AD

AD-E403 369

Technical Report ARMET-TR-11031

M119 HOWTIZER SADDLE GUN FIRE FINITE ELEMENT ANALYSIS

R. Terhune
S. McDonald
M. Kotliar

December 2011

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

Munitions Engineering Technology Center

Picatinny Arsenal, New Jersey

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-01-0188*

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (*From - To)*
December 2001	Final	December 2010 to May 2011

4. TITLE AND SUBTITLE

M119 HOWITZER SADDLE GUN FIRE FINITE ELEMENT ANALYSIS

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS

R. Terhune, S. McDonald, and M. Kotliar

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army ARDEC
Fuze & Precision Armaments/Muntions Systems & Technology Directorate (RDAR-MEF-E/MEM-A)
Picatinny Arsenal, NJ 07806-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army ARDEC, ESIC
Knowledge & Process Management (RDAR-EIK)
Picatinny Arsenal, NJ 07806-5000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Technical Report ARMET=TR-11031

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The M119 howitzer is the current fielded 105-mm artillery weapon. It is undergoing upgrades to the fire control system in which they will be adding new components and brackets to the existing system. Finite element analysis (FEA) was performed to determine the stress contours along the side of the saddle (a sub-system of the howitzer) in regions where holes will be added for fire control brackets. The FEA results were validated by strain gauge data from live fire test and provided the needed insight for verifying the hole locations.

15. SUBJECT TERMS

M119 Howitzer 105 mm Artillery Finite element analysis (FEA) Strain gauge Saddle Fire control

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON R. Terhune
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)
U	U	U	SAR	19	(973) 724-1383

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

CONTENTS

FIGURES

FIGURES
(continued)

INTRODUCTION

The M119 howitzer is the U.S. Army's currently fielded 105-mm artillery weapon system. The M119A3, which is in production, will entail an upgrade to the fire control system. With this upgrade, new assemblies, components, brackets, and holes will be added to the existing M119 gun system in various locations. The scope of this analysis remains on the saddle subsystem of the howitzer. The saddle is the main structural support for the cannon, recoil system, and cradle and remains seated on top of the trail box. The goal of this modeling and simulation effort was to determine if the proposed addition of holes in the saddle should be in regions that see high stress. In addition, the finite element analysis (FEA) results will be compared with strain gauge data from testing for validation in the model.

METHOD

The stress contours and values in the M119 saddle were determined using modeling and simulation. The general purpose finite element program, ABAQUS Explicit 6.10.ef1 (ref. 1) was used. The models were non-linear and dynamic.

GEOMETRY

Figure 1 shows the saddle geometry.

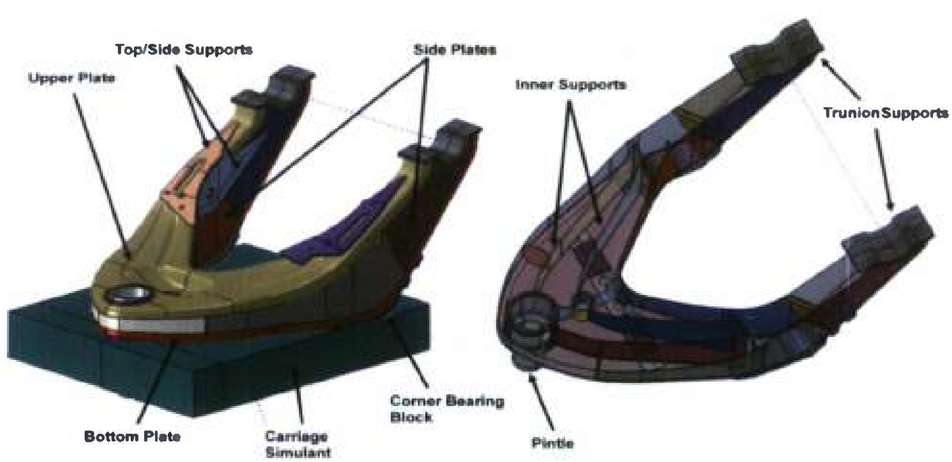

Figure 1
Saddle geometry

FINITE ELEMENT MESH

The finite element (FE) mesh is displayed in figure 2. All the sheet metal parts were modeled with 8-node continuum shell elements with five integration points through thickness. There are 111,065 elements in total in the model consisting of 42,839 8-node hexahedral elements, 66,926 8-node continuum shell hexahedral elements, and 1,300 10-node tetrahedral elements.

