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The performance of the longbow against plate armour at the battle
of Agincourt

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Executive Summary

The effectiveness of the medieval longbow, particularly when paired with the needle bodkin arrow, has long been touted as a decisive factor in the English victory at the Battle of Agincourt in 1415. However, conflicting viewpoints from various historical and technical sources raise questions about the true extent of the longbow's penetrative power. This report critically evaluates the historical context, technical specifications, and scientific principles of the longbow and bodkin arrow to determine their efficacy in combat. By analysing factors such as material composition, design, kinetic energy, and armour penetration capabilities this report provides an evidence-based assessment of whether the longbow merits the accolade of being the primary contributor to the English triumph at Agincourt. Visual evidence and data-driven analysis are incorporated to support the conclusions drawn in this technical report.

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Introduction

This report aims to provide insight into the penetrative capability and limitations of the English longbow against the French plate armour, specific to the battle of Agincourt.

Historical Context

The Battle of Agincourt occurred during the Hundred Years' War (1337–1453) between England and France. In 1415, King Henry V of England sought to strengthen his territorial claims in France due to political instability. Henry exploited internal strife and advanced to France. Embarking on a campaign into France. Approximately two months before the commencement of the Battle of Agincourt, King Henry V led around 11,000 troops across the English Channel and laid siege to Harfleur in Normandy. [1] The town eventually surrendered, after five weeks, Henry's forces suffered significant losses from both disease and combat. Despite the setback, Henry decided to march his depleted army north-eastward towards Calais, intending to meetup with the English fleet for a return to England. However, the French Dauphin, Louis, met Henry at Agincourt with a vast French army of some 25,000 men stood in his path, greatly outnumbering the exhausted English archers, knights, and men-at-arms. Despite the English being vastly outnumbered. Henry's strategy and the effectiveness of his army along with other factors later discussed, secured a decisive victory for the English. [2]

Exploration of Battle Significance

This section delves into the significance of the Battle of Agincourt, figure 1 provides a visual representation of the battle's timeline, facilitating a chronological understanding of key events during the conflict. Additionally Figure 2 details a chart quantifying the size of each army and the corresponding fatalities offers quantitative insight into the scale and impact of the battle [3]. Through this exploration, the aim is to contextualise the historical narrative surrounding the longbow's alleged influence on the outcome of the battle, setting the stage for a comprehensive analysis of its penetrative power and combat effectiveness [1].

