Automotive Torque Converter Sound Power Measurement and Design Parameter Correlation

Craig Reynolds, Mechanical Engineering, Michigan Technological University, USA
Jason R Blough, Mechanical Engineering, Michigan Technological University, USA
Carl Anderson, Mechanical Engineering, Michigan Technological University, USA
Mark Johnson, School of Technology, Michigan Technological University, USA
Jean Schweitzer, GM Global Powertrain, General Motors Company, USA

Long Abstract

Introduction

As the desire for more fuel efficient vehicles increases due to more stringent fuel efficiency standards for automobiles new torque converter concepts are being developed to help meet these efficiency goals. The torque converter is undergoing a change in its basic dimensional characteristics as it is pressured to decrease in both axial length and diameter to allow automatic transmissions to add more gears in the same amount or less space in a vehicle. In addition, the size of the hydrodynamic portion of the torque converter is being reduced to make space for added content in the torque converter clutch and damper assembly. The clutch is applied at lower engine speeds for improved fuel economy. With the large changes in the sizes and configurations of the torque converters comes new challenges. It has been seen in testing that as the converters shrink in size cavitation may become more significant both in acoustic power as well as occuring in a broader range of operating conditions.

This paper discusses how sound power can be measured on a torque converter in a space constrained torque converter dynamometer fixture along with the justification for why sound power as opposed to sound pressure level. The sound power results are then used as inputs to a dimensional analysis to form correlations between the peak sound power generated during cavitation and the various torque converter design specifications and operating conditions.

1.Methods

1.1 Sound Power Measurement

Sound power was required for this research instead of sound pressure level because it was desired to understand whether the torque converters measured were loud enough to cause issues or complaints when installed in a vehicle. In order to do this analysis, the more appropriate sound measurement is sound power because it is independent of the environment in which it is measured. Sound pressure levels are dependent on the environment in which they are measured.

The measurement of sound power is typically done using one of several different SAE or ISO standards such as ISO3741[1] or ISO3744[2]. ISO3744 requires a free field environment which is not possible in an enclosed dynamometer cell and so it is not applicable for torque converter work without a very expensive anechoic environment to simulate the free field. ISO3741 requires a reverberant environment which is much more easily and economically obtained in a torque converter dynamometer cell. However, ISO3741 requires that the reverberant chamber be much larger in volume than the sound source being measured. This again is hard to achieve economically.

Since there were no applicable SAE or ISO standards for the torque converter measurement environment which was accessible for this project a new sound power measurement procedure was created and validated for the particular test environment used. This new procedure used a sequence of calibration steps derived from the ISO standards and a large amount of subsequent testing to validate the approach and microphone locations employed. A set of sound sources were created, each similar in size and volume to torque converters to be tested, that could be calibrated in an anechoic chamber to a given sound power. These calibrated sound power sources were then used in the torque converter test fixture to calibrate the sound measurements made in the fixture for a limited number of microphone positions. A statistical study was done to determine the most robust microphone locations for the sound power measurements[3,4,5].

1.2 Dimensional Correlation

For the sound power measurements to be useful to torque converter designers it is desired that there be an understanding of how the various design variables and operating conditions effect the cavitation of the torque converter[6,7]. While previous correlations have been done on torque converter cavitation, the correlations have been relative to when a converter begins or ends cavitation and have not looked at the sound power level vs. the design variables and operating parameters.

In this paper correlations will be developed between the measured sound power levels and the various torque converter design variables such as torus size and shape, stator design, K-factor, unit input speed, and pump and turbine blade angles. Torque converter operating parameters such as fluid temperature, back and charge pressure, speed ratio, input and output rpm, and input and output torques will also be used in the correlations.

References

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