

Physics Assignment – Abaqus results and theory – Connor Hamill - 2224953

Aim of the assignment

The aim we gathered from this assignment was to determine the different impacts on a material from a projectile (bullet) and in this case the difference was the speed at which the bullet travelled. The different speeds were 1200 meters per second and 700 meters per second, and with results to prove the different impacts.

Purpose of the assignment

The purpose of the assignment overall was to figure out the relationships between stress and strain when the velocity of a projectile (bullet) is changed and how this is going to impact the stress vs strain

The theory behind this can be found using the following formulas

Stress formula - $\sigma = \frac{F}{A}$

σ = stress

F = force

A = area

Strain formula - $\varepsilon = \frac{\Delta l}{l}$

Stress / Strain Theory

Stress is defined as the ratio of the force to the cross section of the area of the object being transformed, the force acts perpendicularly to the cross section of the object, as well forces that act in such a way will not change the length of the object. Whereas strain is the measure of the deformation of an object under tensile stress and is defined as the fractional change of the object's length when the object experiences tensile stress.

When a force acts on an object, the object may change shape by bending, stretching, or compressing - or a combination of all three shape changes. However, there must be more than one force acting to change the shape of a stationary object. There are always forces acting on a material even if it appears to be stationary there will be a force present, the five terms for forces are as follows:

Tension – Can be tested by pulling opposite ends of the metal. The tensile strength can be tested to see if the chosen metal will be fit for purpose by fixing a piece of metal to a point and then loading it with a pulling force.

Compression – Compression can be tested by applying a force on top of the piece of metal. If the metal compresses, then reinforcing the metal could be an option.

Torsion – Torsion can be tested by securing the end of the metal in a vice. The other end can then be twisted to see if the metal can withstand the force. If there is a twist, bracing one piece of metal to another can prevent deformation due to both torsion and shear forces.

Shear - Shear forces act in different directions and cut across a material, but a huge amount of force is needed to shear through a piece of metal. If a piece of metal is cut using tin snips, the cut will have been made by a shear force.

Elasticity is another term for Young's modulus

A change in shape is called deformation:

Elastic deformation is reversed when the force is removed

Inelastic deformation isn't fully reversed when the force is removed – this change in the shape will become permanent

A rubber band undergoes elastic deformation when stretched a little. A metal drink can undergo inelastic deformation when it is squashed.

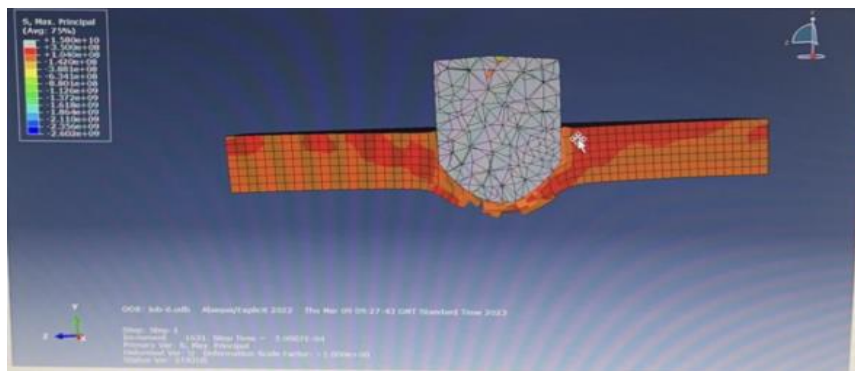
Abaqus/Results

To complete the assignment given to us we had to carry out simulation tasks on a software called Abaqus, the task at hand was to test a bullet going into an aluminium pad, the choice to differ yours from everyone else's allowed us to either change metal of the projectile or change its velocity (meters per second), I decided to go for a changed velocity.

Test number 1 being the steel projectile must be travelling at a velocity of 1200 meters per second and for Test 2 the same steel projectile at the same trajectory to be travelling a 700 meters per second, through the results that will be shown later we can tell the big difference that a velocity of 500 will affect the damage suffered by the pad and the subsequent stress/strain felt by the aluminium pad.