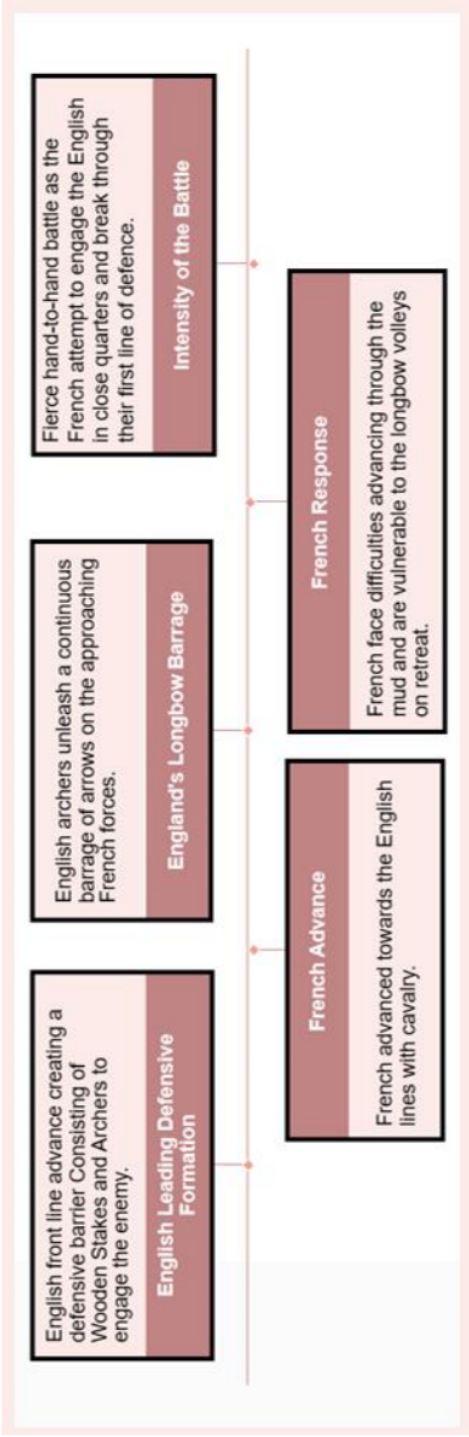


Figure 2- Historical Timeline of Battle

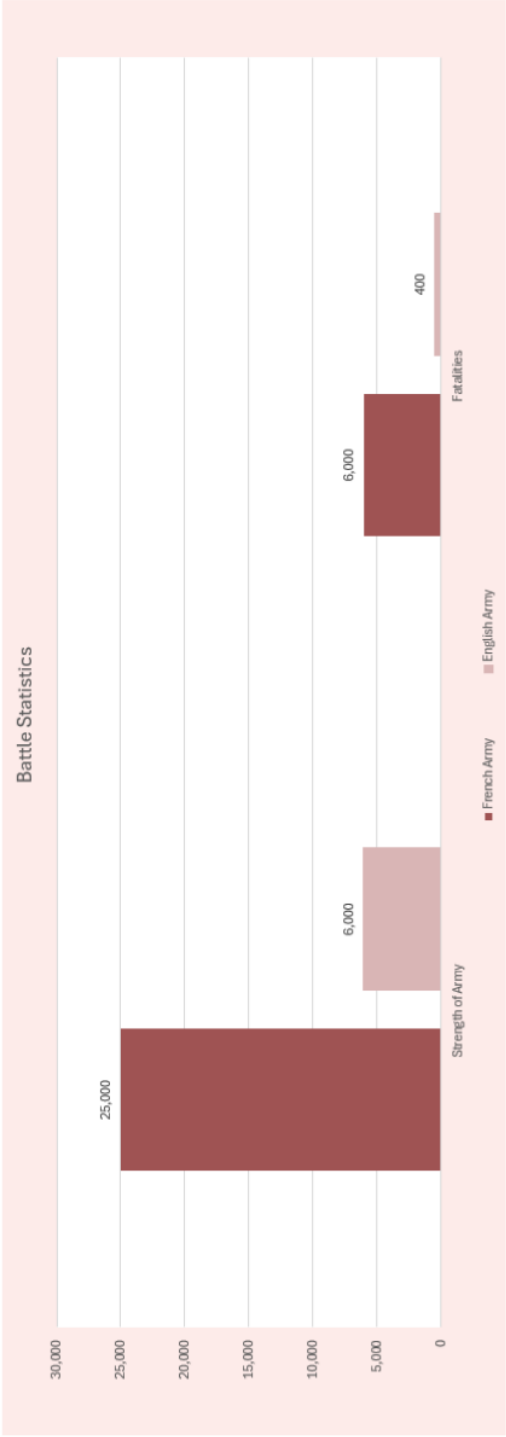


Figure 1- The Numerical Strength of Each Army and the Corresponding Casualties

Discussion

Evaluating the Longbow: A Technical Examination to Determine its Deserved Recognition

Through analysis and experimental data, the effectiveness of the longbow in combat scenarios is scrutinised to determine its deserved recognition in military history.

English Longbow

The English longbow seen in figure 3, was typically crafted to match the physical attributes of the archer who would wield it. While there was no fixed standard for the height of the longbow, it was crucial for the bow's dimensions to suit the archer's height, arm span and draw length. This customisation ensured that the bow's draw weight, or the force required to pull the string back, was within the archer's capabilities and that the bow would not break under excessive stress. By tailoring the longbow to the individual archer, optimal performance and accuracy could be achieved [4].



Figure 3- An English Longbow

Longbows were primarily constructed from European yew wood due to its unique material properties, making them well-suited for crafting high-quality bows. Yew wood is exceptionally strong and resilient, with a high tensile strength that allows it to withstand the stress of being drawn repeatedly. This durability is crucial for longbows, which undergo significant strain during use in battle [5].

Secondly, yew wood has excellent flexibility, allowing it to bend without breaking when the bowstring is drawn back. This flexibility is essential for storing and releasing the energy required to propel an arrow with force and accuracy. Additionally, yew wood is lightweight, which contributes to the overall manoeuvrability of the longbow. A lighter bow is easier for the archer to handle and can be held steady for longer periods, enhancing accuracy.

