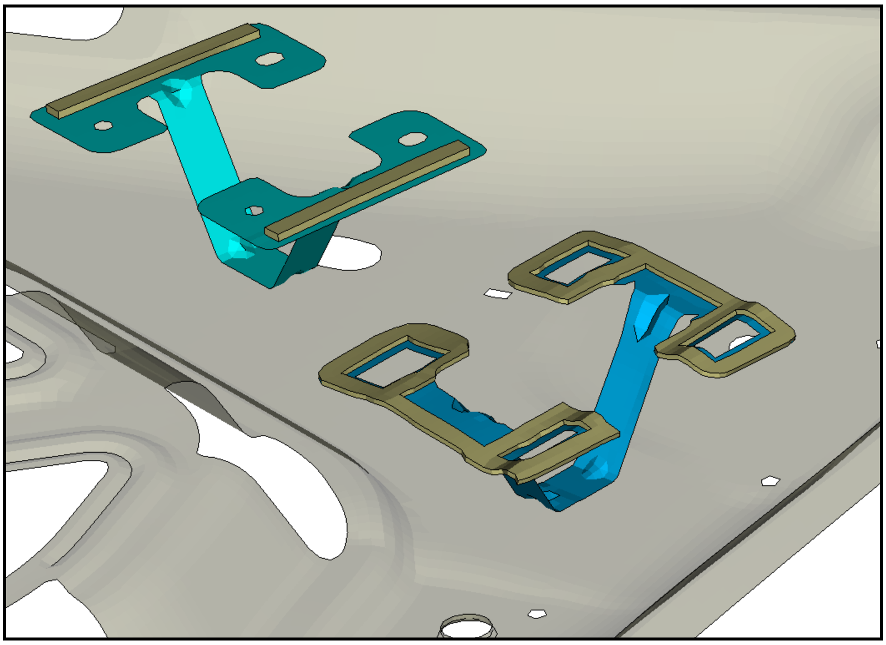

Figure 14 – Differences between the 2 designs of parts calculated in both models and its different locations.

The orientation of the flanges glued to the external surface was changed and the total amount of adhesive increased. That is a relevant fact since the orientation of the connections between external and internal parts also provide relevant influence. Additionally one flange glued to the external surface of the bonnet in the hinge reinforcement was removed, In Figure 15 the modification can be observed. The main idea was to apply the glue on the area that was necessary for the bonnet and avoid the creation of redundant supports.

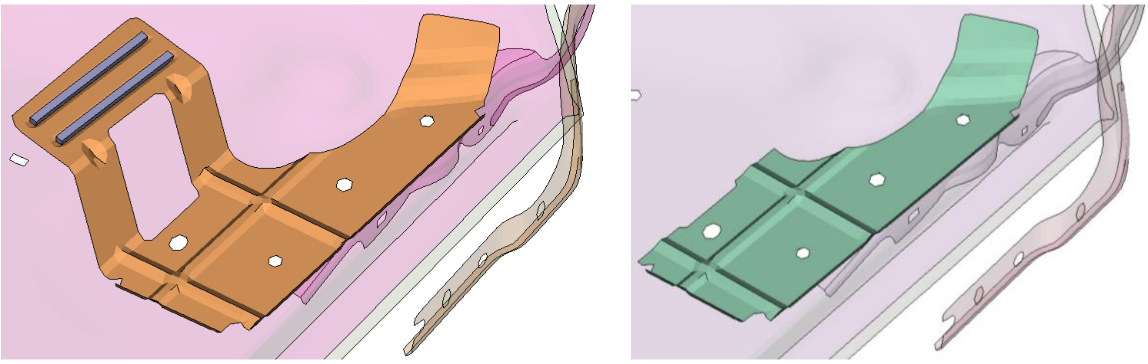

Figure 15 – Differences between the 2 designs in the parts calculated.

Analyzing the results a point with instability problems was observed (in Grey color). On this case the potential of these tools was used to create a small grid around it and to be able to analyze it in deep. Based on this 19 points were created around within 20 mm of distance in X's and Y's; and it is possible to find points without problems near the analysis point. As observable in Figure 16.

