A quieter car cabin – Reducing the squeak and rattle risk using topometry optimisation

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The amount of noise inside a car cabin is an important aspect for users when getting a sense of the car's overall quality. The noise can be generated by several factors, one of which is when the different components in the car come in contact with each other. How can this type of noise be reduced to increase a car's quality?

Premium cars today are a large investment for many people and it is important that the quality of the car live up to their expectations. A noisy car cabin will certainly reduce the overall sense of quality. The reduction of the car cabin noise has become more important in the recent years with the increasing popularity of the quiet electric engines.

The two types of noises evaluated in this work are squeak and rattle, which are caused by parts sliding or impacting against each other because of vibrations generated when travelling on the road. To evaluate the generation of the squeak and rattle, two aspects are studied - geometric variation and dynamic response.

Geometric variation is created by the fact that no manufacturing process is perfect which causes the parts of different cars to have different dimensions. This affects how the parts fit together which in some cases can cause the parts to vibrate in a squeak and rattle inducing way.

The dynamic response evaluates the behaviour of the vibrations between the parts, which in this case are the inner door panel and the steel door. The generation of the squeak and rattle from this aspect depends on how much the parts vibrate and if the parts move with or against each other when vibrating.

Increasing the stiffness of the parts can decrease the squeak and rattle generated by the geometric variation and the dynamic response. This is where the addition of thickness is introduced in this work since it increases the stiffness. The goal is to increase the thickness in the optimal places of the part. This approach is called a topometry optimisation.

To find the optimal places to increase the thickness, computer simulations were used to evaluate the effect. Using computer simulations instead of physical models is a common approach today since it is both more efficient and cheaper. This thesis work mainly focuses on the development of an approach for topometry optimisation using computer simulations.

Research was done prior to the simulations. The research covered parameters that have an impact on squeak and rattle, but also previous studies on topometry optimisation in various contexts. In addition to gaining an understanding of the factors causing squeak and rattle, this also helped to build up the computational environments and provided ideas for the methodology. The general approach consisted of an initial analysis to reduce the computational time and domain. The optimisation was thereafter performed in multiple stages to gradually build up a pattern with thicker areas. During manufacturing, these thicker areas could be replaced with ribs.

Finally, the computational calculations showed that the approach to apply topometry optimisation in multiple stages was successful. The geometric variation and dynamic response were improved for each stage and thus was the risk for squeak and rattle also reduced. However, improvements of the initial analysis can be considered since these results proved to not be fully accurate. This thesis work provides the basis

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for further exploration of using topometry optimisation to enhance the comfort for drivers and passengers in terms of reducing noise in vehicles. The findings in this thesis can be converted to a manufacturing case for validation and to compare if actually applying topometry optimisation will enhance the performance of a car, as it does in the computational environment.