

Tech Report

by Luke Penny

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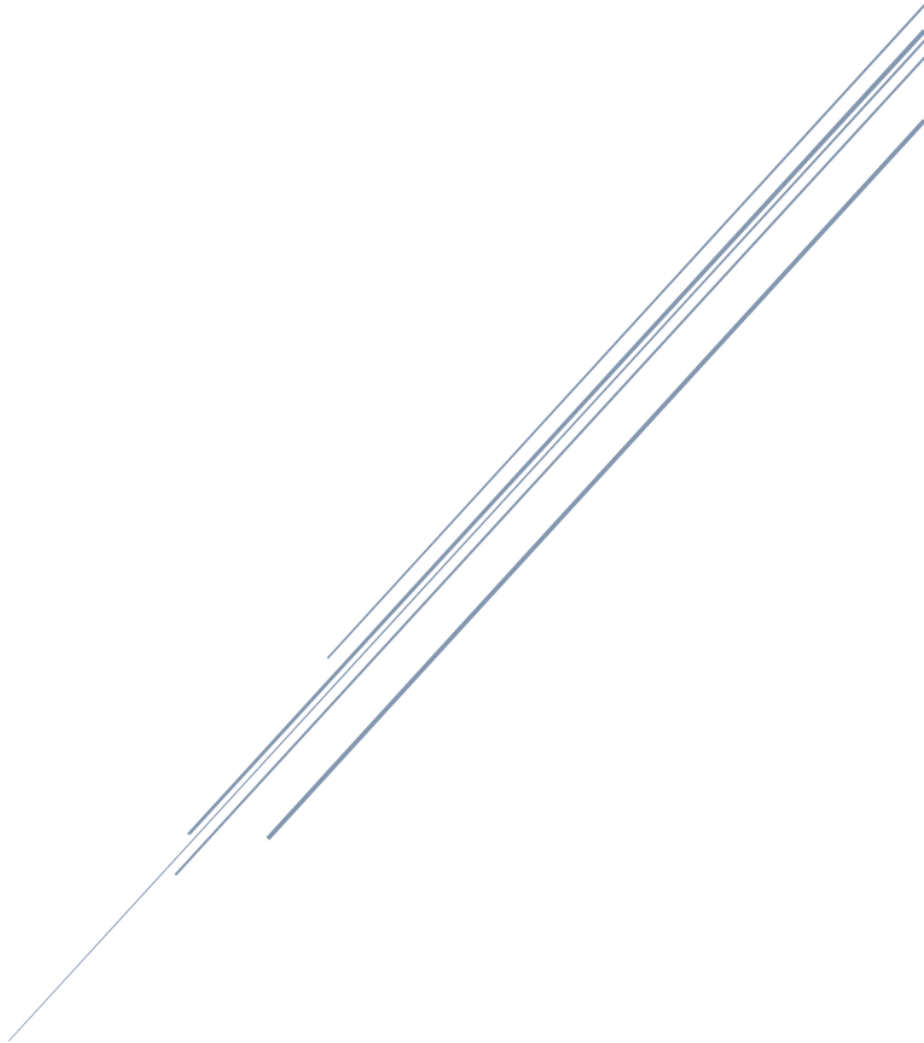
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*“Was the longbow the decisive
weapon at the Battle of
Agincourt?”*



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1810356

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1. Abstract

I discuss and outline the battle of Agincourt and the tactics employed by the English and French ranks. The armament and weaponry of the period and the role they played in the battle of Agincourt. Information gathered from sources about the longbow and bodkin arrow have been inputted into modern day penetration calculations to understand their performance against plate armour. I outline a study into the effectiveness of the longbow at penetrating plate armour. Finally, I conclude that the longbow was the decisive weapon of the battle but not the decisive factor in the English triumph.

2. Introduction

In this report I will outline whether I think the longbow was the decisive weapon at the Battle of Agincourt in 1415. The battle of Agincourt was part of the Hundred Years Wars, a late medieval conflict between England and France. The actual war lasted 116 years, from 1337 – 1453. The reports and sources are limited in availability and many figures change from one source to the next, especially in terms of losses on both sides. There is some bias in English accounts of the battle, exaggerating the size of the French army and the lack of their own men-at-arms.

I will look into the Armour and Weaponry of the period and the part they played in the battle, as well as the technical aspects of modern-day representation of the subject matter. Modern penetration calculations will be used to understand the arrow performance and whether this was the decisive weapon in the battle at Agincourt.

