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Why do we not have Iridium Tools?

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Abstract
Unlike other video games, one of the most precious materials within Stardew Valley is iridium. Iridium quality tools become available to players during late-stage gameplay. This paper considers why axes, pickaxes, and hoes made of iridium aren't used within the real-world through consideration of the properties, mass, and cost of pure iridium.

Keywords: *Computer game; Chemistry; Material Properties; Stardew Valley; Iridium Tools*

Introduction

Stardew Valley is a farming simulation game that allows players to grow crops, rear livestock, fish, forage, mine, and socialise with townspeople [1]. The main tools used by players include a hoe, pickaxe, and axe, shown in Figure 1, with tool upgrades available from the blacksmith's shop as the game progresses. The upgrades available are copper, steel, gold, and iridium, with iridium tools being the most expensive and highest quality [2].

Figure 1 – Pixel art from Stardew Valley showing an iridium quality hoe, pickaxe, and axe [2].

This paper is limited to exploring pure iridium complexes, due to tools in Stardew Valley being made of pure iridium. It should be noted that in reality, iridium is used primarily within iridium-alloys as a hardening agent to make jewellery and pen points [3]. This paper considers the physical properties, required mass, and cost of iridium to determine why it may be an unsuitable material to construct tools from.

Mass and Density of Iridium Tools

To calculate the mass of each iridium tool, the mass of the iridium axe was first found by collecting data of the dimensions of real-world axes. A felling axe was used as the real-world model for these dimensions as felling axes are used for chopping down trees – the same task that the axe is used for in Stardew Valley. From these dimensions and density of iridium (22.56 g cm^{-3}) [4], it can be assumed the iridium axe would have a mass of 8.6 kg. Appendix A shows the dimensions of the felling axes used to determine the mean mass of axe head and handle, and the calculations to determine the mass of the iridium axe. Given the mass of an iridium axe is 8.6 kg, the mass of the iridium pickaxe and hoe can be found by comparing the number of purple iridium pixels in each pixel art shown in Figure 1 and scaling the mass accordingly. These results are shown in table 1.

Tool Type	Iridium pixel count	Mass (kg)
Axe	46	8.58
Pickaxe	45	8.39
Hoe	43	8.02

Table 1 – Mass of iridium tools based on pixel count in each artwork (counted by author).

The average mass of a felling axe with a wooden handle and steel head is ~1.5 kg (Appendix A). This difference in mass can be explained by the difference in density between iridium and steel. Tool steel has a density of 7.79 g cm^{-3} [5], and iridium has a density of 22.56 g cm^{-3} [4]. The density of steel is ~3 times less than the density of iridium. The heavy mass of an iridium tool, compared to a regular steel tool, means there is a higher physical strain on the user, making the tools harder to use and more likely to cause injury. This makes iridium less favourable compared

to steel and is a reason it is not currently used in tool manufacturing.

Cost of Iridium Tools

Iridium has an abundance of ~0.000037 ppm in the Earth's crust [3]. Comparatively, iron, the current industry standard in tool steel alloys, has an abundance of ~56300 ppm [6]. Since iridium is scarcer, tools made from it would be more expensive to construct. As of 22nd January 2025, 1 kg iridium costs € 148,650.00 [7]. Using the current cost of iridium and mass required, table 2 shows the cost of materials to produce each of the tools shown in Figure 1. The total cost of materials for all of these tools together would be over £3 million. Therefore, the rarity and corresponding high cost of iridium explains why it is not used to manufacture tools.

Tool type	Cost 1kg iridium (€)	Mass of iridium (kg)	Cost of materials (€)	Cost of materials (£)
Axe	148,650	8.58	1,274,943.47	**1,059,822.26**
Pickaxe		8.39	1,247,227.31	**1,036,782.65**
Hoe		8.02	1,191,794.99	**990,703.42**

Table 2 – Cost of iridium to make each tool, based on price of iridium at 10am on 22nd Jan 2025 [7] and currency conversion at 4pm on 17th Feb 2025.