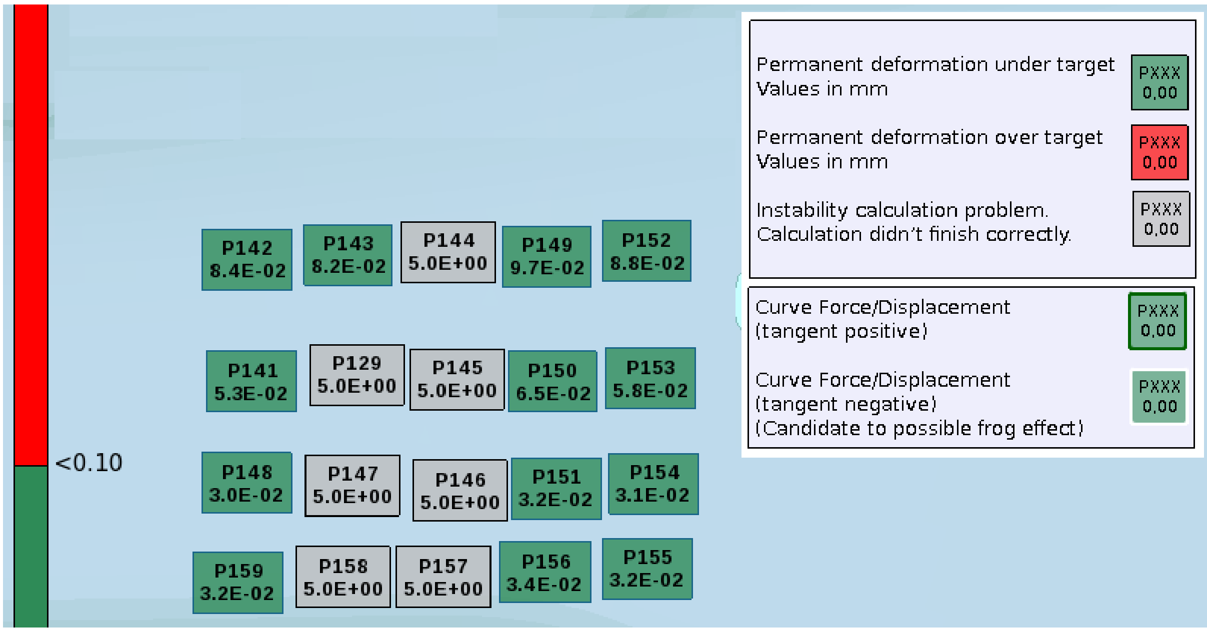

Figure 16 – 19 Points calculated around the P129 point (20 mm X, Y)

These curves have been obtained near the analysis point not having the topology of a candidate of point frog effect. Figures 17-18