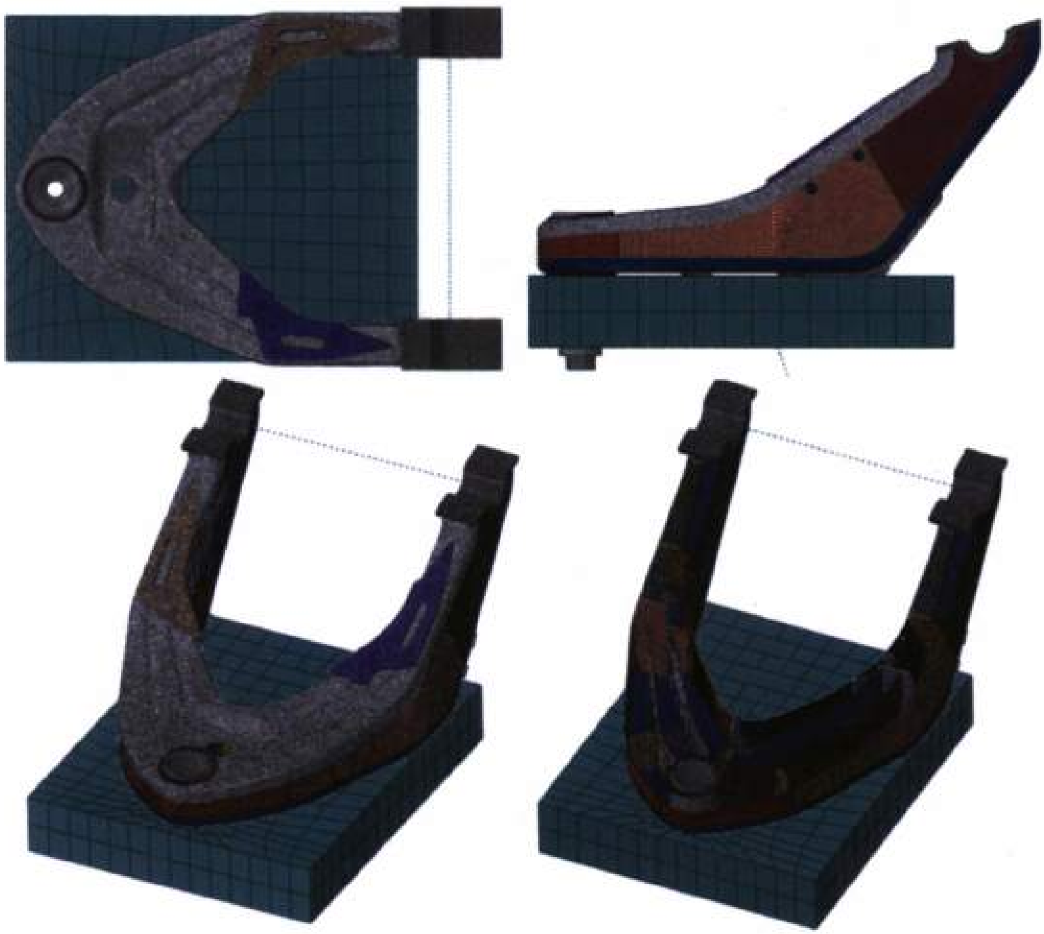

Figure 2
Saddle finite element mesh

MATERIALS

The model used linear elastic material properties. The M119 uses a British stainless steel, but for the purpose of this analysis, a 17-4 stainless steel was used since its material properties match well.

Part	Material	Modulus (psi)	Poisson Ratio	Density (lbf*s^2/in^4)	Yield (psi)	Ultimate True Plastic Strain	Ultimate True Stress (psi)
Entire Assembly	17-4 S.S.	2.85E+7	0.27	.000732	125,000	0.11	163,850

APPLIED CONSTRAINTS

General frictionless contact is applied to the entire model at all contacting surfaces. Tie constraints were used to simulate all the welds that connect each part of the saddle (fig. 3). Given this may artificially strengthen the saddle, it's a close approximation, and since the regions of concern were away from the weld, the overall stress contours should not be affected (figs. 4 and 5).

