SimDesigner

How to Design a Silicone Push Button

Figure 1: Design detail

Gold coated pucks – In order for the button to activate, these two pucks have to touch each other with minimal effort and make maximum contact.

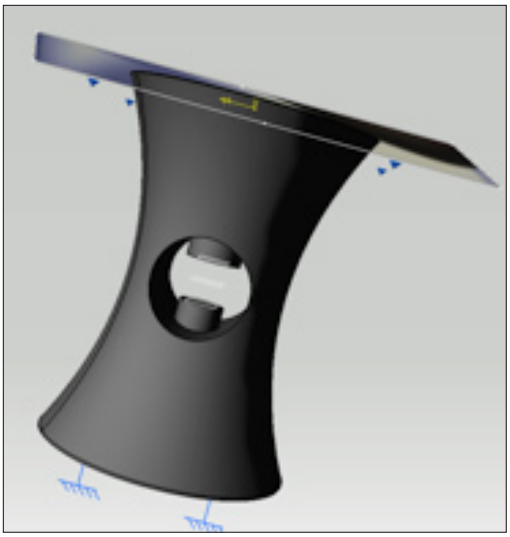

Figure 2: Experimental setup

The bottom surface was restrained to simulate that the push button was lying on a flat surface. To simulate push button activation, a surface was constructed and was displaced 0.01 inches down in Z direction.

MSC Software

One of the most challenging issues facing medical device R&D groups is reducing development cycles while increasing reliability, and at the same time staying within cost targets. To accomplish these diametrically opposing goals, here we used simulation as a means to get to the final design without having to make multiple sets of prototypes. This resulted in capital cost savings of approximately $15-20K and 12-16 weeks reduction in design time.

Business Challenges

In medical device engineering, R&D is required to meet two conflicting requirements:

1. Speed to market: This requirement when translated into product development challenges means less time available to develop the medical device.
2. Increased Reliability: This requirement when translated into engineering challenges means that one needs to understand all possible environmental variables to which the design is subjected to ensure all scenarios are tested so the final design is safe and effective. This translates into extensive testing which would contradict with the first requirement.

To meet these conflicting requirements, it is generally recommended that a coupled approach be used where the FEA testing is utilized in conjunction with physical validation.

Design Challenges

Design a custom molded silicone push button with a gold puck to activate the hand piece. However, challenges can arise if one were not to use simulation for predictive studies. For Instance, there are two things that can go wrong in a molded part:

1. The activation force may be too high – since the button is activated by thumb, the contact stresses cannot be too high.
2. During the process of activation, the button may flex in a wrong direction and fail to activate the push button completely.

When designing silicone molded parts, most mechanical engineers have a difficult time predicting its behavior. The reason is that most mechanical engineers are trained in designing components made out of metals, but when it comes to designing components made out of Silicone, it is extremely difficult for them to guess its behavior. This fact coupled with the usage of traditional engineering methodology, where one was to make mold first and then test the design, would make design process very expensive in terms of time and cost. It may take upwards of three design iterations to come up with a working design and each time one modifies the mold, it takes upwards of 4 weeks and approximately $4000 dollars to get prototypes.

To avoid these aforementioned shortcomings of traditional design-break-test, here we used MSC SimDesigner R2, a CAD-embedded analysis package from MSC Software. The SimDesigner product was selected for following two reasons:

1. Ease of use – Though there are other choices of simulation packages available on the market, one of the primary requirements to speed design-analysis evaluations and time to market is adopting a simulation package that is easy to use and quickly adaptable for a variety of users.