Furthermore, yew wood has a fine grain structure, seen in figure 4, which facilitates precise shaping and carving within the bow-making process. This enables craftsmen to make longbows with smooth curves and consistent thickness, thereby improving their performance.



Figure 4- Cross-section of Yew Wood [4]

Overall, the combination of strength, flexibility, lightness, and workability renders yew wood an excellent material for longbow construction, allowing archers to achieve maximum force, accuracy, and reliability in their shots.

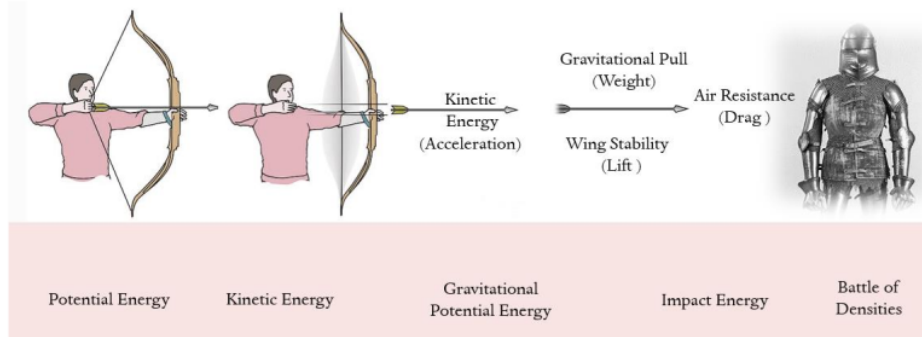


Figure 5- Energy Transfer of Shooting a Longbow

Needle Bodkin Arrow

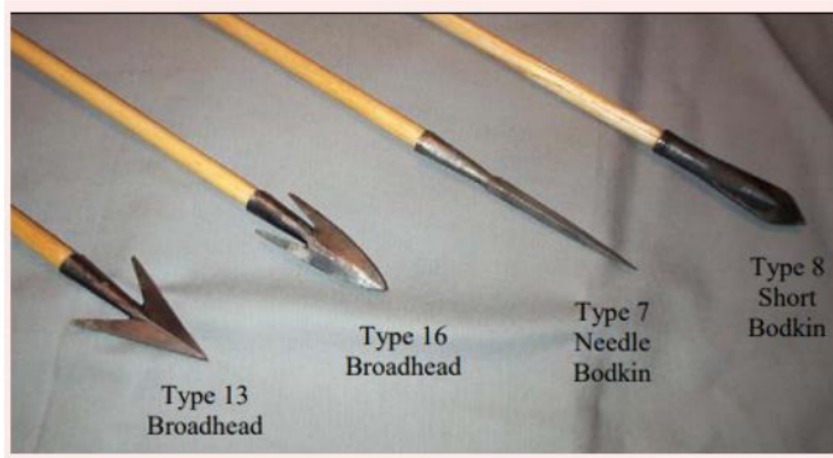
The needle bodkin arrowheads were commonly used in the battle of Agincourt as they were the first long rod penetrator of their time, referring to its specific characteristics and attributes:

Small Diameter: The arrowhead has a narrow diameter, allowing it to penetrate more effectively by focusing its force on a smaller surface area.

High Mass: A heavier arrowhead can deliver more kinetic energy upon impact, enhancing its ability to penetrate armour or inflict damage.

High Velocity: Due to the design and weight of the arrowhead, the needle bodkin could achieve higher velocities compared to its predecessors.

Hardened Tips: Around this period forges introduced hardened tips on arrowheads, this was to prevent deformation upon impact, this was usually through the process of heating them and then rapidly cooling them. This process, called heat treating, made them harder. Afterwards, they were tempered by reheating them to reduce brittleness. This made them strong and durable for use in battle [6].



Figure

6- Arrowheads from This Period [7]

Capability to Penetrate

The ability of an arrow to penetrate a target is primarily determined by its kinetic energy, which is a product of its mass and velocity. Upon impact, the arrowhead transfers its kinetic energy to the target material, initiating a battle of densities. In this interaction, the target material undergoes deformation, while the arrowhead experiences compression forces [7]. The outcome depends on the relative densities and mechanical properties of both the arrowhead and the target material. Higher-density and stronger materials may resist penetration more effectively, while lower-density or weaker materials are more prone to deformation or fracture upon impact. Additionally, factors such as the angle of entry, thickness of the target material, and arrowhead design also play crucial roles in determining the extent of penetration and damage inflicted, more detail are provided below.