Figure 3
Tie constraints between various parts of the saddle

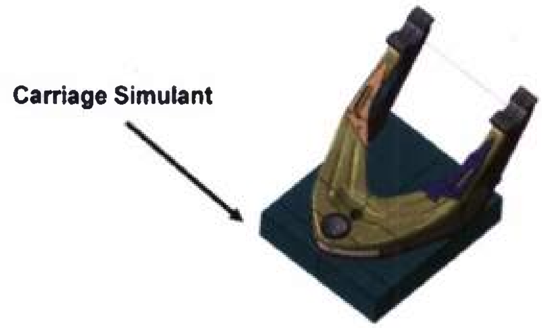

Figure 4
Rigid body constraint on the trail box (carriage) stimulant

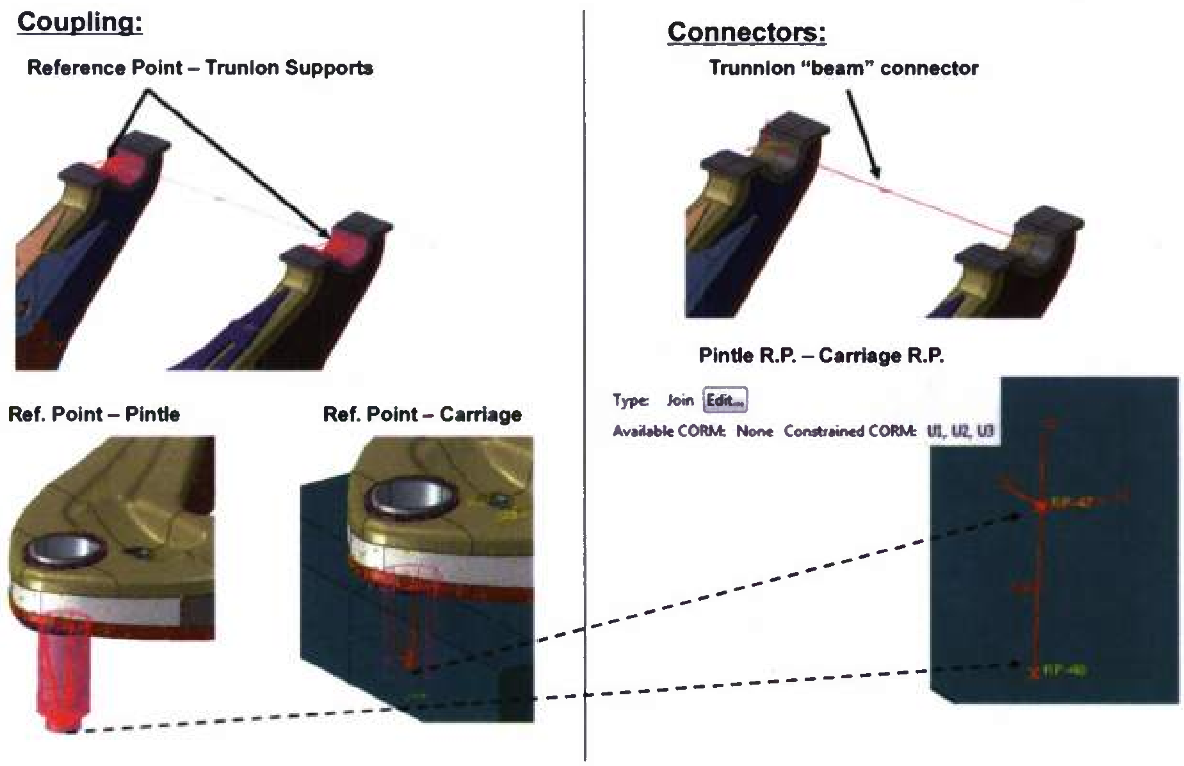

Figure 5
Coupling of reference points to geometry and connectors between reference points

APPLIED LOADS AND BOUNDARY CONDITIONS

The force and acceleration loads for this FEA model were provided by a rigid body kinematics model of the M119 weapon system at a quadrant elevation (QE) of 1244 mil. The force from the trunnions can be seen in figure 6 and is applied to the saddle as seen in figure 7. Figure 8 displays the acceleration boundary condition that is applied to the trail box stimulant as seen in figure 9. This will drive the trail box and saddle motion as it's loaded with the trunnion force.

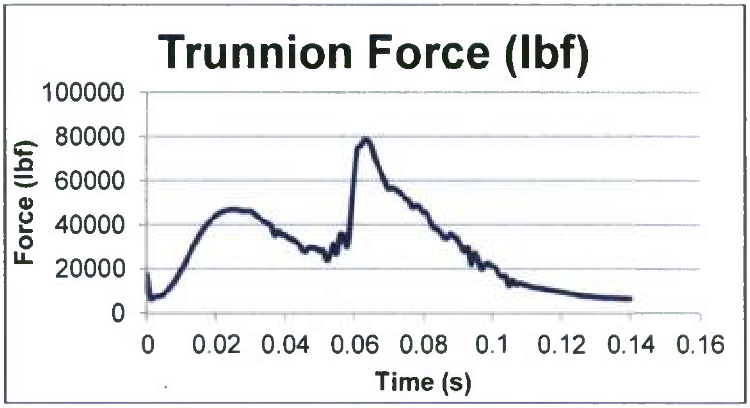

Figure 6
Trunnion force versus time plot

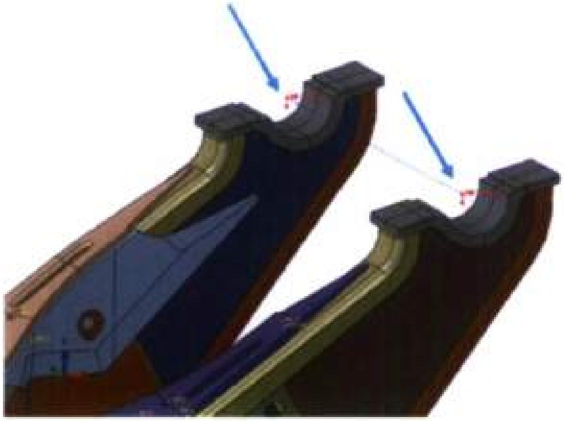

Figure 7
Force loading on the saddle
(Note: half the total load applied at each reference point and load applied with horizontal and vertical components)