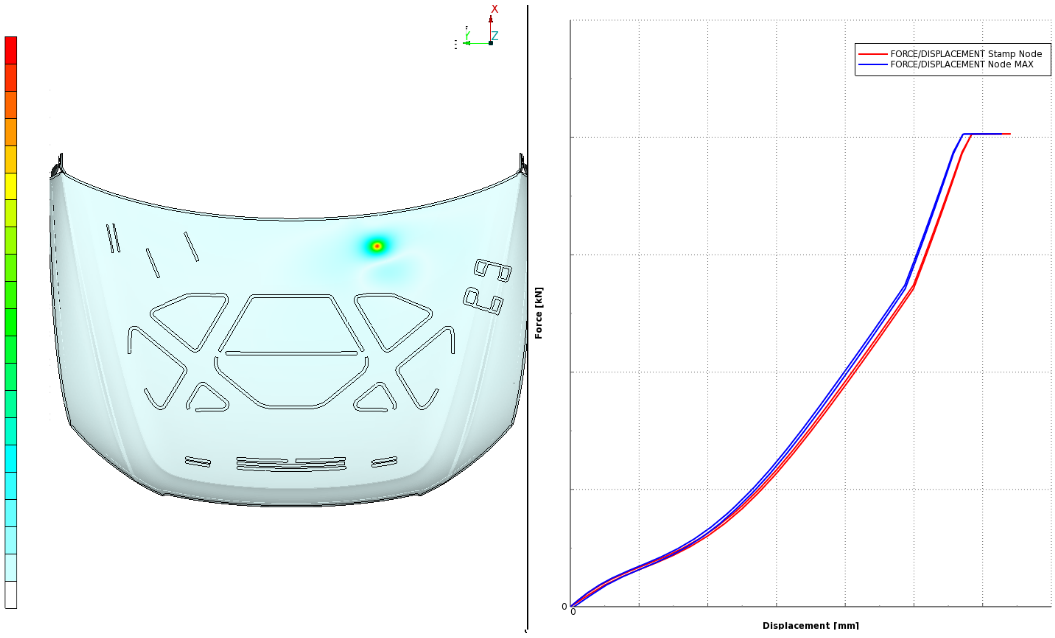

Figure 17 – Point 141.Displaced 20 mm Y's positives

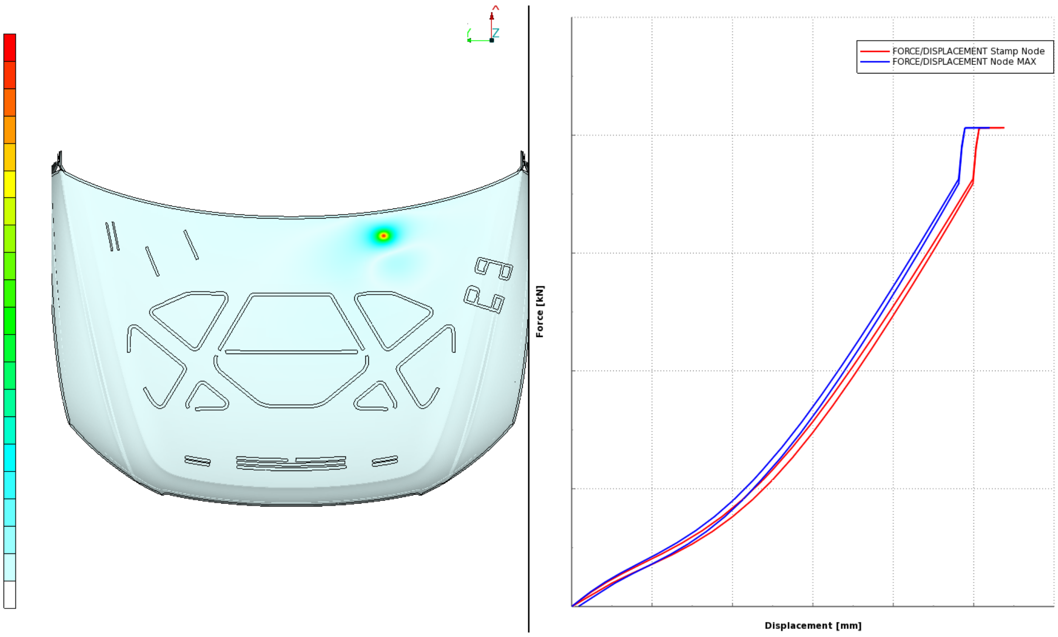

Figure 18 – Point 143 Displaced 20 mm X’s positives.

C) ANALYSIS WITH A DIFFERENT STAMP.

This methodology also permits the use of different stamp geometries in the status calculations without spending much time. As an example the bonnet calculated in the previous analysis that will be reported below. The geometry of the stamp changed basically from 50 mm to 70 mm diameter. In Figure 19 is presenting the obtained results.

