Optimization Driven Design of Compressor Mounting Bracket

APM ENGINEERING & RESEARCH SDN BHD

KS. Kong

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Background of APM Engineering & Research

Seating Systems
- Complete Seating System.
- New seating mechanisms (Track, Recliner, Height adjustment, Lumbar support)

Interiors and Plastics
- Door Panel and Interior trims & head liners.
- Instrument Panel, Bumper System

Climate Control
- Radiator, Condenser core and assembly.
- Blower fan and shroud.
- Complete A/C Cooling module.

Suspension System
- Range of coil, leaf and parabolic spring, air bellow.
- Shock absorber.
- Corner Module.
- Complete leaf spring suspension Module.
- Gas spring
Optimization Driven Design of Compressor Mounting Bracket

• Introduction
  
  ▪ The compressor plays a very important role in the automotive air conditioning system. It is attached to the engine via a compressor bracket and tightened by bolts. The compressor bracket is exposed to the heaviest vibration conditions among the air conditioning parts.
  
  ▪ Present work deals with FEA analysis and topology optimization of compressor bracket using Altair® HyperWorks®.
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• **Objective of Paper**

✓ To determine the natural frequency of the compressor mounting bracket using modal analysis.

✓ Topology optimization on the compressor bracket to get a new bracket design to improve its stiffness.

✓ To determine the axial and shear loads on the mounting bolts for initial and new bracket design by dynamic load analysis.
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• Statement of Problem

✓ To evaluate bolt failure at the engine mounting locations.
✓ To design a compressor bracket with higher natural frequency.
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• Methodology

Preprocessing Phase
• HyperMesh® for meshing

Solution Phase
• RADIOSS® solver for modal analysis and dynamic analysis

Postprocessing Phase
• HyperView® for results visualization

• Optistruct® for topology optimization
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- **FE Model**

- The compressor bracket is appropriately constrained in its engine mounting position and locations.
- The bolts are modeled with 1D beam element.
- The compressor mass is modeled at its C.G and is distributed to its mounting points.
- A load excitation of 30G is applied in the lateral direction at the engine mounting locations.
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- Modal Analysis (Baseline bracket)

First mode natural frequency: 231Hz
• 30 G Dynamic Excitation on Bolts (Baseline bracket)

Consider the operating vibration frequency is 300Hz, the result shows response peak for both M8 and M10 bolts are above the failure criteria at frequency 231Hz.
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- Topology Optimization by using OptiStruct®

Design Space is the space or areas identified by the designer which could be modified. Non-Design Space are the areas which cannot be modified.

Design objective: Natural frequency min 300Hz

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>231Hz</td>
<td>332Hz</td>
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</table>

Natural frequency: \(\uparrow9\%\)
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- Modal Analysis (Optimized bracket)

First mode natural frequency: 332Hz
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- **30 G Dynamic Excitation on Bolts (Optimized bracket)**

![Graphs showing Axial Bolt Force and Shear Bolt Force](image)

- For the optimized bracket design, the response peak for both M8 and M10 bolts are shifted out of the operating vibration frequency (300Hz), and the design is considered safe.
Benefits summary

- In-depth understanding of problem by analysis result.
- Optimized design in terms of performance and packaging.
- High design confidence level with minimum prototypes.
- Less turn around time for new design of bracket.
- Higher productivity through HyperWorks® integration.
Conclusion

- High vibration level plays a major role in engine mounted component design, especially in the compressor supporting bracket.

- To avoid resonance, bracket natural frequency must be more than vibration frequency operating range. The baseline design of the compressor bracket shows natural frequency was below 300 Hz which is under operating vibration frequency.

- Optimization method was applied to give the right design direction at the stage of designing a new bracket which is stiffer, with natural frequency higher than operating vibration frequency.
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THANK YOU!