

Benet Labs Uses CFD to Help U.S. Army Design Weapons With Less Noise, Recoil

by Anna Turnage

Men and women serving in the U.S. Army are often subjected to loud noises, whether at war or in training. Among those facing the biggest threat to their hearing are soldiers operating tanks and other artillery vehicles.

Benet Labs, an Army research laboratory, is working to reduce that threat by using computational fluid dynamics (CFD) and high-end visualization software to simulate weapon noise.

Turning Down the Noise

The noise level from weapons in tanks and other artillery vehicles can be caused by the muzzle brakes that are used to help reduce recoil, says Daniel Cler, a mechanical engineer at Benet Labs. The muzzle brakes reduce recoil by turning some of the propellant flow behind an exiting bullet sideways or backward.

While muzzle brakes allow the design of lighter vehicles - - permitting more of them to be transported to a battle site -- they also emit powerful acoustic waves, which can be detrimental to the hearing of the soldiers firing the weapons, Cler says.

"We hope CFD and advanced visualization will help the Army design efficient muzzle brakes that reduce recoil while at the same time keeping noise levels manageable," he says.

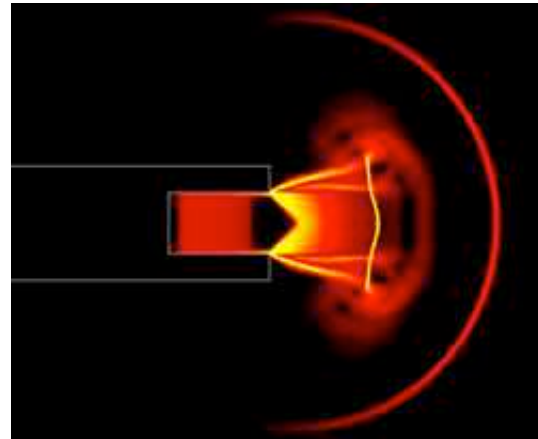
In the past, the only way to measure noise levels was with dynamic pressure instrumentation. This method involves using a 20mm-scale model of the cannon for preliminary results, then a real cannon at the end of the process. It is not only expensive, but also inaccurate, since the data between the scale model and the live cannon don't always match and can alter the final results.

"We hope that by using CFD early in the design cycle, many of the inaccuracies involved in muzzle brake design can be corrected," Cler says.

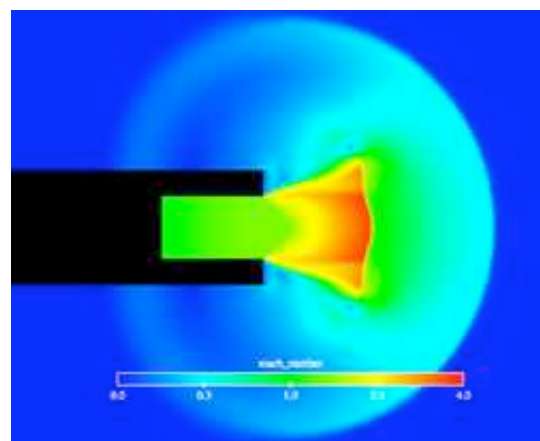
Predicting Blast Waves

Cler starts the CFD process with a CAD model of the gun tube and muzzle brake. A grid for the model is generated using GAMBIT, a meshing tool from Fluent (www.fluent.com). The mesh is then read into Fluent's CFD code to predict the peak overpressure field, which causes the acoustic waves.

"Because it would take an incredibly large, fine grid to model unsteady wave propagation, we use a technique known as unsteady grid adaptation to reduce computational time when tracking the blast waves emitting from the gun barrel," Cler says. "With unsteady grid adaptation, the grid is created only in areas of high-pressure gradient. As the blast wave passes a given location, it is destroyed."



Simulated Schlieren using EnSight gradient function operating on density

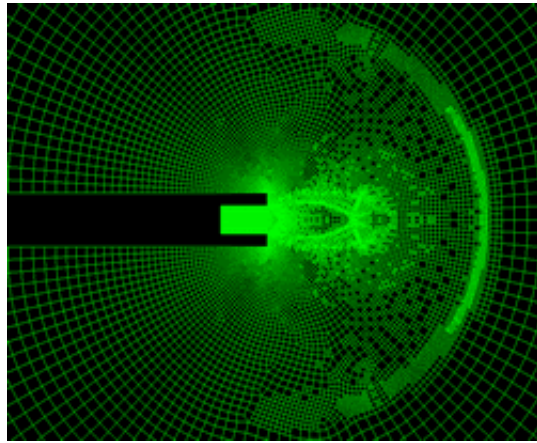


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Making Movies

Adaptation is performed every few iterations of the simulation, making the CFD results transient. The best way to display and understand transient results is through visualization. Benet Labs uses EnSight software from CEI to create animated movies of flow-field properties for the acoustic waves.

"Fluent has the ability to write EnSight-formatted files of scalars, vectors and grid geometry at predefined iteration intervals for unsteady solutions," Cler says. "These files can then be tied together as a single package using an EnSight case file to visualize the flow field as a function of time."



Grid adaptation example at time = $t+$

EnSight has several movie output formats that make it easy to incorporate the files into presentations. Cler uses EnSight to output a Schlieren movie, which depicts pressure or density waves. It helps the researchers understand the strength and motion of shock waves; in this case, the blast wave that follows a projectile before it exits the muzzle of a gun.

"Prior methods to animate CFD results at Benet have included custom programming in Open GL, which can be difficult and time consuming," Cler says. "EnSight makes the task relatively easy. The animations are important, because without them the CFD results of unsteady wave propagation would be challenging to interpret. Seeing the results animated is critical to determining solutions to problems and correcting them."

Successful Test Methods

Benet researchers have learned that a gun muzzle blast can be modeled using Fluent software and the results visualized with EnSight. Cler says he and his colleagues now plan to continue to improve the techniques and apply these tools to actual engineering problems for the Army.

"We expect that these techniques will help the Army meet its goal to produce more efficient vehicles and weaponry while protecting the soldiers operating them," he says.

Click for animation files of this project:

[nearfieldpre_comp.avi - 25.8 MB](#)

[mainflow_comp.avi - 10.7 MB](#)

[farfieldpre_comp.avi - 26 MB](#)

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