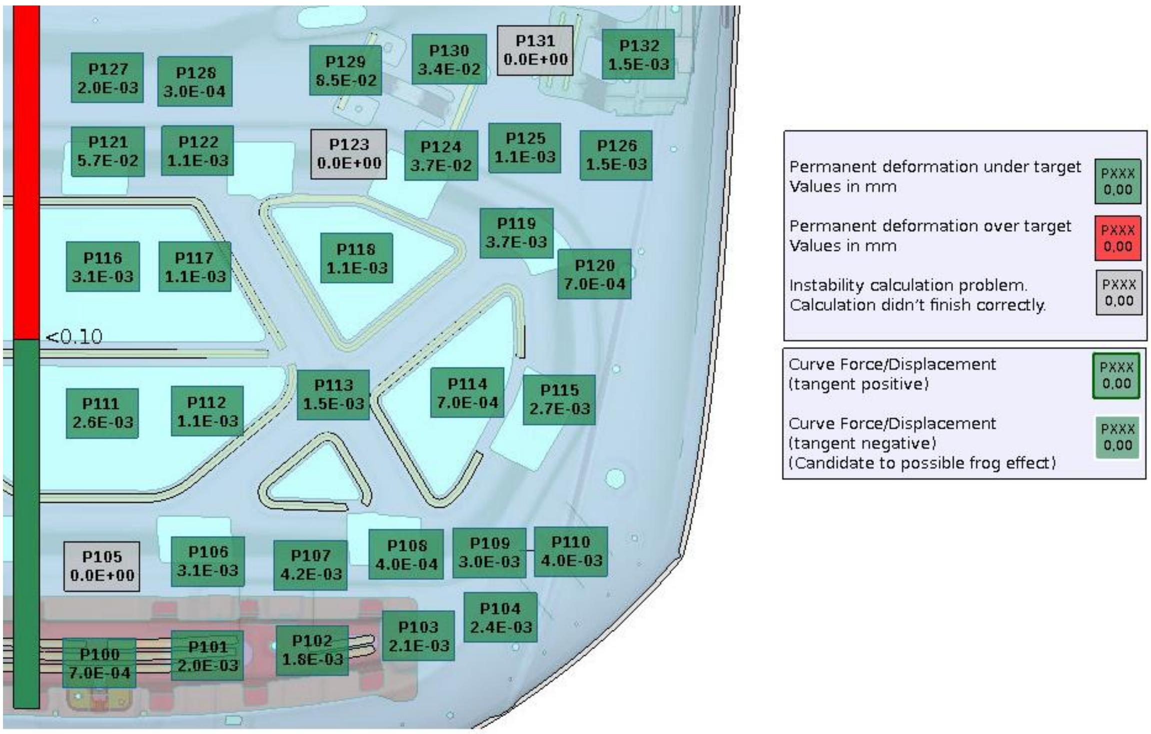

Figure 19- Results with the Stamp geometry B.

In this case it doesn’t appear candidates to frog effect. In Figure 20 it can be seen that the curve Force versus displacement obtained for the point P126. It was a frog candidate in the previous status with the last stamp geometry. As a first conclusion taking in account the different stamps morphologies is mandatory to try to find the frog points candidates.