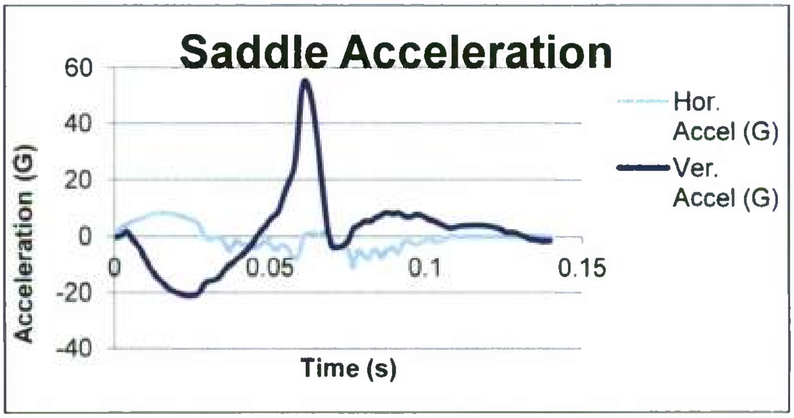

Figure 8
Acceleration versus time plot of the trail box

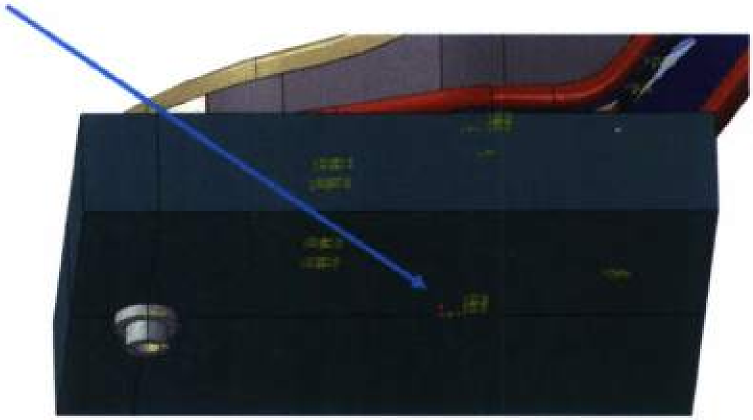

Figure 9
Acceleration boundary condition applied to a reference point couples to the trail box

RESULTS

The FE analysis converged to a solution and produced confident results. At the first peek in the force loading, the stress contour can be seen in figure 10. In figure 11, the stress contour of the saddle at the force maximum is seen. The regions of concern are circled in red. Overall, the regions where holes are being added see low stresses during gun fire.

