Project Specifications

Cummins Active Noise Control

EML4551

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Project Specifications

One key to successful designing lies within the inherit constraints and limitations set forth by the customer, supply, or engineering capabilities. It is these constraints that construct guidelines that can be followed to achieve a successful product. These product specifications aid in focusing the design's progress from initial ideation to project completion. For the active noise control device proposed, the project specifications provide a preliminary description of what the product must do.

The active noise control of an engine cover is to be accomplished by utilizing both active and passive materials. However, the design should incorporate a larger percentage of active material use than passive material use. The active material or materials selected should act as a vibration reducer rather than noise cancelation. The specific active material to be chosen is to be a result of the material's ability to be adapted to the cover's structure, its control over specific frequency and vibration ranges, and its size to actuation force ratio. The active material must also be able to withstand the harsh environment of a diesel engine and the exceptionally long life that diesel engine manufacturers boast. In particular, the material must be able to withstand high temperatures, be environmentally sealed due to electrical power and durability, and perform at different orientations that might arise due to the use of the engine. The passive materials must also be able to withstand a typical diesel engine location. The passive material or materials selected are to target a higher frequency range that the active material will most likely not be able to comply to. These two components of the overall noise control system are to work together to reduce or eliminate surface vibrations that act as the source of the propagated noise.

Due to the characteristics of the Cummin's diesel engine considered for the design, certain geometrical limitations must be met. The main cover being addressed in the project is the gear cover that is oriented vertically on the front size of the engine. The design must not increase the effective thickness of the cover by more than 15 mm, or beyond its outline when viewing the cover from the front. Despite the size limitations, the active material may be applied anywhere on the cover or its connection to the engine. The connection cannot compromise potential joint sealing between the cover and its periphery. If passive materials are considered to be used in conjuncture with the gear cover's periphery, layer materials such as isolation gaskets must be accounted for in the design.

The design project does not require a fully sized working model on a gear cover. A scaled working prototype utilizing active control is a more practical and feasible means for this stage. However, the potential for a comparison of noise reduction relative to a plain cover must be assessable for characterization of the design system's performance and practicality. Due to the improbability of not being provided or able to attain a physical diesel engine, some type of vibration simulator is to be used to replicate the actions of a working diesel engine. The simulator might need to be scaled pending on the magnitude of the targeted vibrations. The prototype must also be completed on the initially set budget of $1500 within the time constraint of two college semesters.

Quantifiable Charts

Any design can be broken up into different components or subsystems. Within the design for a noise reduction devise lie two evident components; an active system and a passive system. The following charts provide a tabular means of portraying the available materials in respect to their specifications.

Active Materials:

		Materials				
		High Temperature Piezo	*Single Crystal Piezo*	*Macro Fiber Composite*	*Galfenol*	*Terfenol*
Attribute	*Temperature Range*	*****	**	**	*****	****
	Frequency Range	*****		**	*****	***
	Force	****	****	**		*****
	Displacement	***	*****	***	****	****
	Ease of Attachment	***	***	****		
	Ease of use	****	****	*****	***	***
	Cost	***	***	*****	*	*

		Attributes					
		Curie Temp (°C)	*Density (g/cm^3)*	*Displacement (pm/V)*	*Force*	*Frequency*	*Dielectric Constant*
Material	*High Temperature Piezo*	450	7.7	401	1000 N	MHz	1578
	Single Crystal Piezo	160	8	2700	1000 N		4000-8500
	GaFeNol	500		1200		MHz	
	Terfenol	380	9.25	1200	1330-1370 N	0-30 KHz	
	Macro Fiber Composite	140	N/A	460	650 N	10 kHz	

Passive Materials:

		Attributes						
		Broadness of Frequency Range	*Temperature Range*	*Cost*	*Ease of Adaptation*	*Attenuation*	*Durability*	*Size*
Materials	*Viscoelastic Sheets*	max attenuation in 3000-8000hz	up to 347 °F		***	max of 35-45 db's (high freq.)	****	**
	Damped Sheet Metal PVP	max attenuation in 3000-8000hz			***	max of 35-45 db's (high freq.)	****	
	Melamine Foam	max attenuation from 1000-4000hz	up to 300 °F	*****	***	82-99% reduction from 1-4 kHz	*****	***
	Damper Layer SWEDAC	*****				****		
	Damping Glue SWEDAC			****	*****			*****

QFD Chart:

		Engineering Requirements										
		Orienation	*Thickness*	*Density*	*Material Strength*	*Durability*	*Toughness*	*Curie Temperatures*	*Attenuation (in DB)*	*Frequency Ranges*	*Force*	*Actuation*
Customer Requirements	*Size*		X	X								
	Operates in Wide Temperature Ranges					X		X				
	Withstand Shock					X						
	Cost				X	X	X	X	X			X
	Withstands Surface Velocity Impact								X	X	X	X
	Geometry	X	X	X								X
	Environmentally Sealed	X				X	X					
	Application		X					X				

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    Jayasimha Atulasimha,1,a_ George Akhras,1,b_ and Alison B. Flatau2,c_
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Additional Note: Reference to the product description provided for the Senior Design course and documentation provided by Cummins representative Richard Varo is to be acknowledged.