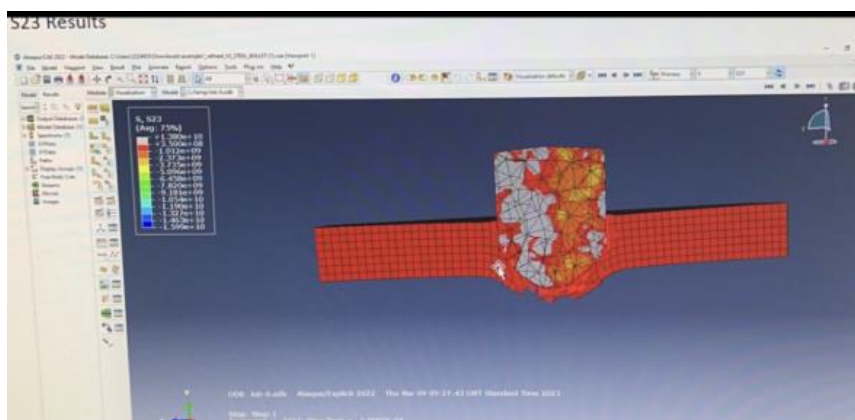
For the 1200 velocity projectile the results shown below indicate a high/heavy impact with the strain and stress being immense

Image 1 – Test 1



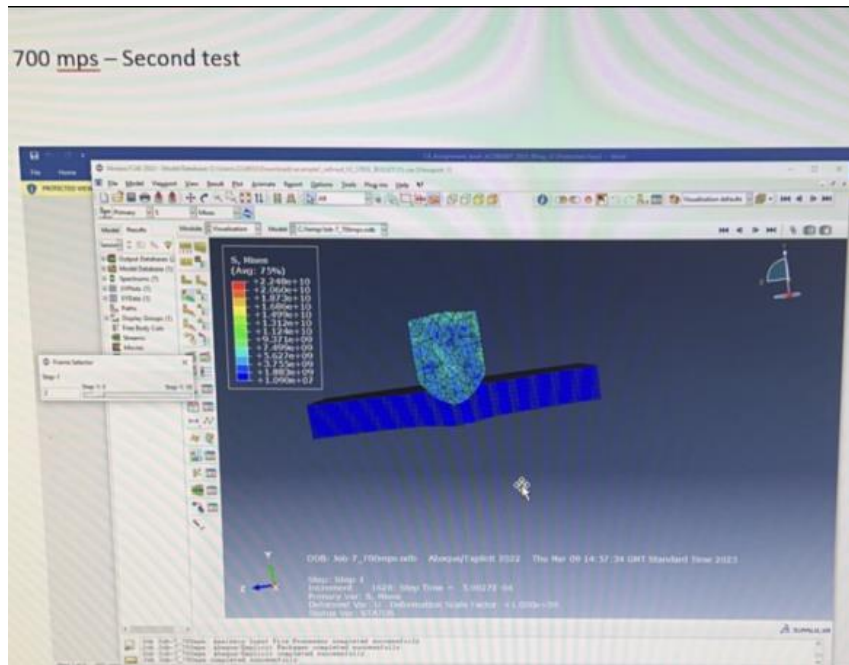
The first image shown shows the initial impact of the steel projectile, initially stress waves can be seen flowing within the aluminium pad just ahead of the projectile. These waves start to dissipate towards the edge of the material and the back side of the plate starts to deform due to the strain caused by impact.

Image 2 – Test 1



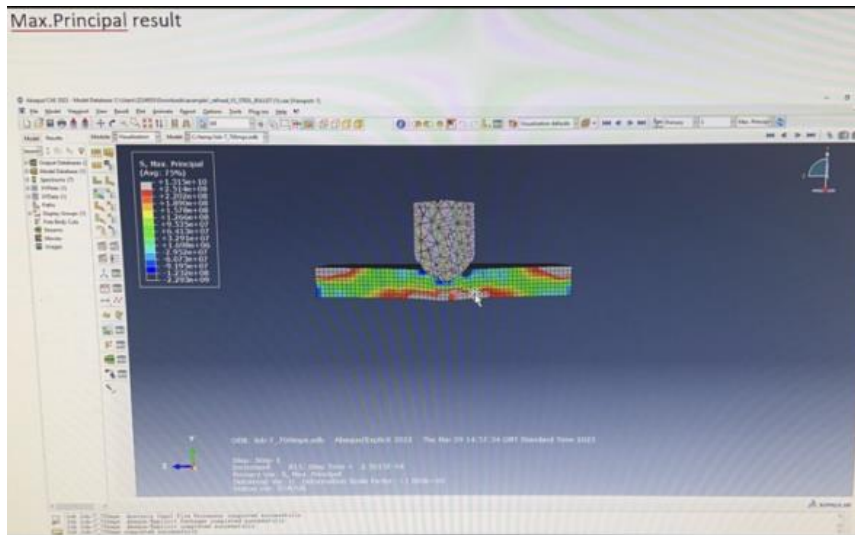
shows how the back of the aluminium plate has been affected from major deformation with regards to the substantial increase levels of tension across the surface. The failure to withstand the projectile is shown by the change in colour at back of the plate which has changed to a full red colour representing stress of $+3.5 \times 10^8$