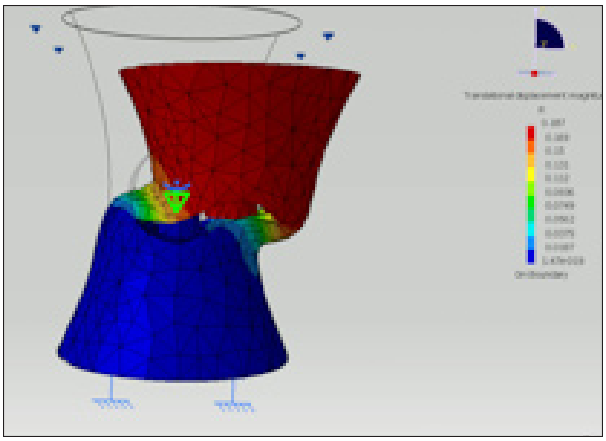

Figure 3: Translational displacement

Push button moves uncontrollably.

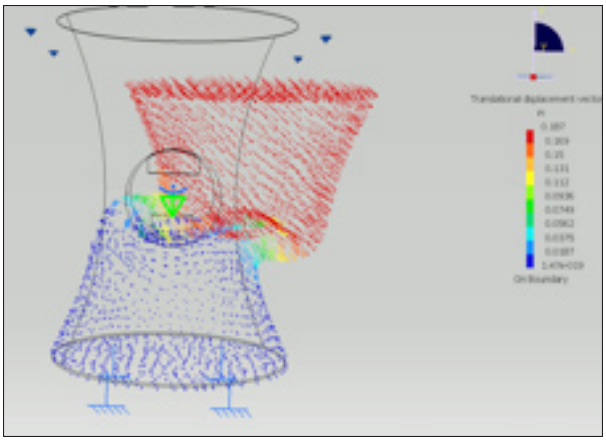

Figure 4: Translational displacement vector shows that the gold pucks miss each other completely during activation process.

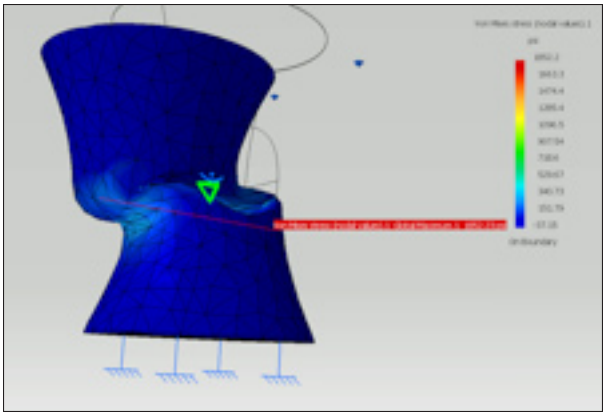

Figure 5: Activation stress are too high (1855 psi). Push button moves uncontrollably. The activation stresses are too high and would have caused the operator discomfort.

2. CAD-embedded – When analysis is performed inside the CAD environment, it simplifies the overall process of performing simulation. One can work directly with the CAD geometry, mesh the part or assembly, apply loads and boundary conditions, run the analysis; and then post-process and chart the simulation results without ever leaving the CAD environment. This leads to greater efficiency when compared to traditional methods of doing analysis which often require point CAE tools. The goal is to avoid data translation errors and inefficiencies that result from exporting geometry, translating data, and running multiple point tools to get answers. The objective is to get answers faster so engineers can make smarter design decisions earlier.

Experimental Setup

This design was simulated as a contact problem using the MSC SimDesigner Structures Workbench.

1st Design Iteration

First design iteration consisted of two gold pucks insert molded in insert molded in a silicone base

Conclusion on 1st Design Iteration

If one had molded this push button design, it would have required that mold be modified. This is because during the activation process, not only does the push button collapse on to one side and the gold pucks miss each other, it would give inconsistent activation and the activation force would be too high. Based on the aforementioned findings of high activation force and uncontrolled collapsing of the push button, the design was modified and was evaluated again.

2nd Design Iteration

To overcome the shortcomings of the prior design (collapsing of the push button during activation and high activation force), two side ribs were added.