Figure 7- Material Penetration Experiment

The Figure above shows an experiment whereby a 75lb longbow was used at maximum power (angled at 90°) to simulate a 110lb longbow at longest range (angled at 45°) to receive data on the energy required to penetrate armour. We can see that in all images the needle-bodkin arrowhead successfully penetrated through each defensive barrier. Although perforating through the jack coat and butted maille, probable death would not be indicated by the thinnest plate armour found at this time [8]. Other factors to consider when evaluating this experiment would be:

- Individuals of higher financial status could afford thicker and higher-quality armour, which not only provided superior protection but also influenced the energy absorption capabilities upon impact. Thicker armour had the potential to dissipate and absorb more kinetic energy from incoming projectiles, reducing the likelihood of penetration and mitigating the impact on the wearer [9]. As a result, the financial situation and status of individuals directly impacted their ability to withstand and survive encounters on the battlefield. Many men with such defensive armour were present at the battle of Agincourt [10].

- The curved design of plate armour conformed closely to the wearer's body, resulting in the deflection of certain arrows upon impact, unlike the sheet metal depicted above in figure 7. A visual aid for deflection can also be seen in Figure 8 below.



Figure 8- Arrow Deflection

- Depending on the angle of entry, would depend on how much energy the arrowhead would need to get through the armour seen in Figure 9.
- Plate armour was often layered with additional protective materials, such as deer skin and garments, creating additional distance between the wearer and potential threats.

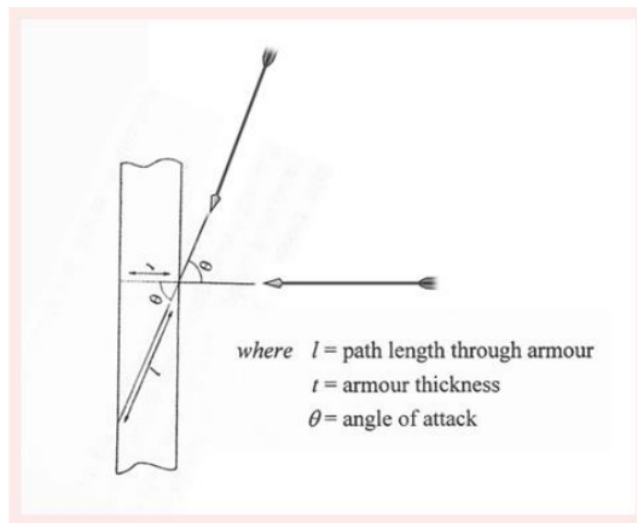


Figure 9- Angle of Entry and Armor Penetration

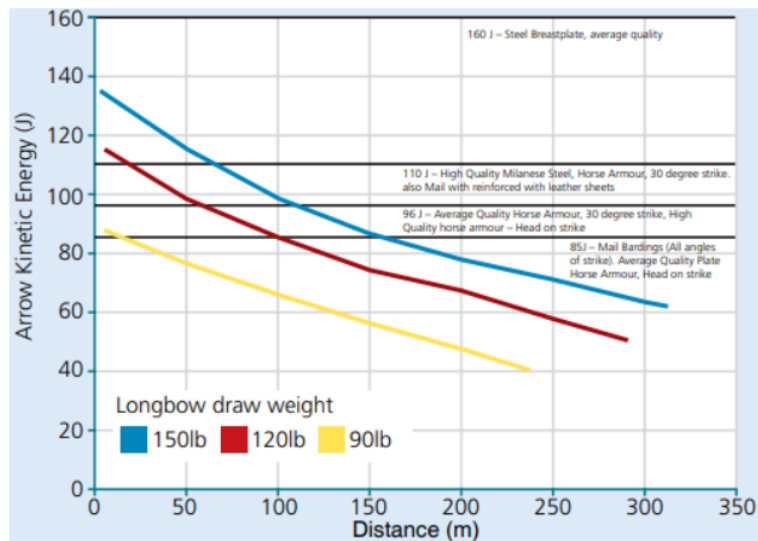


Figure 10- Penetration of Armour with Range [11]

From the experiment above the kinetic energy of the longbow has been calculated utilising identical variables and material properties as those observed. It is assumed that a vacuum provides the theoretical maximum energy transfer, although real-life scenarios entail additional factors such as drag and gravitational energy affecting the projectile in flight. The results concluded $ke = 96.99$ Joules of energy was stored within the longbow, upon comparison of this data with the graph above, it becomes evident that the longbow does not store sufficient energy to break the bonds within the armour, resulting in deformation of the projectile and the molecular structure of the breastplate remaining undamaged and intact, full theoretical calculations can be referred to in Annex A [12].