3. The Battle of Agincourt 1415

Henry V, on the 11 August 1415 sailed from Southampton with an army of approximately 12,000 men. After 3 days of sailing, they reached the northern French coast and started their campaign by surrounding the port of Harfleur. The siege lasted until the 22nd of September and lost Henry more soldiers than anticipated. Henry and his campaign marched east with dwindled numbers, reports claim around 9,000 men, but some chronicles from the period claim the numbers to be much lower as shown in *figure 1*. [1]

The Gesta Henrici Quinti (c. 1417, Latin) – A re-print of “The Deeds of Henry the Fifth”, translated from Latin. It can be generally agreed that the more reliable and accurate account of the events at Agincourt can be taken from this text although the author is anonymous, it was still partly written as a direct result of the battle. The ‘Gesta’ was written shortly after the campaign with the last date in its text being 20 November 1416. It starts with the coronation of Henry as king on 9th April but it is not a full narrative of his reign. [1]

Table 1. Chroniclers' estimates of numbers

Chronicle	English army	French army	English dead	French dead
<i>Gesta</i>	6,000 ^a	60,000	4 named: 9–10	5,598–6,598
<i>Liber Metricus</i>	7,000 ^b	60,000	2 named: 30	9,310
Walsingham	8,000	140,000	7 named: 28	3,080
Otterbourne	1,500 ships	60,000	2 named: 30	1,598
Usk	10,000	60,000	27	8,523
Streeche	8,000	100,000	–	–
Tito Livio	c	–	2 named: 98	10,004
Pseudo Elmham	–	–	2 named: 100	9,000–10,000
Capgrave, <i>De Illustribus Henricis</i>	7,000 ^d	60,000	2 named: 30	8,614
Capgrave, <i>Abbreuiacion</i>	8,000 ^e	140,000	9 named: 28	4,078
Hardyng	9,000	100,000	4 named	1,508
Basset, <i>College of Arms MS 9</i>	16,500 ^f	150,000	4 named: 10	2,400?
Benet	11,000	100,000	–	–
<i>Brut</i>	7,000	120,000	2 named: 26–28	11,000–12,000
London Chronicles	10,000	60,000–80,000	5 named: 23	5,000
Latin <i>Brut</i>	8,000	100,000	2 named: 100	11,000+
Religieux	12,000 archers	8	–	4,000
De Cagny	80,000–100,000	–	–	5,000–6,000
Ruisseauville	8,000–9,000	–	–	7,600–7,800
Des Ursins 1	20,000–22,000 ^h	–	–	4,000
Des Ursins 2	38,000 ⁱ	8,000 ^j	–	–
Monstrelet, Waurin, Le Fèvre	11,000 ^k	50,000	600(M): 1600 (Waurin Le Fèvre)	10,000+
Bourgeois de Paris	–	One and a half times English	–	–
Berry herald	16,500–17,500 ^l	10,000 men-at-arms	2 named: 300–400	4,500–4,600
Tramecourt	–	–	–	10,000
Richemont	11,000–12,000	10,000	–	–
Morosini	100,000 ^m	–	–	–

Figure 1 - Chroniclers estimates of numbers [1]

Henry marched east with an attempt to reach English-controlled Calais. French forces followed them trying to block any route and force a battle. Henry and his forces evaded the French and crossed the river Somme on the 19th of October only to be confronted with French forces some 45 miles south of Calais, near Agincourt.

On 25th October, Henry led the English army into battle against the French at Agincourt. A larger French force was led by Charles D'Albret. It had rained for several days before the battle and Henry had positioned his troops well on top of a hill with trees either side. The French in their confidence for victory, decided to charge the English line with their cavalry rather than sending in archers and infantry first. The horses were slowed down by the quagmire of mud from the previous days rain and the burden of the knight's armour. They were decimated with arrows and many a knight found himself on foot – *this could be an indication of the longbow's penetrative power at long distance*. The remains of the mounted French brigade were only to be stopped by pikemen and large stakes buried in the ground at chest height. They made a retreat and, in the confusion, trampled many a French man-at arms. They carried on marching forward taking many casualties until they reached the English line and were severely weakened, exhausted and subsequently defeated.