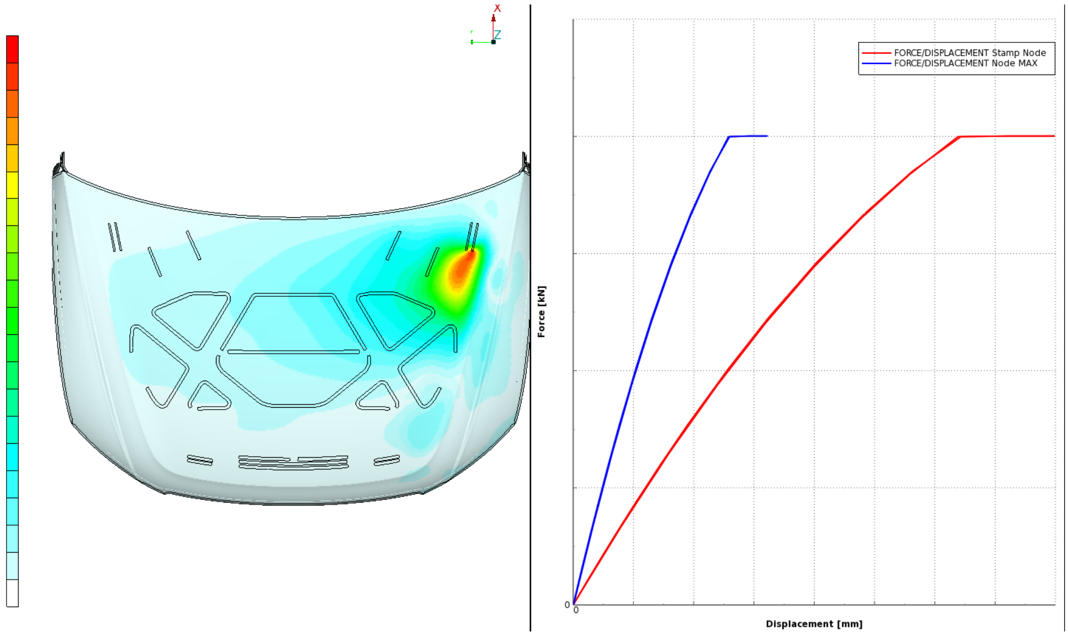

Figure 20 – Results in P126

In Figure 21 are showed the results with the geometrical optimizations realized with the 50 mm diameter stamp. It doesn't appear frog candidates, despite this, some simulations have not been ended correctly and it was necessary to solve displacing the stamp 20-30 mm and recalculating the new placement of the stamp.

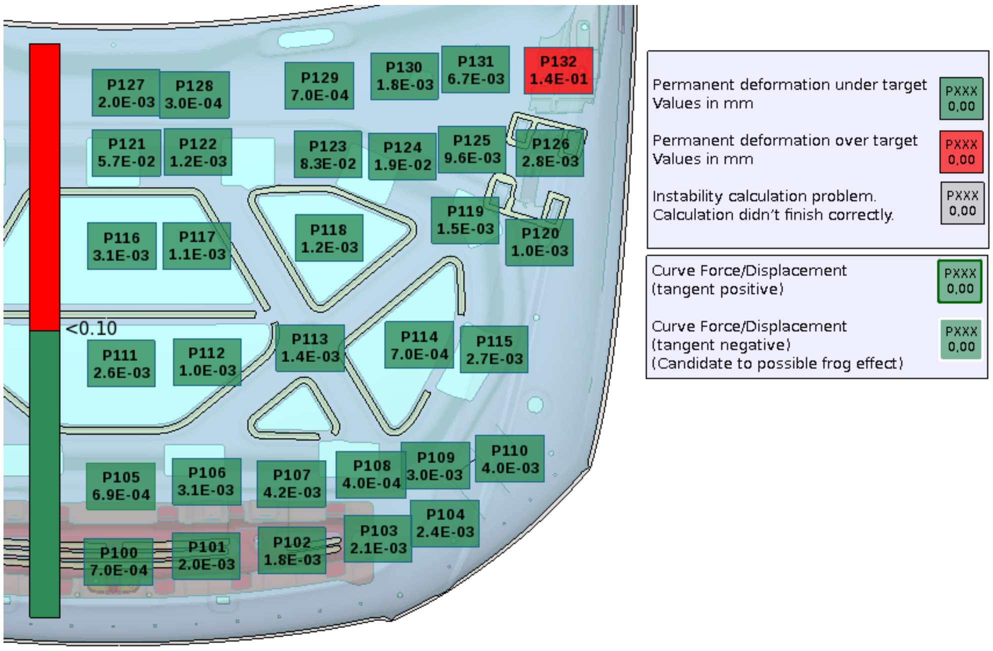

Figure 21 – Results obtained with the geometrical improvements.

In order to have more information about the behaviour of the bonnet in the improving area more test points have been selected and calculated as it is displayed in Figure 22.

