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# DERIVATION OF SHARPNESS METRIC FOR NAILS FROM EXPERIMENTAL INFERENCES

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## ABSTRACT

Currently no standard test for sharpness exists in the industry. Thickness at cutting edge is an indicator of sharpness, but it's not accurate as other factors such as hardness, nose radius, etc. play an important role and are overlooked. In the following paper a new type of test for sharpness has been defined and applied to study the effect of geometrical parameters on sharpness. The force required to shear a uniform cardboard is taken as a measure of sharpness. Force required for shearing is measured for different nails. Defining a relation and applying a regression model to calculate the parameters.

The experiment aims to quantify the sharpness of pointed objects, and to relate it with geometric properties such as taper angle and nose radius. The experiment is significant because it can be used to inspect pointed objects such as nails, stapler pins, stationary pins, needles etc and this parameter can be used to determine the tip's sharpness/bluntness. In this experiment, cardboard has been used as base material and nails of varied geometric parameters were analyzed for sharpness. The force required to pierce the cardboard was averaged out for each nail. The forces were measured using load cell. The results were then correlated statistically with geometric parameters to arrive at logical conclusions.

**KEYWORDS***:* Smash Lab, Nail Sharpness, Sharpness, Load Cell, Regression

## I. INTRODUCTION

Several factors contribute to sharpness of a nail or a knife, but no unit for sharpness has been defined yet. A measure of sharpness is its thickness at cutting edge, measured in molecular thickness. At basic level, a blade is an example of wedge, and a wedge's mechanical advantage is its length divided by width. For knives, this is expressed as its grind angle.

Currently there exist no standard tests for measuring the sharpness. Each industry uses its own test for measurement. Though the thickness of cutting edge is good measure of sharpness, we simply cannot grind blade to a very low angle. This is because the thinner the edge, more the blade is prone to bending and chipping. These two actions account for dullness of most blades.

## BACKGROUND

The sharpness of an object is of different types, it may be due to static load or due to a sudden momentum. The sharpness of the object depends on parameters like, taper angle or grind angle, hardness of material, thickness of cutting edge, radius or thickness of material, material type, pre-processes like quenching or annealing, etc. These various factors make it hard to quantify hardness in one unit for different materials.

For a nail, piercing through a block takes place in four steps. Firstly, elastic deformation of surface followed by inelastic deformation takes place. After inelastic deformation, the shearing of the surface takes place followed by penetration. The theoretical Force Vs Penetration curve and view of pin end are depicted in the following Figure 1 and Figure 2 respectively.

After shearing the force required to penetrate further increase linearly as it overcomes friction between nail and the object. A theoretical graph of Force required Vs Penetration is shown in figure 2.