As shown in previous battles, such as Crecy & Poiter, the French were extremely over confident of their ability to win and thus made serious tactical errors which led to their defeat. The wet weather combined with other factors meant they were vulnerable to the English sword and arrow or drowning in the mud. [2]

4. Armour & Weapons

The English longbow combined with the bodkin arrow was thought to be the winning factor in Henry winning the battle at Agincourt. From previous engagements at Poitiers, Peter Hoskins claims that the battle was won by discipline in the British army, experience of the senior leaders and the French incompetence not solely the English archers with the longbow, but did the longbow cause disruption within the ranks, wounding soldiers and making it harder to swing a sword with an arrow lodged between your armour plate, the same can be thought for Agincourt. [3]

Longbows required a huge amount of force to draw the bow, even by today's standards. It is widely disputed what the typical draw weight would have been for an English longbow but it is widely regarded to be at least 80 lbs and possibly up to 150lbs. This all depended on the user and experience. Considerable practice was required in order to produce an effective shot. Skeletons of longbow archers have been found with enlarged limbs and bone spurs on left wrists and fingers. The English were trained from a very young age to wield a bow so it isn't unlikely to have draw weights upwards of 100lbs. [4]

Arrows were designed to penetrate plate and chain armour. The arrows were quite large with an elongated pyramid end, which resulted in a very sharp and narrow point. Typically referred to as the Bodkin arrow. The combined weight of the arrow with the arrowhead meant they weighed around 65-100 grams. This is 2 or 3 times heavier than modern day arrows. [4]

The Armour worn by the French at the time of Agincourt would have been extremely well made, using slopes and inclinations to deflect arrows. Most arrows were ineffective at full penetration even at short distances. During this period, they were experimenting with material properties, with lack of understanding of the underlying principles, they still understood they were improving the hardness quality of their armour thus improving the effectiveness against arrows.

Full plate armour would have been extremely expensive during the 15th century so only the most noble and wealthy of knights would have been able to afford a full set, most men-at-arms in the French ranks would have used wrought iron armour or armour mix, decreasing the overall effectiveness at stopping an arrow. Plate armour still had weaker parts to the armour, the breastplate tended to be the thickest part. The limbs would be relatively much weaker than the rest of the armour so an arrow could potentially penetrate this part of the armour.

5. Strategy & Tactics

The longbow played its part in the battle of Agincourt but an argument could be made that the tactics and strategy employed on both sides is what tipped the scales. The French, vast in their numbers thought they could overcome the English with great ease, without the use of their archers and longbow men and left them at the rear or their main battalion. The battle-plan for the French was to imitate the English policy by placing dismounted men-at-arms in a central body and two wings, with archers to the side, something they failed to achieve. The French ranks saw their archers as superfluous and they took little to no part in the battle. [5]

The English were allowed to take a defensive position, flanked by rows of trees. They deployed a tactic not seen in previous engagements by placing sharpened wooden stakes in the ground at chest

height, assigned to the two wings of the French cavalry. [5] The combination of the muddy battlefield and heavy armour worn by the knights would have slowed them down enough to take a barrage of arrows on their way to the English line. The wooden stakes provided mass confusion within the French cavalry and on their retreat, knocked down many of their own men to become an easy target for the lightly equipped English ranks.

6. Longbow v Armour Test

A report done by Mattias Bane "English Longbow Testing" highlights a few tests into whether armour would be protective enough against arrows. [6]

There are very few records of longbows from the period of Agincourt, but some bows were recovered from the H.M.S Mary Rose. They range in size, from 75 inches to 80 inches with the average draw weight of 100lbs. For the tests highlighted in the report, a longbow with a draw weight of 75lb was chosen. The arrows chosen for the tests were 4 different arrowheads. A couple variations of the bodkin arrowhead and the broadhead arrowhead. They slightly differ in their weight and profile as shown in *figure 2* below.

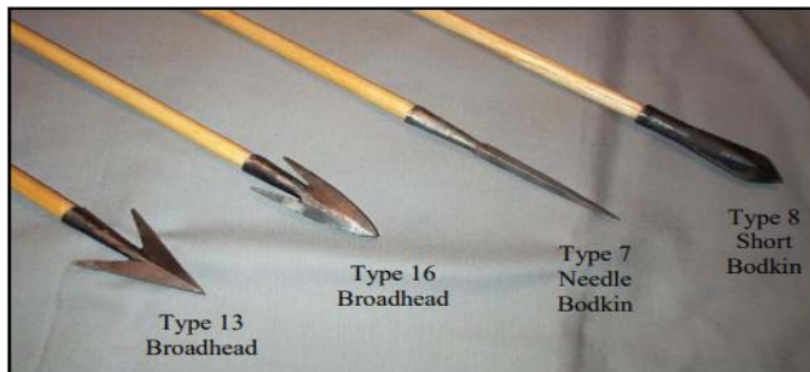


Figure 2 - Medieval Arrowheads



Figure 3 - Needle Bodkin [6]