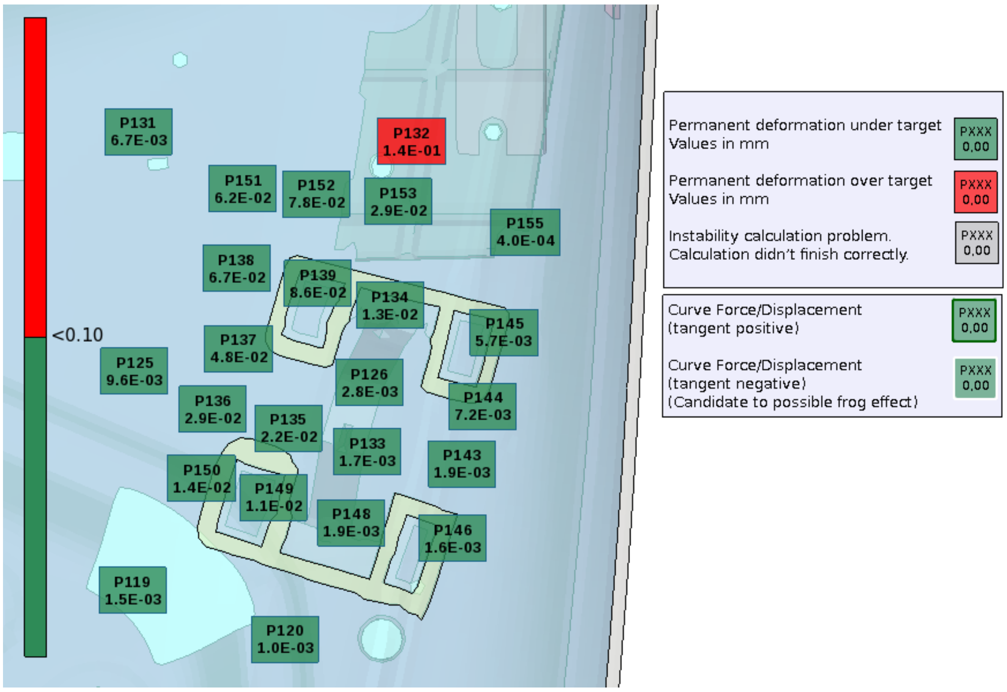

Figure 22 – Results refined near the Point 126 to find frog candidates

Only a point has been detected with permanent deformations but without frog curve characteristics. Therefore this topological optimization has been demonstrated as a good start point leading to a good bonnet configuration parts that avoid surface buckling.

4. EXPERIMENTAL CORRELATION.

In order to compare the results obtained with the SEAT FEM Surface Buckling Tools in Figure 23 are showed some problematic points found along the external surface in the bonnet with experimental tests.

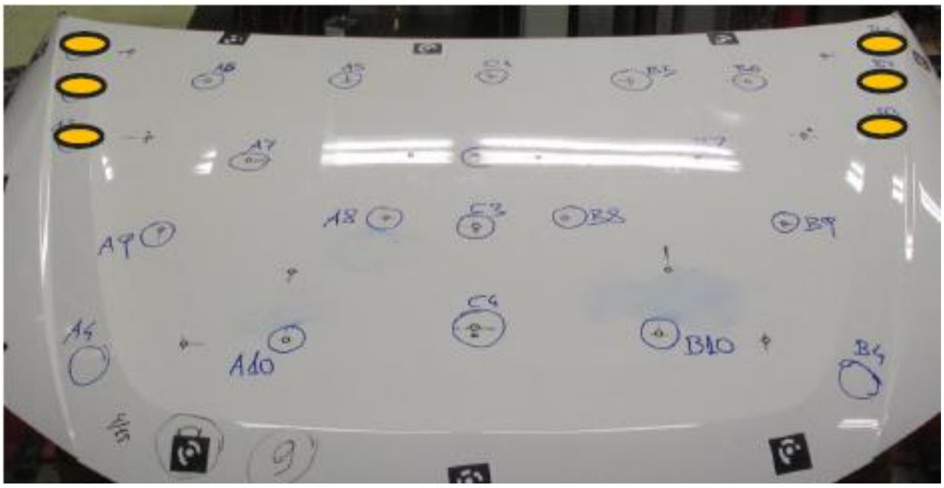

Figure 23 – Frog points area found it in the bonnet.