Fig 1: View of Pin End

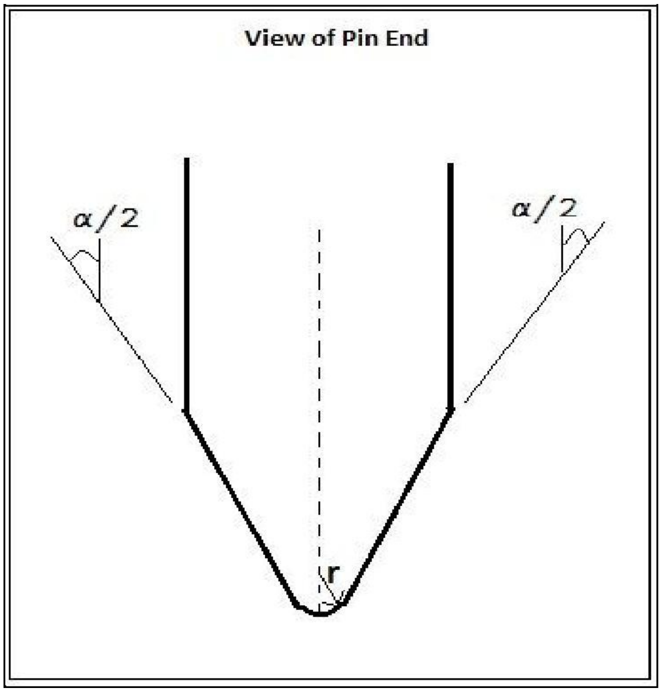
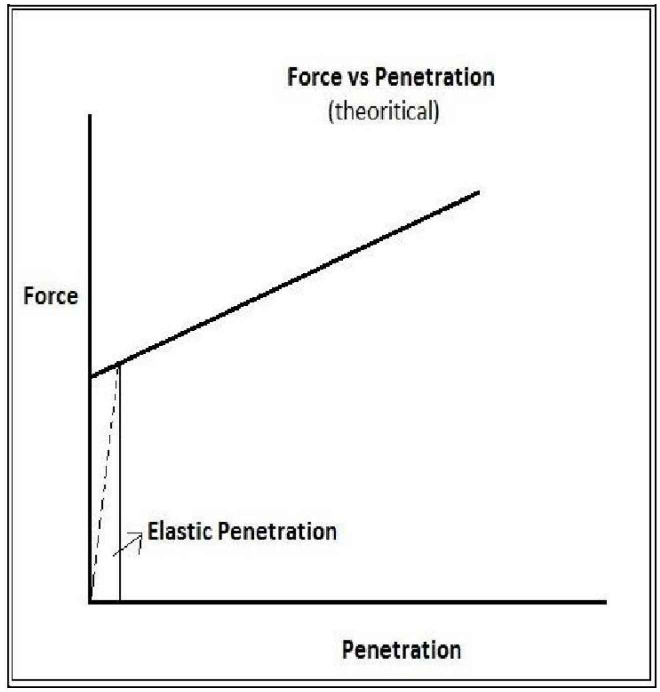



Fig 2: Force vs Penetration



## II. OBJECTIVES

1) Measuring sharpness of a nail by checking its capability to pierce through a block of fixed hardness.
2) Understanding the effect of parameters like taper angle, radius and nose radius on piercing capability.

## III. EXPERIMENTAL PLAN

We plan to measure sharpness of nails by piercing it through an isotropic material block and measuring force required to pierce, piercing may be due to static load or momentum. Here, we try to increase load as steadily as possible, and note the value of load when shearing happens.

**APPARATUS**:Load cell, nails of different radii, nose radius, taper angle, DC power supply, voltmeter,cardboard, weights, VernierCallipers

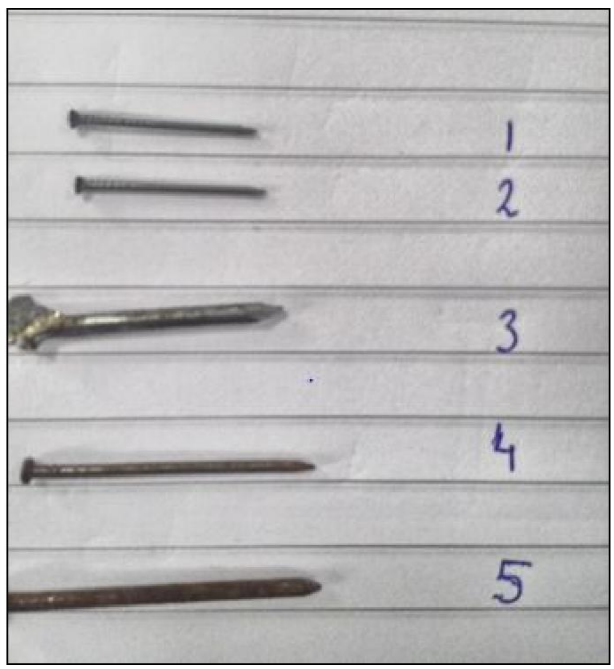



Fig 3: Load cell Setup Fig 4: Nail Specimens

## IV. EXPERIMENTAL PROCEDURE

1. Setup load cell and potentiometer, to measure force applied.
2. Calibrate load cell by putting known weights and note voltage at different loads.
3. Label the nails of different parameters and put a marker on each.
4. Put the cardboard piece on one end on the load cell.
5. Apply load steadily till piercing takes place. Note the max value.
6. Try piercing at different locations to compensate for material variations.
7. Repeat steps 4-6 for different nails.
8. Take a highly zoomed image of each nail.
9. Process image in computer and measure the values of nose radius, angle.
10. Measure radius of nails using VernierCallipers.