Figure 3 - Short Bodkin [6]

The arrows were fired into different armour types but I will focus on the plate armour. Plate armour was made up to represent the armour of the period. The thickness of the armour is the key factor in the stopping power of an arrow. The minimum thickness was roughly 1.2mm and the thickest being 4.57mm. The study uses the 1.2mm thick plate armour for the tests with the longbow. [6] The results of the test highlight that the plate stopped most arrows from penetration. The needle bodkin penetrated past the threshold but would not hinder the wearer but would impart some energy into the target. The conclusions from the report state that most soldiers on the battlefields would have been at risk from arrows. Only the most expensive and well-made armour of the period would have had the potential to stop an arrow.

Table 6. Plate					
		Test #1		Test #2	
Arrow Style	Armor Label	Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	M	0.5"	0"	0.5"	0"
Short Bodkin	M	0"	0.1"	0"	0.1"
Broadhead	N	0.25"	0"	0.2"	0"
Type 16 Broadhead	N	0"	0.1"	0"	0.1"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

Figure 5 - Results from Plate Test [6]

This report needs to be taken with caution, as the longbow used in the test isn't representative of the time with a draw weight of only 75lbs. The armour in the test has no inclinations of sloping which would have helped with the deflection of the arrow. The armour is a single plate of only 1.2mm thick, to be more accurate, more tests need to be carried out on a varying thickness of armour and to include the inclinations of the typical period armour. The material properties of the armour will differ in quality from what was used by the French at Agincourt, this is hard to represent with the lack of historical artifacts.

7. Long Rod Penetration Calculations

I have inputted the data below from the table into the Long Rod penetration formula to understand if the delivery system of the time was capable of penetrating through plate armour. This formula is mainly used in the hydro-dynamic region due to the extreme velocities so the figures may not represent an accurate velocity. The formula accounts for the obliquity of attack and the thickness of armour required to penetrate.

$$V_{lim} = [16.38 \frac{d^3}{W} (\frac{p \sec \theta}{d})^{1.12}]^{0.5}$$

Where;

V_{lim} = limiting penetrator velocity (m/s^{-1})

p = armour thickness (mm)

d = penetrator calibre (mm)

θ = impact obliquity

W = projectile weight

Type of Ordnance	Bodkin Arrow
Delivery System	Longbow
Length of Ordnance (w/o Bodkin)	585.5mm
Diameter of arrow shaft	11.11mm (assume same diameter for bodkin)
Mass of Arrow	0.166kg (1800 grains)
Density of Penetrator	Bodkin 6.25 gcm ³ Yew Wood 0.67 gcm ³
Density of Plate Armour	2.85gcm ³ (rank and file) 5.75gcm ³ (knight)
Thickness of Plate Armour	2.5mm – 4mm
Angle of obliquity of impact	30° to the normal or greater
Yield Stress of Armour	350-600 MPa (foot-soldier & knight/king)
Velocity of system at impact	Arrow 53.34ms ⁻¹ Knight on horseback 8.95ms ⁻¹ Foot soldier 0.9ms ⁻¹

The formula below is for the smaller of the thickness of armour (2.5mm) and angle of obliquity of 30 degrees -

$$V_{lim} = [16.38 \frac{11.11^3}{0.166} (\frac{2.5 \sec 30}{11.11})^{1.12}]^{0.5}$$

$$V_{lim} = 147.210$$

The formula below is for the larger thickness of armour (4mm) and angle of obliquity of 30 degrees -

$$V_{lim} = [16.38 \frac{11.11^3}{0.166} (\frac{4 \sec 30}{11.11})^{1.12}]^{0.5}$$

$$V_{lim} = 191.533$$

8. “German” DeMarre Equation [7]

This can be used for sub-hydrodynamic regions. It doesn’t take into account obliquity of attack and assumes the angle of impact is 90 degrees.

$$S = \sqrt[0.7]{\frac{G^{0.5} * V}{K * d^{0.75}}}$$

Where;

S = Thickness of Armour Penetrated (dm)