Analyzing the same geometry with the SEAT FEM Surface Buckling Tools in Figure 24 the results are displayed.

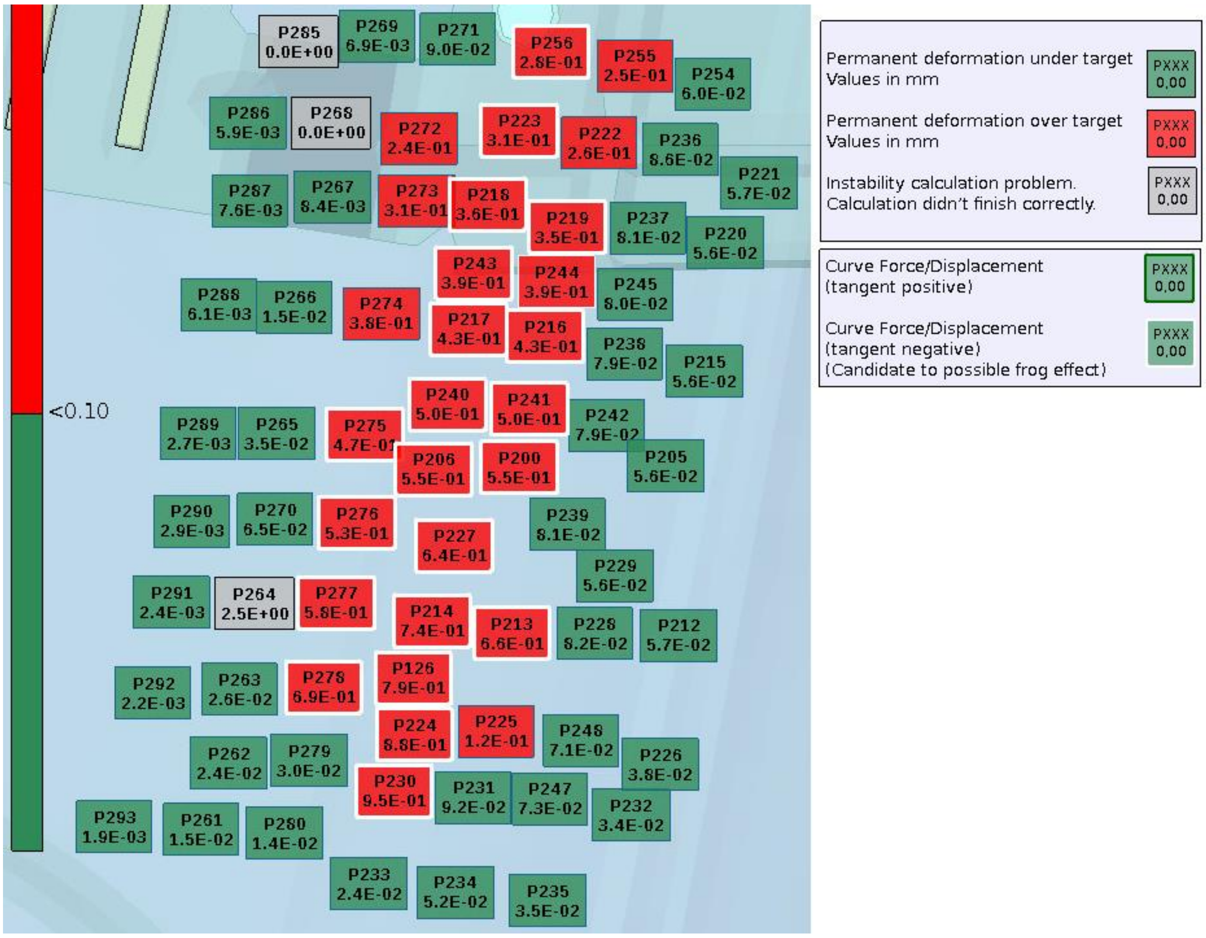

Figure 24 – Local area points calculated

The locations and force magnitude of the points with frog effect has been compared with experimental results in Figures 25 and 26.