All these factors provide evidence that a shot from a longbow wasn't guaranteed to penetrate each time, as the Longbow had limitations in its kinetic energy, resulting in insufficient force to overcome the armour's resistance. The question must be asked, why did 5,000 archers at Agincourt fire potentially 100,000+ arrows at the French if they couldn't expect to inflict damage to the charging knights?

- 1) The English believed their previous success at the battle of Crécy whereby they held off 16 cavalry charges with the English longbows would once again bring them victory [13].
- 2) The English adopted extremely good aim, from practicing since childhood, so perhaps they were aiming for their opponents' weak spots, such as the back of retreating horses or weak spots within the French armour, seen in Figure 11.
- 3) The real aim was to cause disruption to the French advance by targeting the cavalry charge their own horses would create blockades on the battlefield, trapping the French men underneath the horses or throwing the riders from their backs.
- 4) The energy transfer of the rain of arrows would cause exhaustion, disorientation, and blunt force trauma to the French, allowing for an easy kill.

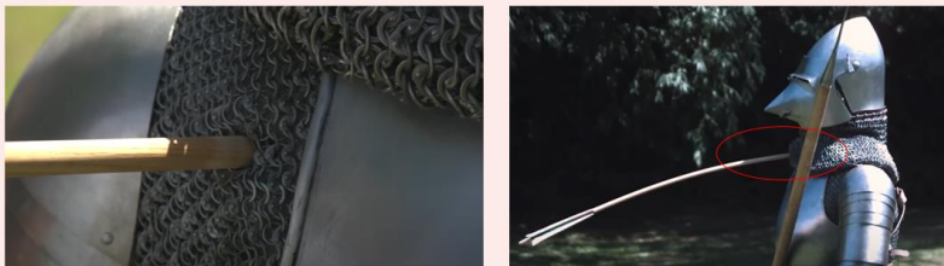


Figure 11- Armour Exploiting Weak Spots

Analysis of Other Victory-contributing Factors

English Bowman

When assessing the individuals who wielded the longbows, it's crucial to recognise that not all longbowmen can be categorised in the same manner. While many longbowmen were yeomen and peasants who had undergone considerable

archery training from an early age, there were several exceptions [11]. Some longbowmen may have come from different social backgrounds or received training through alternative means. Furthermore, the motivations and experiences of individual longbowmen were likely diverse, with some motivated by duty or allegiance to their king, while others may have had more personal reasons for fighting. Other factors to consider include the archers' performance, this may have been compromised, as they were battling the effects of dysentery and enduring fatigue and sickness resulting from the strenuous fighting and extensive travel they had undergone. Later discussed, is how this benefited the longbowmen in battle.



Figure 12- Different Types of Armour Comparison

Terrain

The French selected battleground near Agincourt castle. Initially unknown to England, this favoured them. Both armies took positions, surrounding woodland offered natural defences for advancing English, as seen in Figure 13. Despite French holding favourable high ground north, conditions turned against them. Heavy rainfall the night before, coupled with churned farmland, transformed terrain into boggy morass. This worsened when French advanced with heavy cavalry and men-at-arms facing significant obstacles due to softened ground [1].