Conclusion on 2nd Design Iteration

In the 2nd design iteration, one can control the uncontrolled collapse of the push button, but it still shows that there may be cases when the gold pucks may not touch each other. To address this short-coming, 3rd iteration was done on the design.

The displacement in this iteration is 25% more than the compared to second iteration, and this should definitely improve the tactile feel. Sectional view shows the even distribution of displacement on both ribs which allows the push button to be activated easily.

Addition of ribs increased the tactile feel and further reduced the maximum stresses by 10 PSI compared to second iteration.

Final Conclusion

By performing predictive, in-process analysis on the design before making actual prototypes using a simulation package that is ‘easy to use’ and offers a breadth of CAD embedded capabilities such as those available in MSC SimDesigner Workbench for CATIA V5, the result was a net savings of $15-20K in terms of mode modification and 12-16 weeks were cut out of the development cycle which should result in increased revenue opportunity for the company. Most importantly, the end result was a good design that delighted the end user.

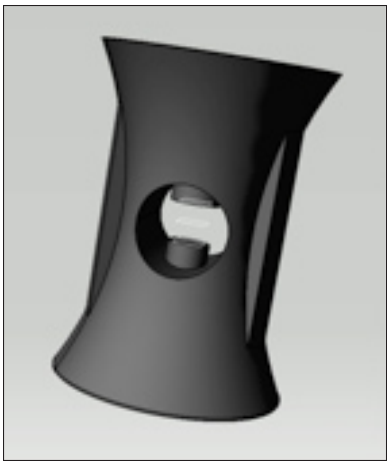

Figure 6: New design

Ribs were added to provide structural integrity.

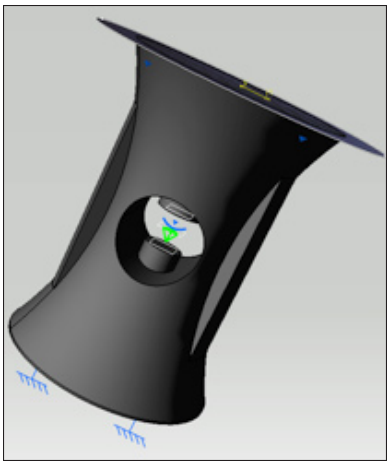

Figure 7: Experimental setup was kept same for the contact analysis.

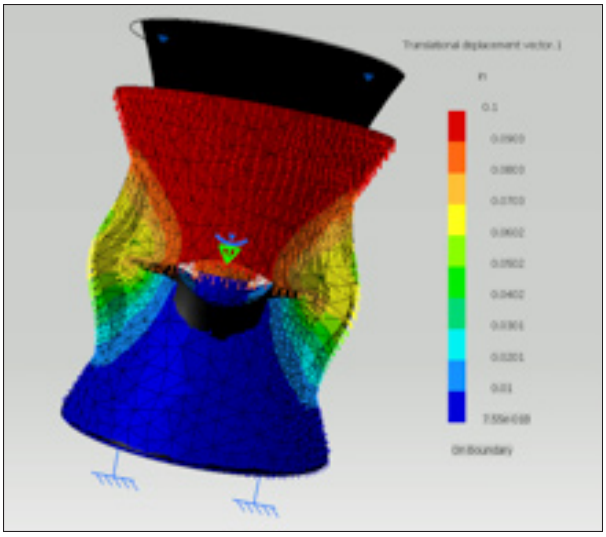

Figure 8: Translational displacement analysis shows that both gold pucks come barely in contact with each other and may not provide adequate tactile feedback to the end user.