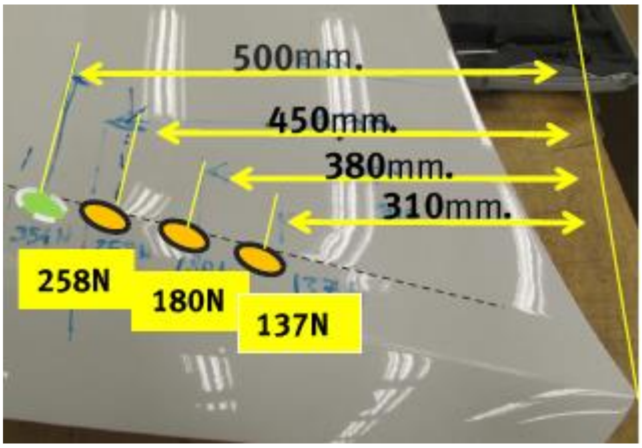

Figure 26 – Approximated distances and forces obtained.

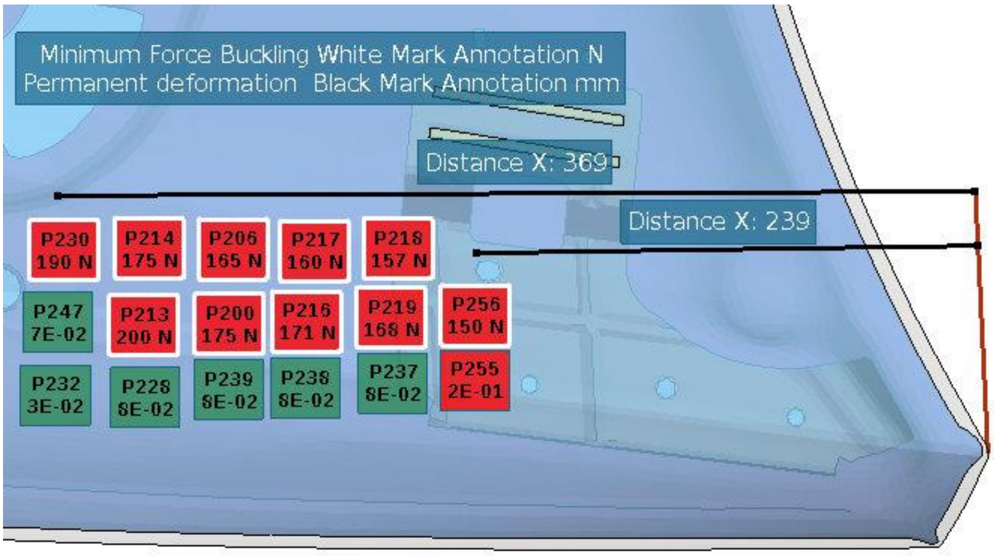

Figure 27 – Distances and Forces obtained with the FEM results.

The points obtained in the FEM model have been located near the test locations found. The initial area X line has had only a difference of 71mm approximately and the last X line has 81 mm. Taken into account only the relative coordinates the X length of the frog area that has been obtained was quite similar: 130 mm in the FEM model and 140 mm in the TEST model.

As a limitations of the study, it is important to highlight that there are a some variables that have not been implemented in the model that could have a relevant influence and in a further study should be taken into account: the residual stress due to the manufactures procedure, thickness differences (stamp procedure) or also the stress induced in the parts assembly.

5. CONCLUSIONS

Following the different geometries and the analysed models on this paper, it has been demonstrated the utility of this tools to find an initial list of points candidates to have frog effect and buckling surface effects. Not only these tools have been proved to be useful to try to avoid this effect but they also permit to evaluate a very big amount of points effortlessly, and check different proposals without spending many resources.

The comparison between experimental and simulations results in the example case analysed has also provided quite good tendencies and good correlation with the experimental values, therefore validating such methodology.

Related to the permanent deformations calculated, this proposed tools compilation provides a relevant initial point of study to continue working in order to try to refine the model for improved results.

REFERENCES

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