G = Weight of Projectile (kg)

V = Striking Velocity (m/sec)

d = Projectile Diameter (dm)

K = an empirical factor (2000 to 2500 for AP/APC)

- *Knight on Horseback (62.29m/s)*

$$S = \sqrt[0.7]{\frac{0.166^{0.5} * 62.29}{2000 * 0.111^{0.75}}}$$

$$s = 0.021dm$$

$$s = 0.21cm/2.1mm$$

- *Foot soldier (54.24m/s)*

$$S = \sqrt[0.7]{\frac{0.166^{0.5} * 54.24}{2000 * 0.111^{0.75}}}$$

$$s = 0.016dm$$

$$s = 0.16cm/1.6mm$$

The DeMarre formula shows us that both the foot-soldier and the knight of the period would have been inflicted with some damage from an arrow and potentially cause penetration into the armour. This formula uses an empirical factor for the armour type and might not be representative of the armour used in the 15th century.

I have then transposed the DeMarre formula to try and solve for “V” (striking velocity m/s), from this we can see the velocity required to penetrate the armour at a set depth. Below I have inputted the depths of the typical armour of the period. Limbs being 1-2mm thick and breastplate around 4mm.

$$V = \sqrt[0.7]{\frac{S(K * d^{0.75})}{G^{0.5}}}$$

$$V = \sqrt[0.7]{\frac{0.01(2000 * 11.11^{0.75})}{0.166^{0.5}}}$$

$$V = 54.03m/s$$

$$V = \sqrt[0.7]{\frac{0.025(2000 * 11.11^{0.75})}{0.166^{0.5}}}$$

$$V = 102.62m/s$$

$$V = \sqrt[0.7]{\frac{0.04(2000 * 11.11^{0.75})}{0.166^{0.5}}}$$

$$V = 142.6m/s$$

The results show a linear increase in velocity compared with the depth of penetration as shown in figure 6 below. From this formula it is clear to see the arrow did very little penetration damage to the plate armour due to not being able to deliver the system at that velocity.

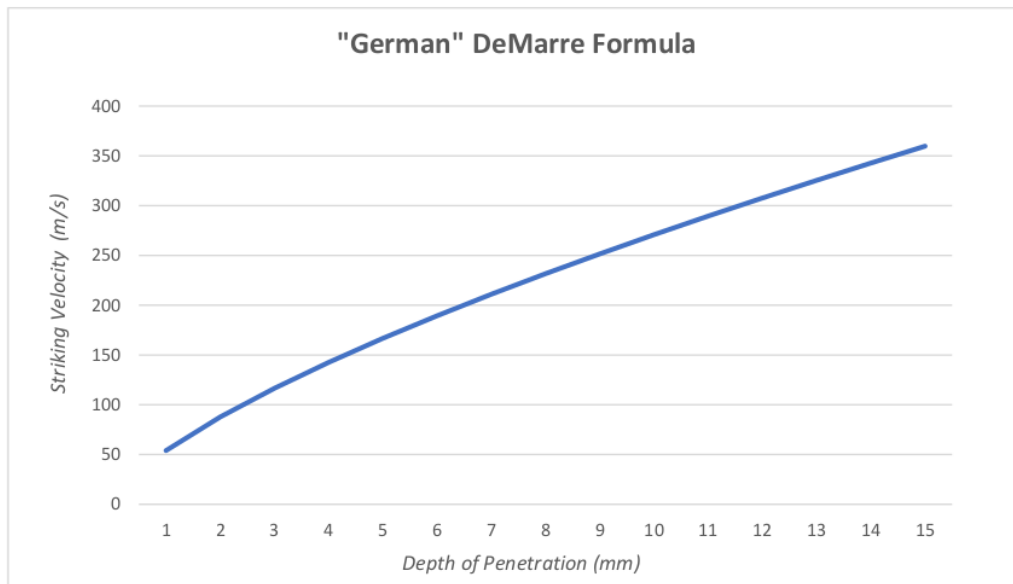


Figure 6 – "German" DeMarre Formula

9. Krupp Formula [7]

$$B = \frac{V * \sqrt{P}}{K * \sqrt{D}}$$

Where;

B = thickness of armour penetrated (dm)

V = Velocity of the shell on impact

P = Mass of projectile

D = Projectile Calibre

K = Resistance constant (represents the quality of armour) When in doubt use 2400, which was the standard quality armour used in soviet calculations. [7] *Decreasing this value might represent the typical armour strength of the period.*