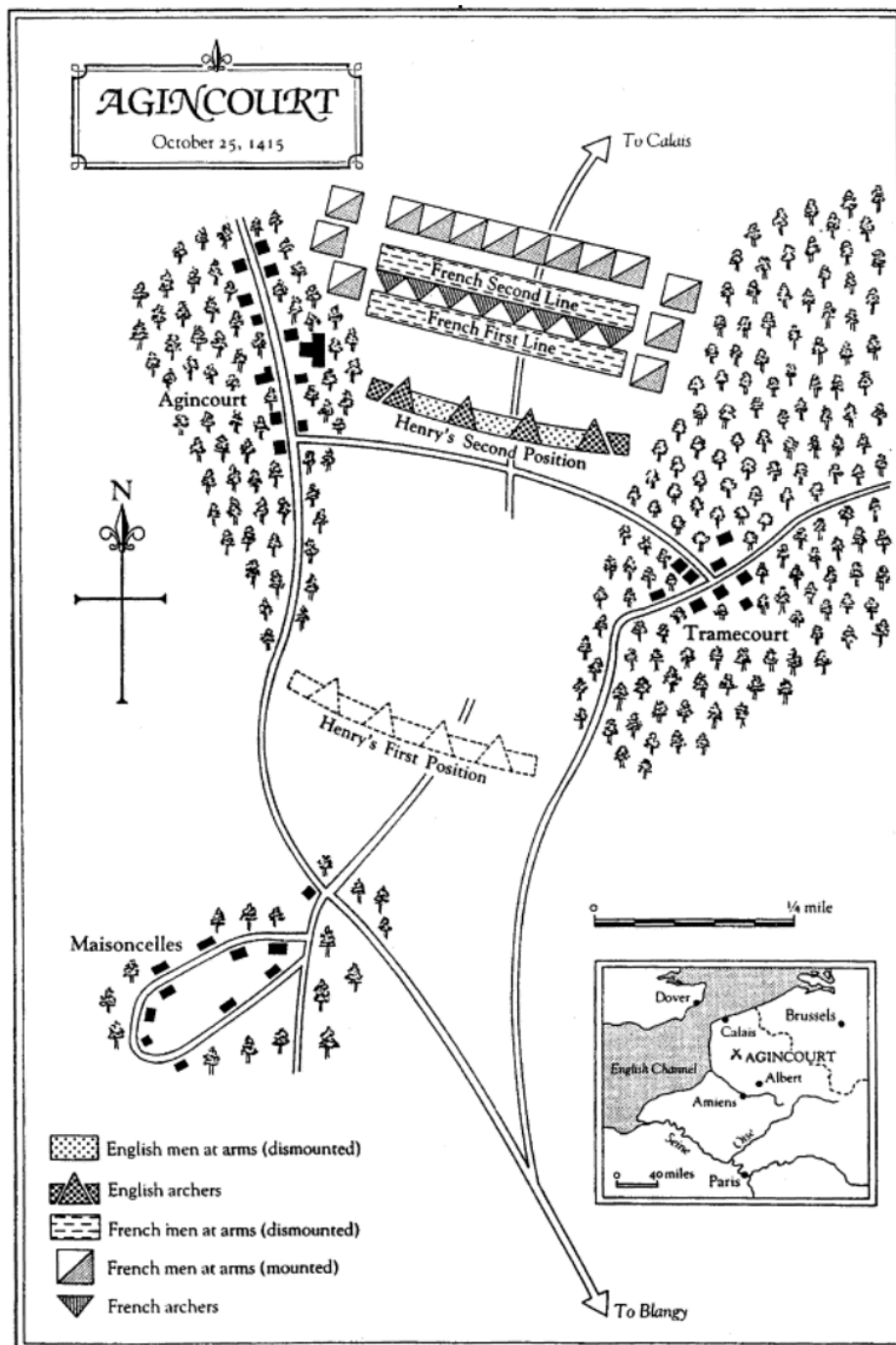


Figure 13- Map of Battlefield [14]

Battle Tactics

As mentioned, the effectiveness of the Longbow barrage coupled with the challenging terrain significantly impeded the French advance. However, several other critical factors must be considered. A pivotal error by the French commanders was their failure to align their army closely with the adjacent woods, instead positioning themselves north of the narrowest point. This oversight prevented an opening for potential flanking manoeuvres by their cavalry when the English advanced. The boggy terrain further impeded the French, as their troops struggled through the mire, while agile English archers were able to manoeuvre freely to retrieve arrows and kill trapped or wounded foes with swords or daggers due to the light armour they wore. Furthermore, the strategic deployment of wooden stakes by the English effectively slowed and disrupted the advancing cavalry, further complicating the French advance [1].