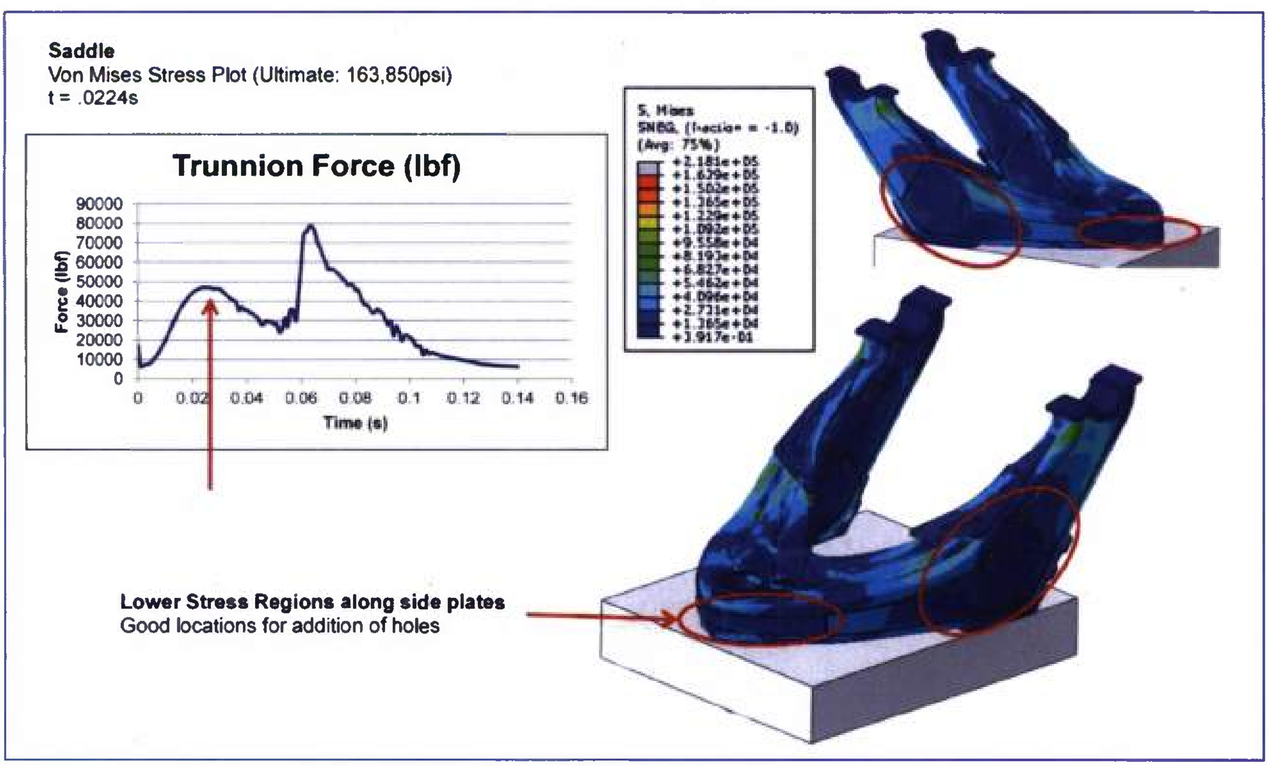

Figure 10
Von Mises stress contour plots of the saddle at t=0.0224s

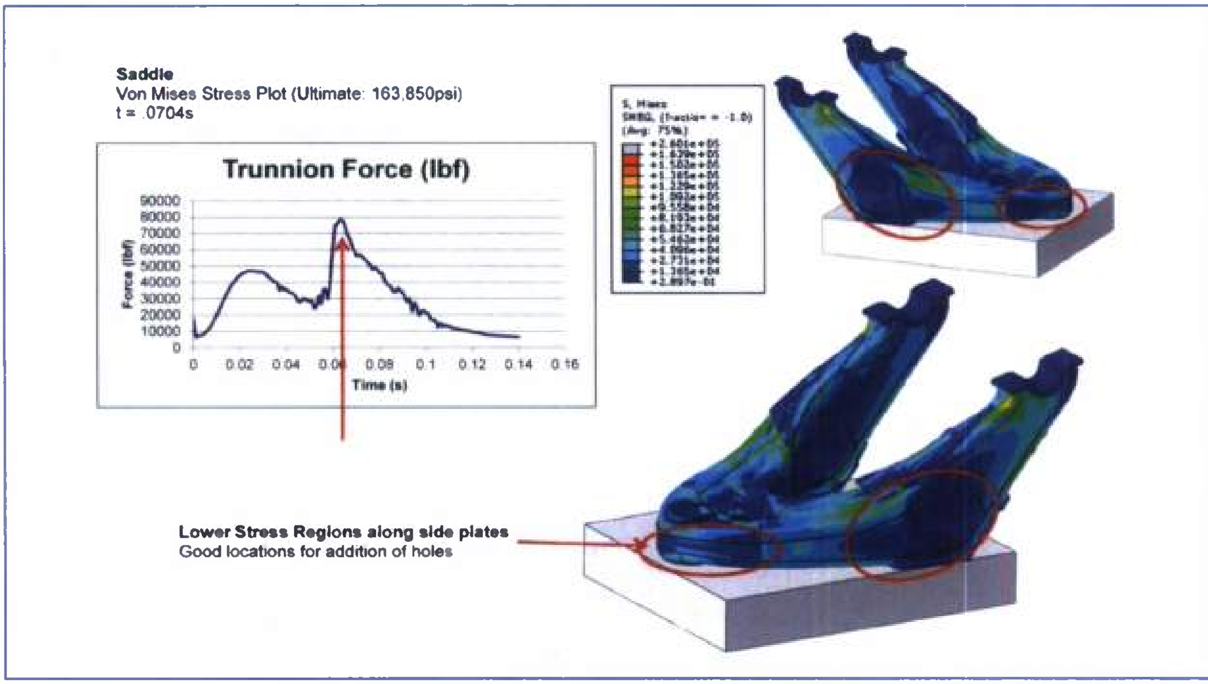

Figure 11
Von Mises stress contour plot of the saddle at t=0.0704s

The Von Mises stress values at specific locations on the saddle were recorded in the analysis so they could be compared to strain gauge derived stress values. Figures 12 and 17 show the locations and element numbers that were chosen. Stress