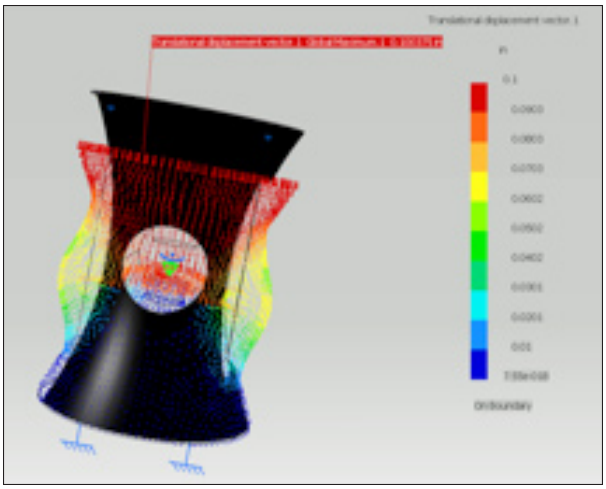

Figure 9: Displacement vector analysis shows that both pucks come in contact with each other, however, if one were to consider the manufacturing variances, in some cases, the puck may not come in contact with each other. In addition to the fact that even in perfect case, there is an issue of tactile feel. To simulate push button being activated, this surface is pushed downward by 0.01 inches.

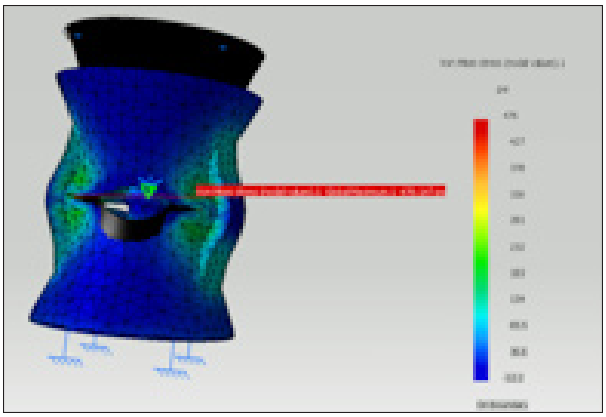

Figure 10: Maximum stresses in this design have dropped from approximately 1200 PSI to 476 PSI, which in turn would reduce the activation force.