- *Knight on Horseback*

$$B = \frac{62.29 * \sqrt{0.166}}{2400 * \sqrt{11.11}} \quad B = \frac{62.29 * \sqrt{0.166}}{2000 * \sqrt{11.11}}$$

$$B = 0.031dm \quad B = 0.038dm$$

$$B = 0.31cm/3.1mm \quad B = 0.38cm/3.8mm$$

- *Foot-soldier*

$$B = \frac{54.24 * \sqrt{0.166}}{2400 * \sqrt{11.11}} \quad B = \frac{54.24 * \sqrt{0.166}}{2000 * \sqrt{11.11}}$$

$$B = 0.027 \quad B = 0.033$$

$$B = 0.27cm/2.7mm \quad B = 0.33cm/3.3mm$$

The Krupp formula is another penetration formula, above the results show the arrows would have caused penetration into the plate armour. The armour type used in the equation is not representative so I have decreased this value to show an increase in penetration.

10. Metallurgical Analysis

The development of steel throughout the 15th century shows an effort was made to improve the material properties of the steel. The developments in armour are shown when transitioning from chain armour to a full plate covering but this was due to the ever-improving weapons being used against the armour.

Some studies have been undertaken to characterise the structure and manufacture process of medieval longbow arrowheads and armour. The introduction of carburisation heat treatment demonstrates a clear knowledge of material properties in order to harden a material despite a lack of the underlying scientific principles. Arrowheads of the period were boiled in bone meal to increase their carbon content and have a hardened tip from this process. The tests carried out, were conducted to assess the penetration performance against representative targets. The results showed that by the early 15th century, armour was capable of protecting the vital organs of the body but not the extremities such as arms and legs, this was due to keeping the armour thin enough around the limbs to not hinder the wearer. [8]

11. Conclusions

I think the longbow was the decisive weapon at the battle of Agincourt but not the decisive factor for the English winning over the French. A combination of factors played a key role, such as the lack of leadership in the French ranks, being over confident in their numbers to think it would be an easy battle. The poor decisions by the French in the lead up to the battle to not include their archers in the main battalion or the experienced English ranks, trained from a young age to wield a longbow and be very accurate from a long range. The decision to allow the English the defensive position and make full use of their archers did play a key role, the slow march from the muddy French ranks towards the English line made them an easy target for multiple barrages of arrows.

It is hard to represent the longbow's penetrative power from modern day equations, they are less likely to represent the velocities at which the projectile is travelling, most armour piercing formulas are dealt with in the hydrodynamic region when material properties play a key role and the speed is assumed to be extremely fast. I can see from some of the calculations with the correct arrowhead, it could penetrate some plate armour and potentially cause a fatal wound if struck in the correct place when the armour is at its thinnest. The arrows would have the potential to pierce through weaker armour so could have caused a lot of damage to the French men-at-arms.

References

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- [3] P. Hoskins, *In the Steps of the Black Prince*, Boydell Press, 2013.
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- [6] M. Bane, 2006.
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- [8] P. N. Jones, "The metallography and relative effectiveness of arrowheads and armor during the middle ages," 25 April 2003. [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S004368890300109U>. [Accessed 28 October 2022].

Tech Report

GRADEMARK REPORT

FINAL GRADE

32/50

GENERAL COMMENTS

Instructor

In your contents page there is an error at the conclusion. It is also unclear what the [7] next to the DeMarre and Krupp formulae represents. I'm presuming it was the carry-over of the reference but immediately I'm looking for the reference or footnote.

In the abstract, the second sentence is not a sentence and needs to flow from the first, or be rewritten.

I loved the quotes from the Gesta Henrici Quinti, which would have excited the historian, and demonstrated that you had considered his/her background before writing the technical report.

Table 1 is not very clear and relevant information could have been better identified. Could you have use an overall summary? Was it relevant when you had already stated numbers? What was the yellow highlight for? Again, it caught my eye in a sort of negative Gestalt way.

I found the [7] when Krupp was introduced. It is not good practice to use the reference within the heading but to refer to it in the text. However, good use of three formulae and the presentation of data. I particularly liked the way you represented the DeMarre formula graphically to demonstrate velocity vs penetration.

Word count 2995, well done.

Overall, your conclusions flowed from the logic of a structured technical report. There were some errors which detracted from the reading but you demonstrated that you can construct an impartial view from limited information.

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