## V. OBSERVATIONS

| S.No | Weight(g) | Voltage (in mV) |
|---|---|---|
| 1 | 100 | 0.14 |
| 2 | 50 | 0.09 |
| 3 | 150 | 0.23 |
| 4 | 250 | 0.44 |

Table 1: Calibration of load Cell

| Nail No | Force 1 | Force 2 | Force 3 | Force 4 | Force 5 | Force 6 | Avg. Force |
|---|---|---|---|---|---|---|---|
| 1 | 1.47 | 1.25 | 1.06 | 1.44 | 1.22 | 1.35 | 129.83 |
| 2 | 1.44 | 1.78 | 2.06 | 1.67 | 1.41 | 1.44 | 163.33 |
| 3 | 2.73 | 1.96 | 2.59 | 2.20 | 2.18 | 1.98 | 227.33 |
| 4 | 2.32 | 2.14 | 1.66 | 1.95 | 2.16 | - | 204.60 |
| 5 | 2.64 | 2.34 | 2.43 | 2.69 | 2.31 | - | 248.20 |
| 6 | 3.42 | 2.91 | 2.80 | 3.71 | 3.01 | 2.86 | 311.83 |

Table 2: Forces for shearing

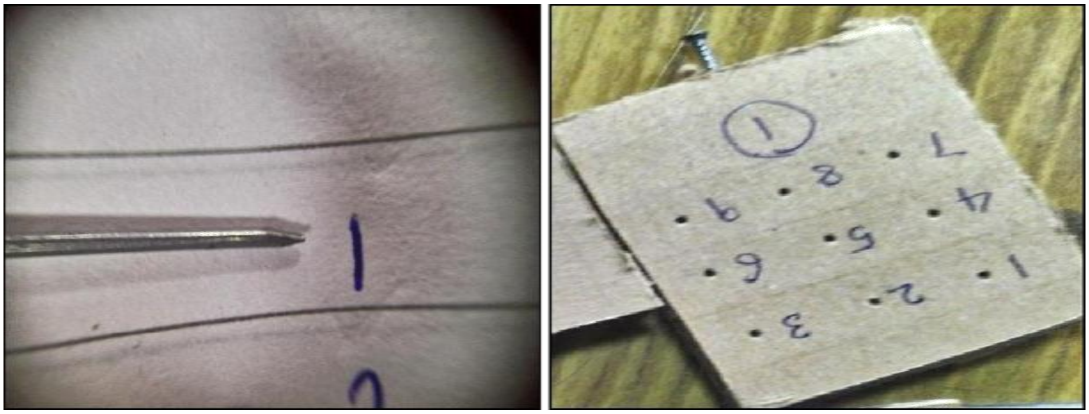


Fig 5: Parameters of Nail 1

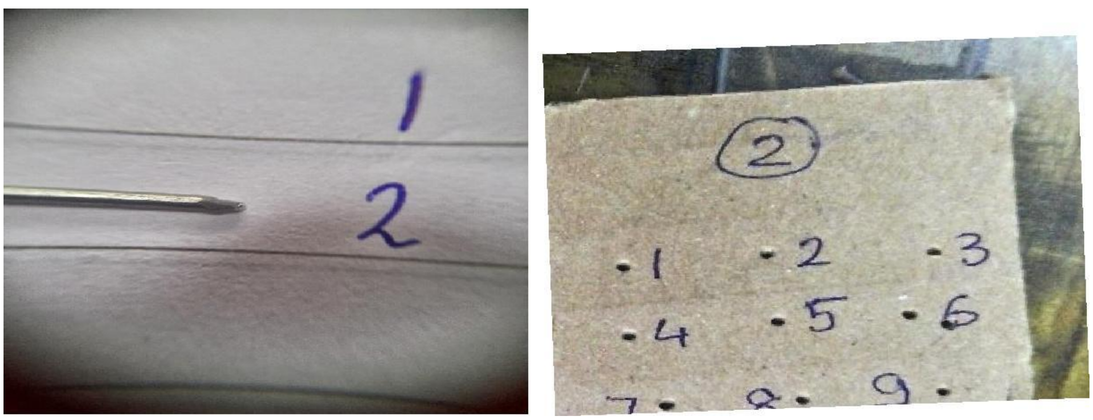


Fig 6: Parameters of Nail 2

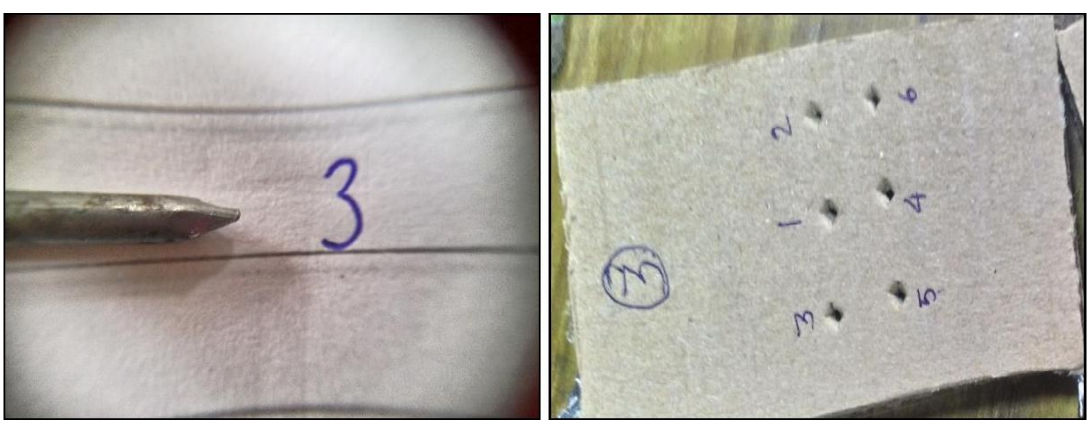


Fig 6: Parameters of Nail 3

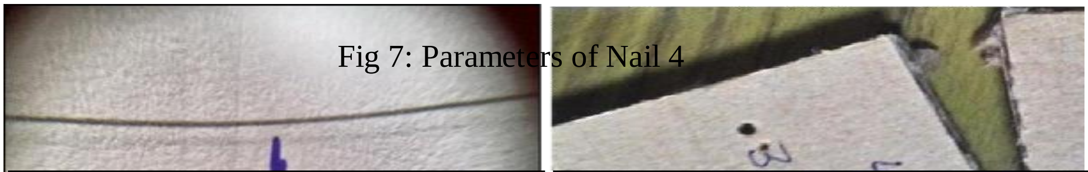


Fig 7: Parameters of Nail 4

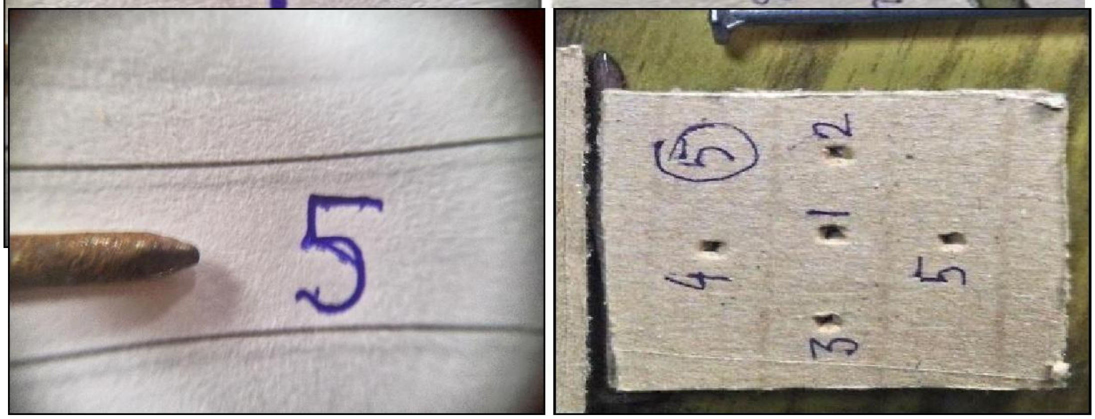



Fig 8: Parameters of Nail 5

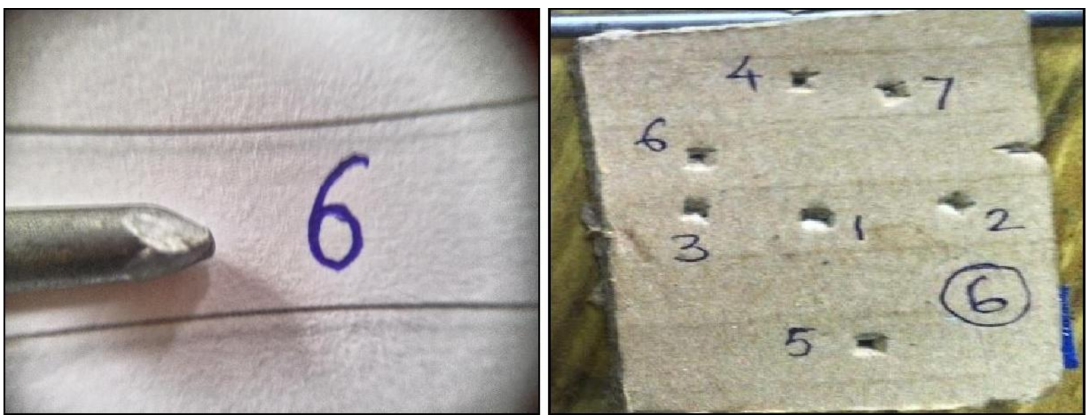



Fig 9: Parameters of Nail 6

| Specimen | Radius (mm) | Nose Radius (mm) | Taper angle (degree) | Force (N) |