comparisons for gauges 1 to 4 are displayed in figures 13 through 16 and for gauges 17 to 19 in figures 18 through 20.

Gauge	Part Instance	Element Number
SG1	I19200_12591876_PLATE	341
SG2	I19200_12591876_PLATE	1096
SG3	I19200_12591876_PLATE	1397
SG4	I19200_12591858_PLATE	463

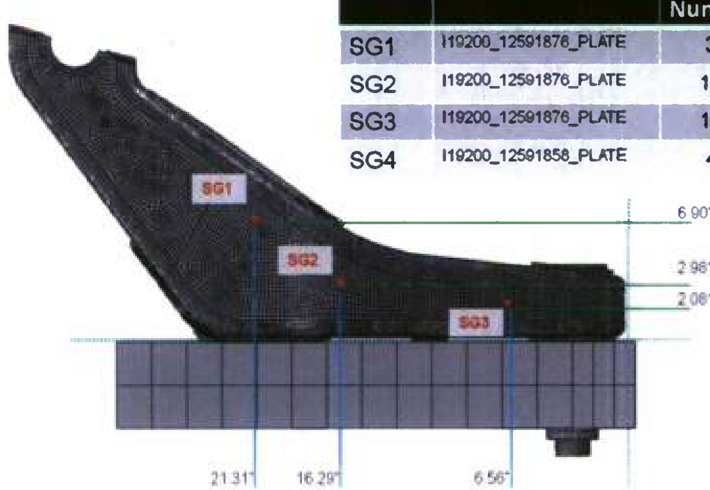

Figure 12
Strain gauge locations 1 to 4 used to compared to live fire testing

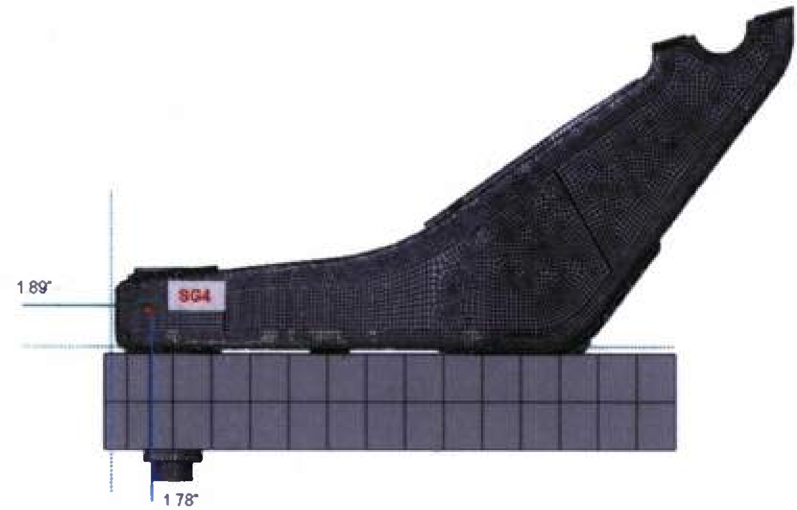

Figure 12
(continued)