Chemical Properties of Iridium

Comparison of the chemical properties of iridium and steel, such as hardness, forging temperatures, and brittleness, can provide insight into the suitability of iridium for use in tools. For simplicity, it is assumed that real-world axes, pickaxes, and hoes all benefit in the same way from the chemical properties of steel. The heads of real-world felling axes are made of tool steel [8], and it can be assumed real-world pickaxes and hoes are made of a similar steel alloy.

Hardness

Tool steel is extremely hard, tough, and inert to local overheating [9] caused when an excess of energy is supplied to one area of the material. These characteristics are important requirements for these tools due to their usage in high impact activities such as chopping down trees and breaking rocks. There are multiple ways to measure the hardness of a material; Brinell hardness measures the depth a tungsten carbide ball penetrates into a piece of material [10]. Mild steel has a Brinell hardness of 130 [10] and iridium has a Brinell hardness of 565 [11], meaning iridium is a harder material than mild steel. However, there are limited examples of the Brinell Hardness of tool steel, which is a harder metal than mild steel. Therefore, it is likely that the hardness of tool steel is more comparable to that of iridium. For this reason, it is important to look at additional factors related to the properties of iridium and steel. Hardness is not the only consideration of whether a material is suitable to produce tools, as iridium is also incredibly brittle [9]. This means if iridium was used to produce tools, although it may be harder than other real-world axes, it may also splinter under high impact during use.

Forging Temperatures

Forging steel requires elevated temperatures of up to 1,150 ˚C [12]. This allows the steel to be moulded to the desired shape, such as the head of an axe or pickaxe. For comparison, aluminium and copper alloys require temperatures of ~400 ˚C and ~750 ˚C for forging, respectively [12]. At temperatures between 1200-1500 ˚C, iridium becomes ductile [3]. Therefore, the cost to forge iridium into the desired shape would be greater than steel due to the higher temperatures required during the forging process.

Conclusion

It has been calculated that iridium tools would be over 3 times heavier than current industry standards for the same tools, and that the materials to make these tools would cost, in total, over £3 million. Whilst iridium demonstrates it has positive chemical properties for use in tools such as a hardness similar to steel, iridium is too brittle to withstand the high impact force during use. Lastly, due to the elevated temperatures of forging iridium, the industrial production process would be expensive to scale leading to even higher costs.

Therefore, it can be concluded that iridium tools are likely not used within the real world due to the expense of materials and manufacturing process. Also, the high density and brittleness of iridium means that even if these tools were constructed, they would function as a novelty item rather than of practical use within industry.

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Appendix A – Axe Dimensions Calculation

Table showing the data collected for different felling axes on the market, and calculations to determine the volume of axe head.

Name	Axe head weight (g)	Axe head height (cm)	Axe head length (cm)	Axe head thickness (cm)	Handle length (cm)	Handle weight (g)	Overall length (cm)	Overall weight (g)	Volume of axe head (cm3)
Barebones Felling Axe HMS-21033	700	6	15.8	1.5	54	460	60	1160	142.2
Alder Rheinland Axe, felling axe	1250	5.5	19.5	3.7	63.5	704	69	1954	396.825
Fox Knives Sekira Axe, FX-701, felling axe	1000	5	18.5	3.8	55	635	60	1635	351.5
Hultafors felling axe, HY 10-0,9 SV, 840085	900	6.1	16.2		60.2	440	66.3	1340	
Gransfors Bruk Small Forest Axe 420		8.3	15.3	2.7	40.7		49	935	342.873
Gerber Bushcraft Axe, 31-003780		9	17.5	2.5	46		55	2041	393.75
TOPS Knives HIM-01 High Impact felling axe			14	0.9			50.8	1666	
Muller Forestry axe Biber Classic-S 1200g	1200	6.5	21	3.7	63.3		69.8		505.05
Means	**1010**				**54.7**	**559.8**	**60.0**	**1533**	**355.4**

Table showing the calculation values to find the mass of iridium required to construct an iridium axe head of volume 355.37 cm^3, based on values calculated in the table above.

Volume of axe head (cm^3)	Density of iridium (g/cm3)	Mass of iridium axe head (g)	Average handle mass (g)	Mass of iridium axe (kg)
355.37	22.56	8017.06	559.75	8.58