Figure 14- Depiction of Battle

French Disorganisation

The French commanders were noted to be unaware that out of the 6000 English troops, over 5000 were longbowmen. Additionally, the deployment of wooden stakes caught them off guard, as it was the first time such a tactic had been utilized. In previous battles like Crécy, the English had relied on trenches to repel cavalry charges, demonstrating the effectiveness of the longbows. Furthermore, the French favoured a strategy of starving out the English rather than confronting them directly in a pitched battle. Finally, the failure to execute the flanking sweep by the French cavalry resulted in a majority retreat, leading to widespread chaos among the French forces [10].

Psychological Impact

Henry V was deeply religious, firmly believing that God was on his side and would ensure victory. The English soldiers, hungry, sick, and fatigued, fought with a mindset of survival it was a matter of kill or be killed [15].

Conclusion & Recommendations

To Conclude, the longbow was an advanced weapon for its time, however the longbow accompanied by the bodkin needle arrowhead could not penetrate armour effectively or consistently, alone they would not have brought the English victory against the French. Further research is recommended in the energy transfer upon successful impact, with accurate weaponry and defensive materials from this period being replicated, whilst taking all external factors into consideration, such as sub-hydrodynamics and the velocity at which the target is traveling would begin to give more concise data.

In summary the longbows were used to harass enemies and prevent flanking manoeuvres by causing havoc to the opposition, their impact was legendary in battles like Agincourt and Crécy so much, so they remain etched in history today in ways such as tapestries and historical recordings, nonetheless it is through the addition of many other contributing factors, they were successful on this day.

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Appendices

Appendix A

The Physics of Medieval Archery

Historical Values

(bow weight) $f = 110 \text{ lbs} = 489.5 \text{ N}$

(draw length) $x = 28'' = 0.7112\text{m}$

(efficiency) $e = 0.9$

(mass arrow) $m = 1000 \text{ grains} = 0.065 \text{ kg}$

(mass bow) $m_b = 1 \text{ kg}$

(kinetic energies) $k = 0.04$

Equation 1- Velocity of Arrow

$$v = \sqrt{\frac{efx}{(m + km_b)}}$$

$$v = \sqrt{\frac{0.9 \times 489.5 \times 0.7112}{(0.065 + 0.04 \times 1)}}$$

$$v = 54.62592791$$

$$v = 54.63\text{m/s}$$

Equation 2- Kinetic Energy of Arrow

$$k = \frac{1}{2} \times m \times V^2$$

$$k = \frac{1}{2} \times 0.06 \times 54.63^2$$

$$ke=96.99419925$$

$$ke=96.99J$$

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GRADEMARK REPORT

FINAL GRADE

34/50

GENERAL COMMENTS

Summary:

Libby,

This was a well written report, which does you justice. I know that maths is not your strong point but you could have used limiting velocity, in conjunction with your research to knock the ball out of the park on your conclusion. As ever, I provide some constructive comment for your to improve your technical authoring skills further. Your continuous professional development is in the ascendancy so please keep this up. We do need to work on your confidence with the maths stuff of OME but that will come. A score of 68% on this to go with your 84% on the presentation is a very high overall mark indeed. Well done.

Detail:

1. Excellent executive summary. if you write like this in your major project you will be on for a very high grade. Really well done, and I can say the same of the conclusion.
2. Your table of contents is as one would expect, followed up by figures, tables and equations. You have taken the time to learn how to do this, which will stand you in good stead for future submissions.
3. Your similarity score is okay, but there were a lot of references drawn in your historical context - approx 75% of the wording was from 3 references. If you do this, you must either reference the source, or change the wording as Turnitin will spot it.

4. Your use of figures, tables and equations is what this module was all about and they bring life to the paragraphs associated with them. As such the report is pleasing to the eye.

5. I found the construction of the longbow really interesting and yes I did learn something myself in this section.

6. If you do use a figure or table etc, you must anchor it in the text with a cross reference. I cannot see this for figure 5, 6 and 10 as an example. It could be argued what their purpose is. For example: The needle bodkin arrowheads (see Figure 6) were commonly.....From the experiment above (see Figure 10).....

7. Good effort on Figure 9, just the job. Nice to see your removed the human element from Figure 14.

8. Your description of other factors is sound and a basis for solid research. Well done.

9. Your conclusion and recommendations are as I would have expected from the content of the report, well done.

10. You have dodged the maths, which I know is not your strong point, but you could have used limiting velocity based on the velocities I gave you to prove that penetration was not possible for the types of armour employed.

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