|---|---|---|---|---|
| 1 | 0.489 | 0.193 | 22.67 | 129.83 |
| 2 | 0.470 | 0.139 | 25.37 | 163.33 |
| 3 | 1.307 | 0.412 | 31.20 | 227.33 |
| 4 | 0.782 | 0.204 | 35.51 | 204.60 |
| 5 | 1.068 | 0.365 | 35.49 | 248.20 |
| 6 | 1.559 | 0.520 | 44.97 | 311.84 |

## VI. DISCUSSION

| S.no. | Variables | Coefficients | Standard Error | t Stat | P value |
|---|---|---|---|---|---|
| 1 | Intercept | -1.94 | 36.27 | -0.05 | 0.96 |
| 2 | Radius | 25.36 | 100.61 | 0.25 | 0.82 |
| 3 | Nose Radius | 108.31 | 262.12 | 0.41 | 0.72 |
| 4 | Taper Angle | 4.88 | 1.79 | 2.72 | 0.11 |

$$\boldsymbol{Force} = 25.36 \times \boldsymbol{R} + 108.31 \times \boldsymbol{N\,R} + 4.88 \times \boldsymbol{T\,A} - 1.94$$

**Regression Statistics**

On regressing forces on all the three geometric parameters i.e. radius, Nose radius and taper angle, coefficients of all the factors come out to be positive, this implies that increasing any of the factors will increase the force required to pierce the cardboard.

T Statistic of Taper angle is greater than one in absolute value; showing that only taper angle is the significant factor while measuring the forces of penetration.

Obtained regression statistics show that the model is a good fit of forces on factors as R square value is 97% and Adjusted R square value is 93%.

| | |
|---|---|
| R square | 0.97 |
| Adjusted R Square | 0.93 |
| Observations | 6 |

Table 3. Parameters for Nails

## VII. CONCLUSION

In this paper, we have modelled force required for penetration to a defined extent as a function of taper angle, nose radius and radius of nail. Inferences derived from the experiment suggest that force primarily depends on taper angle and can be used as an indicator of sharpness of a tool. The regressed model can be used to obtain the force required from the given geometrical parameters. This value of force can be used for comparative study of sharpness of different objects. For example specimens with higher force values will be less sharp (more blunt) than the ones with lower values of force. This experiment can be extended to compare sharpness of specimens of different material properties as this version used specimen of the same material properties.

## VIII. REFERENCES

1. G.A. Reilly, B.A.O. McCormack, D. Taylor, (2004). Cutting Sharpness Measurement: a critical review. Journal of Materials Processing Technology, Pages 261-267