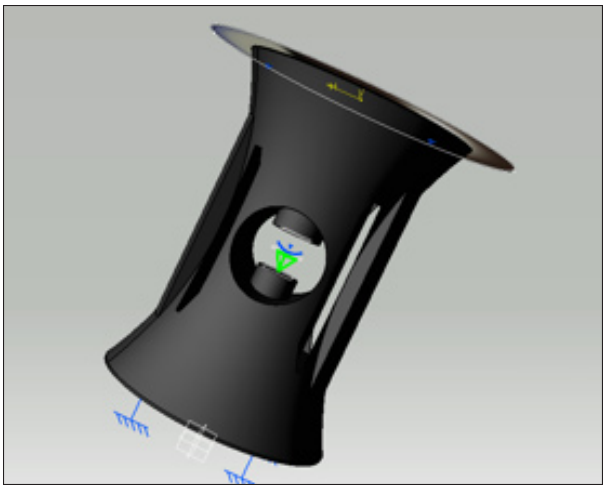

Figure 11: 3rd design iteration - with slots

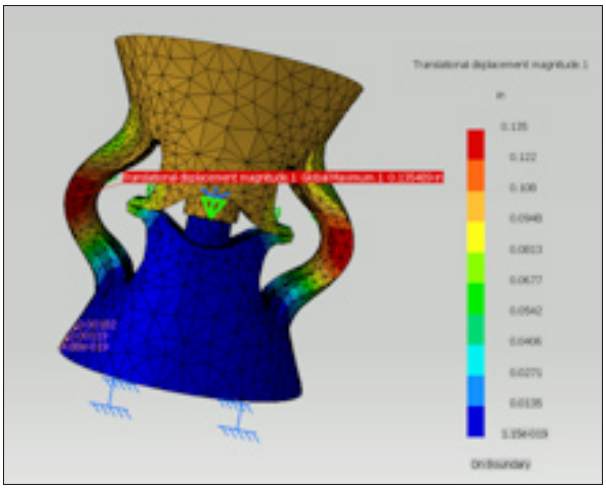

Figure 12: Translational displacement magnitude

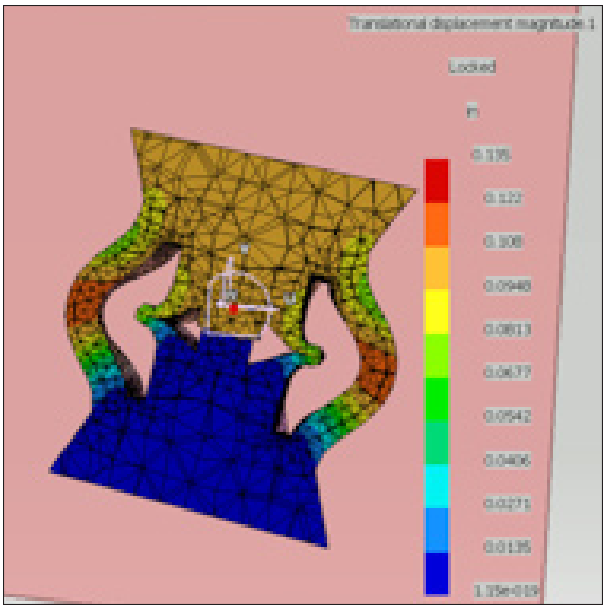

Figure 13: Sectional translational displacement magnitude

The displacement in this iteration is 25% more than the compared to second iteration, and this should definitely improve the tactile feel. Sectional view shows the even distribution of displacement on both ribs which allows the push button to be activated easily.

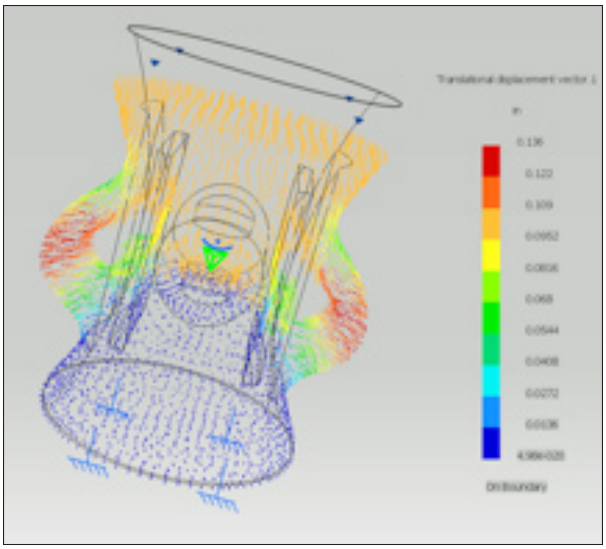

Figure 14: Translational displacement vector plot

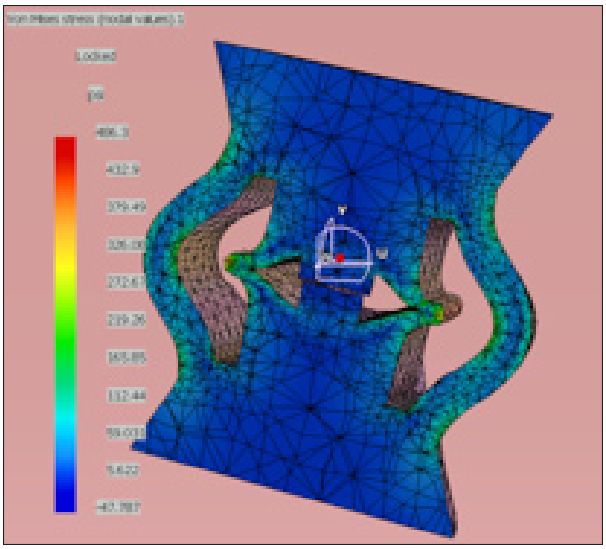

Figure 15: Von Mises Stresses Plot

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