Image 3 – Test 2



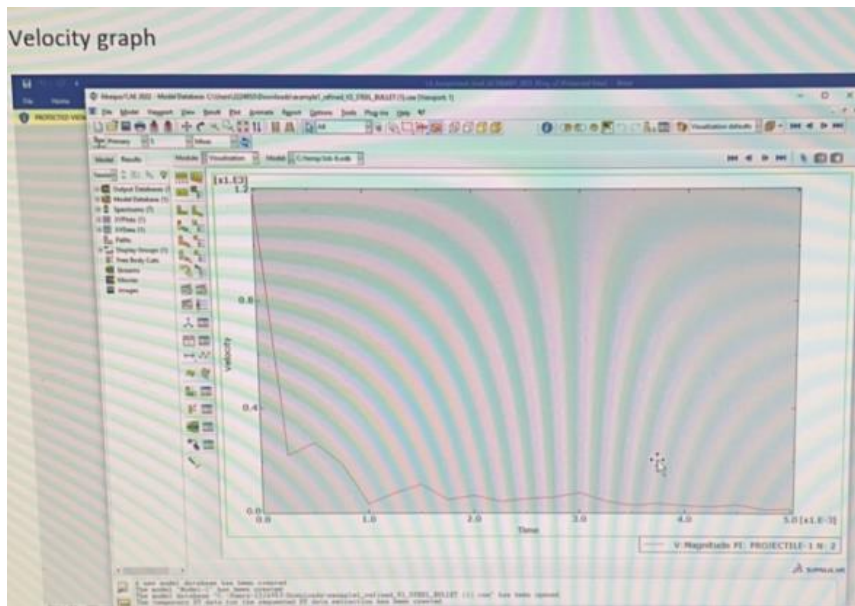
The third image shown shows the initial impact of the steel projectile, this time however at a speed of 700 meters per second, compared to the first projectile the second one due to going at a speed of 500 meters per second less than the original barely penetrates the aluminium pad and produces a much less stress compared back, instead giving a value of 1.090×10^7

Image 4 – Test 2



Within Test 2, like the first test initially stress waves can be seen flowing within the aluminium pad just ahead of the projectile. These waves start to dissipate towards the edge of the material and the back side of the plate starts to deform due to the strain caused by impact. However due to the reduction in speed the waves are travelling with a lower impact, but if you look at the bottom the grey and red areas suggest that there is high pressure there as well as the corners due to the bending of the aluminium pad.

Image 5 – Test 1 velocity/time graph



The velocity graph shown above indicates the high speed the projectile was travelling at and after it collides with the aluminium pad it ends abruptly almost collapsing down and reaching 0 meters per second.

Conclusion

Overall, during the course of completing and writing this report I have gained knowledge in both areas of stress/strain and as well as the technical Abaqus side of the experiment. Through various images and the velocity time graph the results are apparent that due to the test 12 having a much higher velocity (1200 meters per second) compared to the test 2 which had a lower speed of only (700 meters per second), the first test clearly penetrates the metal producing a much higher stress on not only the projectile itself but the aluminium pad that it collides with. If we were to repeat this experiment it would be valuable to change the models properties such as metal used and bigger velocity differences, this could lead to gaining more beneficial and accurate data. User error could have also come up whilst completing this assignment which would limit the observations gathered within the experiment, but substantial knowledge surrounding CAD and FEA software was gained. Overall, the experiment was a success and a great learning experience for the user as a better understanding of ballistics and modelling was developed.

References

1. [Forces and stresses - Metal-based materials - AQA - GCSE Design and Technology Revision - AQA - BBC Bitesize](#)
2. [12.3 Stress, Strain, and Elastic Modulus - University Physics Volume 1 | OpenStax](#)
3. [Stress and Strain - Definition, Stress-Strain Curve, Hooke's Law, SI Units \(byjus.com\)](#)