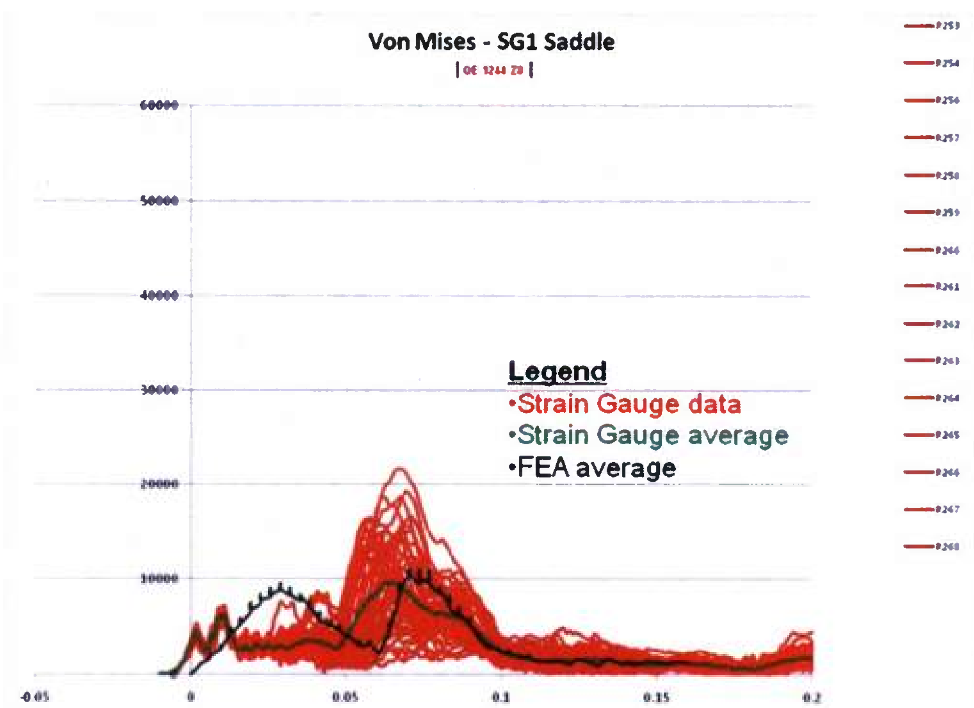

Figure 13
Strain gauge 1 comparison

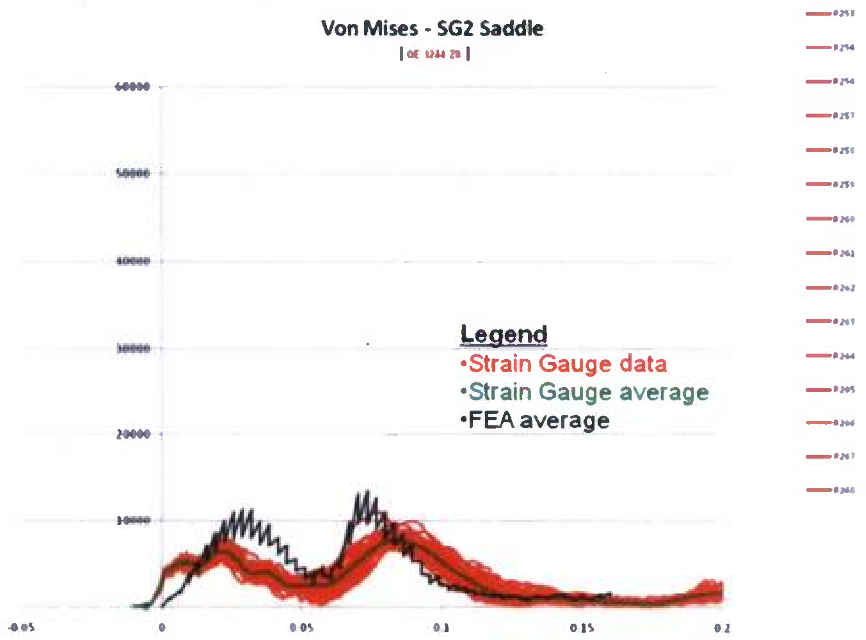

Figure 14
Strain gauge 2 comparison

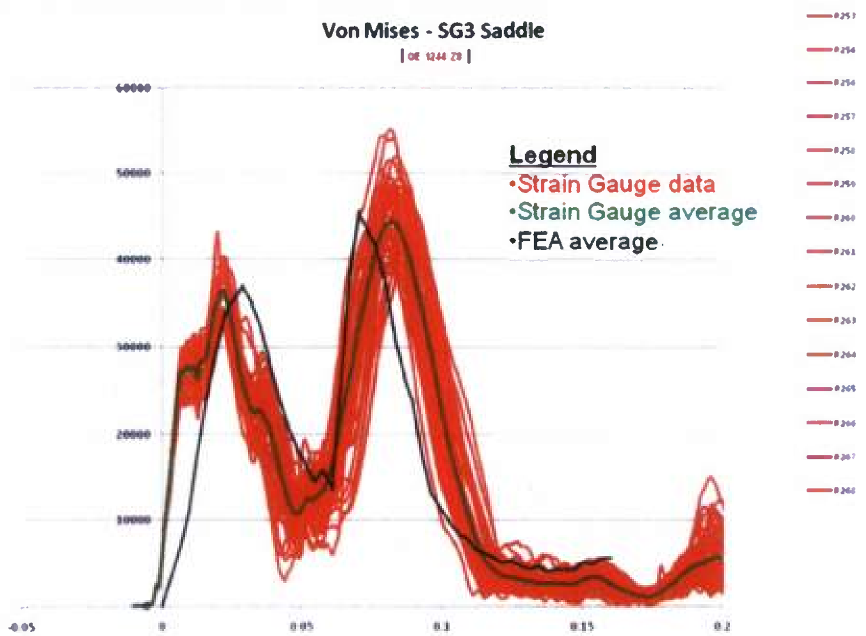

Figure 15
Strain gauge 3 comparison

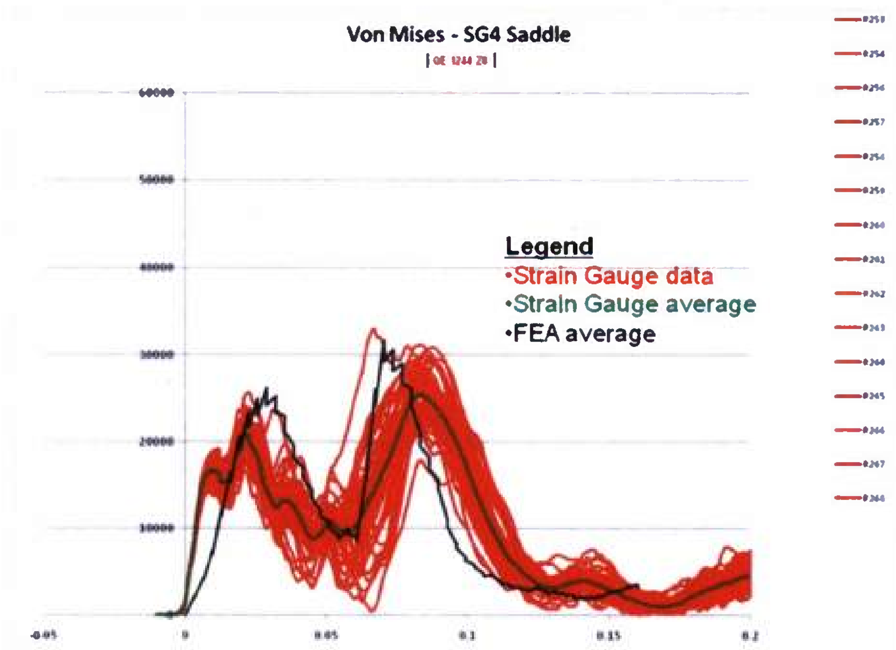

Figure 16
Strain gauge 4 comparison

Gauge	Part Instance	Element Number
SG17	I19200_12591867_PLATE	11700
SG18	I19200_12591867_PLATE	3151
SG19	I19200_12591860_PLATE_BOTTOM	2549

