Next generation rolled homogeneous steel armor evaluation

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Introduction

Rolled Homogenous Armor (RHA) is commonly used in the composition of almost every armored vehicle. It is often used for the comparison and enhancement of the hardness of various types of armor through processes such as metallurgical alloy modification, ballistic tests, and heat treatments. Two possible paths for next generation RHA experiments are work with FeMnAl and micro-alloyed RHA. FeMnAl is composed of iron (Fe), manganese (Mn), and aluminum (Al). The purpose of this project was to test RHA as a baseline for comparison in future testing with FeMnAl. The aim was to decrease the weight by at least 10%, equivalent to ~6000 lbs. in a M1A2 Abrams tank. FeMnAl has beneficial composition for further experimentation as the alloys contain features such as low density, high tensile strengths, and high-energy absorption (Howell, 2011). The V_{50} Ballistic Test that was conducted is a standard that provides general guidelines for procedures, equipment, physical conditions, and terminology for determining the ballistic resistance of metallic, nonmetallic and composite armor against small arms projectiles ("V_{50} Ballistic Test for Armor," 1997). This test method was implemented to provide a baseline for the different scopes of the project.

Materials and Methods

This experiment was conducted using an RHA plate, averaging 0.0258 m of thickness on the side being tested with a standard deviation of 0.0001 m. The plate was shot with 0.50 caliber APM2 rounds to evaluate the V_{50} of the given plate and the commonly found RHA baseline data. The ballistic set-up and features are found in figure 1. This set-up was locked behind doors when the shot was taken. Precautions and many standing operating procedures (SOPs) were followed inside the range as well. Every button or dial that had a purpose in the shot was locked up and the propellant was prepared in a separate room, so there were no inadvertent shots being taken. As shown in figure 1, the powder gun was placed outside of the room where the sample was being shot. There was a door that closed around the barrel of the powder gun, so it perfectly fit through to allow for proper measurements. Right past the door is a break screen. The break screen was connected to the high speed camera, so when the circuit was opened, the camera started recording. Behind both the break screen and the sample was the witness plate. Behind the witness plate was a sample of old steel to protect against threats to the range.

Materials and Methods (cont.)

The plate was shot five times with variability in the placement on the plate to keep the different shots from disfiguring each other. The grains of propellant was ultimately the independent variable, while the change in velocity and type of penetration were the dependent variables. The starting velocity was calculated at approximately 850 m/s, which required 205 grains of propellant. As the testing went on, propellant was added and taken out as necessary to meet the requirements of the V_{50} test. Several outcomes can occur, all depending on the amount of complete penetrations (CP) and partial penetrations (PP) found in a certain amount of trials. These include 1 + 1, 2 + 2, and 5 + 5 (# of CPs + # of PPs). The 5 + 5 is the most accurate representation of the ballistic evaluation, but is not always used.

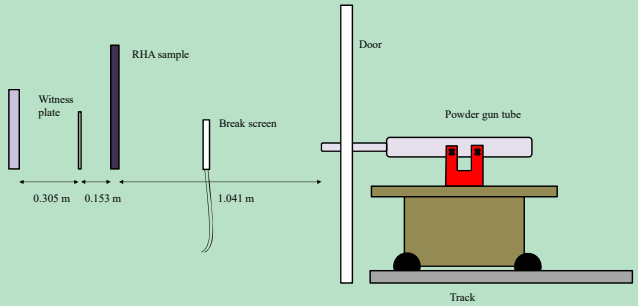
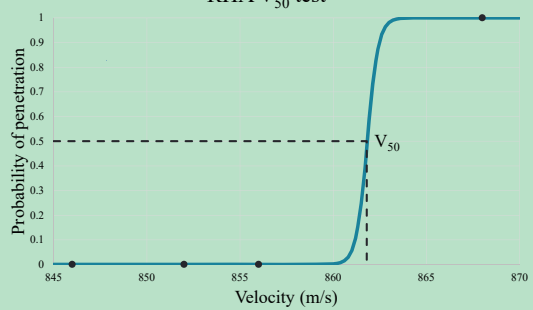


Figure 1 (above): Side view of experimental set-up.

Results



Graph 1 (above): The line graph above contains the five points collected from different trials with RHA. This was created for a baseline as comparison to test other compounds, especially FeMnAl. The V_{50} value is found at 861.8 m/s.

Results (cont.)

After the polishing procedure, the laser confocal microscope was used to properly examine the samples and configure the correct s-curves and V_{50} values. The s-curve found in the graph represents the baseline of common RHA. A zone of mixed results (ZMR) was not found within the RHA data. Dashed lines are present to display the V_{50} value of RHA. The value for the RHA data was about 861.8 m/s. The 2 + 2 test was implemented for this set of data, as it reached two of each complete penetrations and partial penetrations in a span of four trials.

Conclusion

The scope of this project was to assist the development of a new steel alloy's decrease in weight. RHA samples were polished for practice before real samples were applied. FeMnAl samples with misaligned chemistry were also polished. The percentage of aluminum in these samples was too light, which led to cracking. These samples were tested, polished, and studied under the laser confocal microscope. Many pictures were taken of the FeMnAl for a comparison. The mechanical property characterizations found were a poor indicator of ballistic performance, as the elongation is not directly proportional to the data found as a whole. A majority of the field work included the cutting down and polishing of older samples as practice for the real samples being received. Many problems were encountered along the way, especially with the polishing procedure. The plates used on the polishing table were almost always scratched up with some material other than the one the plate was intended for. These problems could be easily fixed by finding newer plates. The future of this project is beneficial to the evolution of armor applications, and therefore, should be continued. With a comparison to RHA, FeMnAl has many unique properties in its structure and ballistic performance. Throughout further experiments and studies, the change in chemistry of the FeMnAl samples will assist in the search for lighter armor.

References

Howell, R. A., Ph.D. (2011). *Microstructural influence on dynamic properties of age hardenable FeMnAl alloys* (Dissertation). Aberdeen Proving Ground, MD: U.S. Army Research Laboratory.

V_{50} Ballistic test for armor (Rep. No. MIL-STD-662F). (1997). Aberdeen Proving Ground, MD: U.S. Army Research Laboratory.