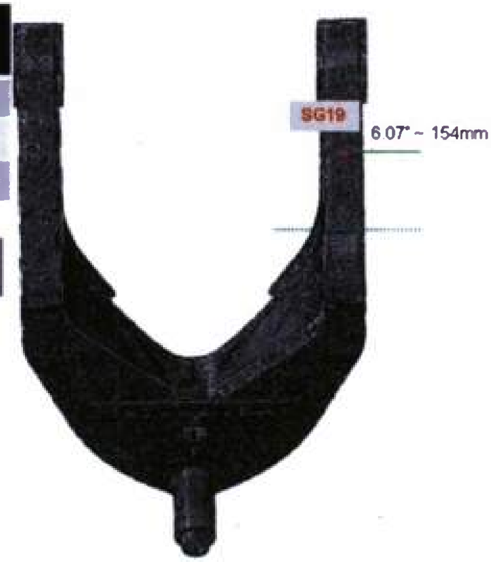

Figure 17
Strain gauge locations 17 to 18 used to compare to live fire testing

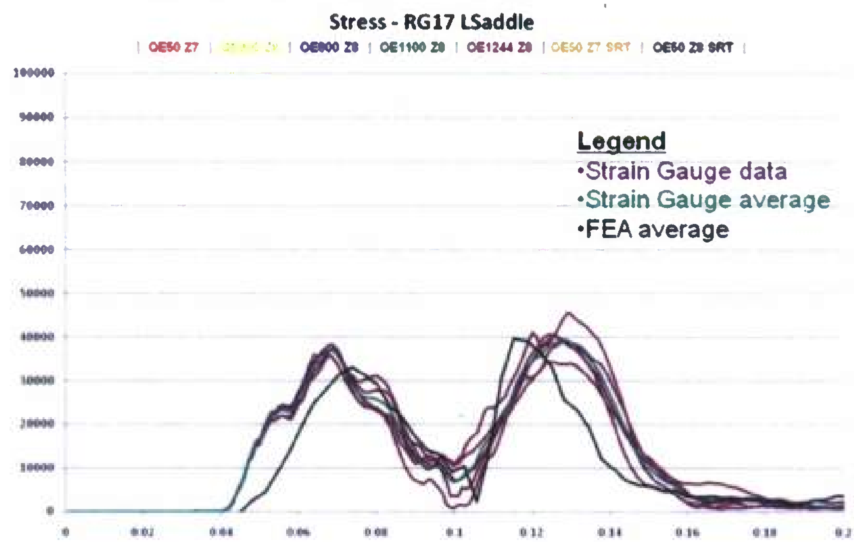

Figure 18
Strain gauge 17 comparison

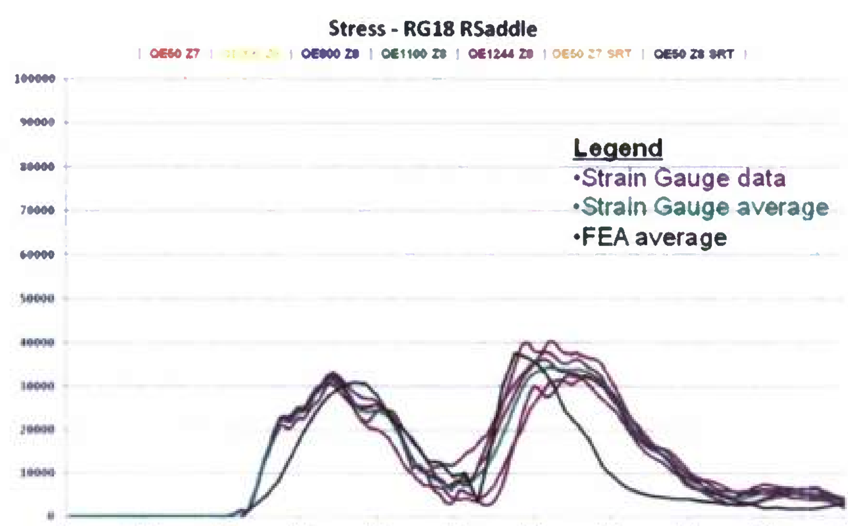

Figure 19
Strain gauge 18 comparison

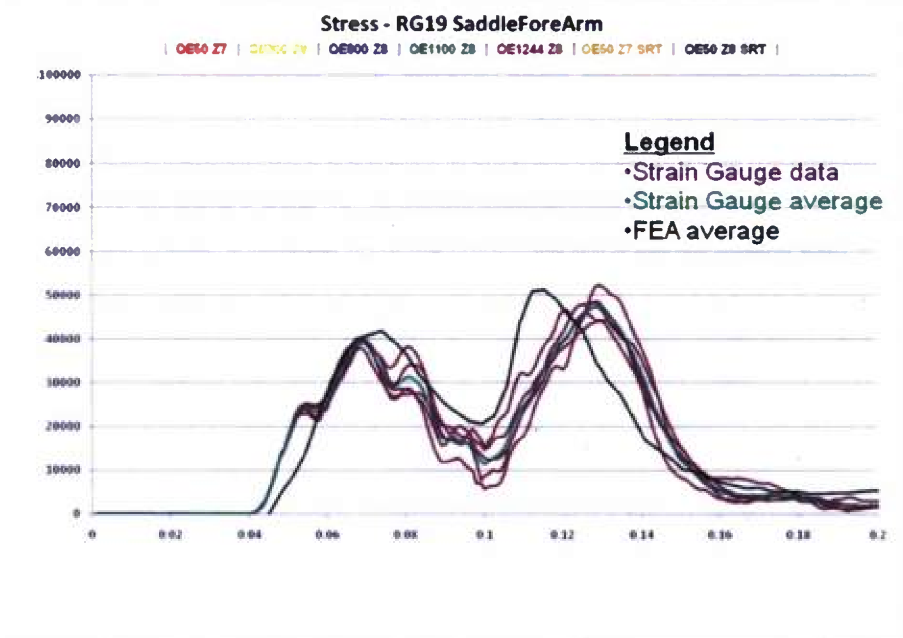

Figure 20
Strain gauge 19 comparison

CONCLUSIONS

The model and simulation was able to capture the high rate gun fire event with confidence and proved to be an effective aid in the redesign to the weapon. Mesh refinement models were also run to verify that continuum shell elements produce accurate stress results as compared to typical three-dimensional hexahedral elements. Overall, the analysis results provided accurate stress contours over the saddle in the regions of concern. Validation and correlation was achieved as the finite element analysis stress values matched up well with live fire test strain gauge data at multiple locations on the saddle. With confidence in the model results, decisions can be made with regards to what locations would be appropriate for adding holes in the saddle for new components.

REFERENCES

1. "ABAQUS User Manual V6.10.1," Dassault Sysstems 2004-2010.

DISTRIBUTION LIST

U.S. Army ARDEC
ATTN: RDAR-EIK
RDAR-GC
RDAR-ME, J. Hedderich
RDAR-MEF, W. Smith
RDAR-MEF-E, R. Terhune (2)
RDAR-MEF-E, D. Troast
A. Totten
RDAR-WSW-I, M. Kotliar
S. McDonald
Picatinny Arsenal, NJ 07806-5000

Defense Technical Information Center (DTIC)
ATTN: Accessions Division
8725 John J. Kingman Road, Ste 0944
Fort Belvoir, VA 22060-6218

Commander
Soldier and Biological/Chemical Command
ATTN: AMSSB-CII, Library
Aberdeen Proving Ground, MD 21010-5423

Director
U.S. Army Research Laboratory
ATTN: AMSRL-CI-LP, Technical Library
Bldg. 4600
Aberdeen Proving Ground, MD 21005-5066

Chief
Benet Weapons Laboratory, WSEC
U.S. Army Research, Development and Engineering Command
Armament Research, Development and Engineering Center
ATTN: RDAR-WSB
Watervliet, NY 12189-5000

Director
U.S. Army TRADOC Analysis Center-WSMR
ATTN: ATRC-WSS-R
White Sands Missile Range, NM 88002

Chemical Propulsion Information Agency
ATTN: Accessions
10630 Little Patuxent Parkway, Suite 202
Columbia, MD 21044-3204

GIDEP Operations Center
P.O. Box 8000
Corona, CA 91718-8000