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Manufacturing Processes and Defects

Materials and Introduction to Processing

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Abstract

The aim of this report is to select three daily objects: a stainless-steel spoon, a Polyethylene Terephthalate (PET) water bottle and a ceramic coffee mug. By choosing three distinct materials, analysis can be conducted on the material choice, manufacturing process, and mechanical and thermal properties. Comparing this data alongside lifespan, cost and environment will allow for alternative materials to be researched to understand if there's a more suitable material. The key material properties in the report include strength, ductility, modulus of elasticity, melting temperature and heat resistance. The findings show that stainless steels' high tensile strength, heat resistance, and corrosion resistance make them the most suitable for cutlery, such as spoons, manufactured through the metal stamping process. PET used in the manufacture of water bottles provides high ductility and is suitable for large-scale manufacturing when compared to alternatives such as glass. Ceramics exhibit high compressive strength and heat resistance; however their low ductility means a brittle product compared to stainless steel, which provides improved resistance to fracture under impact, resulting in a more durable material choice.

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1 Introduction

The aim of this report is to analyse three objects and their materials, making systematic comparison and justification of materials and manufacturing processes. Materials chosen in this report are stainless steel, PET, and ceramics. Comparing this diverse range of materials enables an investigation into their key distinctions and understanding the differences in their material properties, allowing for conclusions to be made on whether the correct material has been chosen.

2 Literature Review

2.1 Importance of Mechanical Properties and Manufacturing Processes

Understanding a material's mechanical properties and manufacturing processes is vital for engineers. According to (Elmardi, 2024), to select appropriate materials, and processing techniques for specific applications, you must have knowledge of the material properties and understand how the structure affects the material properties. Failure to properly analyse mechanical properties can lead to product failure. The causes of failure of a part in service can usually be traced back to defects in materials and processing (Kutz, 2002). This highlights the importance of engineers understanding the mechanical properties of the material, as failure in the product could lead to major safety risks.

2.2 Engineering Materials

According to (Jagannatha Guptha, 2023), common engineering materials can be classified into several groups as shown in Figure 1.

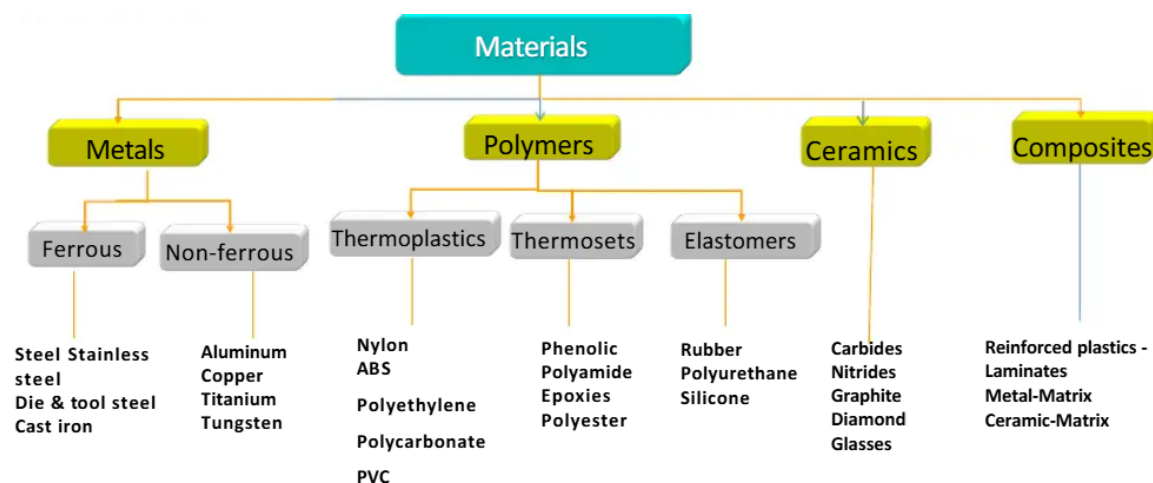


Figure 1: Engineering Materials (Jagannatha Guptha, 2023)

Figure 1 outlines the wide variety of materials an engineer can choose, each providing different mechanical properties and manufacturing characteristics which can range on their application for the required product.

3 Research and Discussion

3.1 Selection and Description

To make comparisons of manufacturing process and material properties, three distinct everyday items were selected. The objects chosen are manufactured from a single material which allows for variation in their properties and manufacturing process.

3.1.1 Stainless-Steel Spoon

A stainless-steel spoon was selected due to most households containing multiple units, indicating a high-volume manufacturing process. Although the selected material of stainless steel, other materials used are plastic, silver, and wood. However, stainless steel is commonly used in the manufacturing of metal spoons for their corrosion resistance and durability (Kumar, 2024). The most common grade of stainless steel used for spoons is grade 304 (British Stainless-Steel Association, n.d.).



Figure 2: Stainless Steel Spoon (Robert Dyas, 2026)

3.1.2 Water Bottle (PET)

Plastic water bottles are commonly used objects and provides valuable data when comparing mechanical properties. They are commonly made from PET due to its superior transparency, lightweight nature, and high production efficiency (Vivian,

2025). Plastic water bottles are typically used once before disposal which emphasises the need for a high production manufacturing process.



Figure 3: Plastic water bottle (Vivian, 2025)

3.1.3 Ceramic Coffee Mug

Ceramic is often a chosen material to produce coffee mugs. Ceramics are non-metallic materials that exhibit such useful properties as high strength, hardness and high melting temperatures (Britannica, n.d.). High strength and melting temperatures are important characteristics of a coffee mug which are used for safely holding hot liquids.



Figure 4: Ceramic Coffee Mug (Adorn Themes, 2026)

4 Manufacturing Method Comparison

4.1 Metal Stamping

Stainless-steel spoons are primarily manufactured using a metal stamping process as shown in Figure 5.

Metal Stamping Process

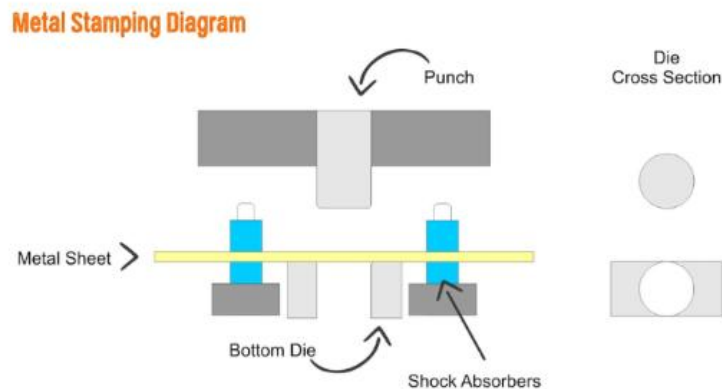


Figure 5: Metal Stamping Process ((Baison, 2023)

Metal stamping is a simple process with the highest cost associated with the process is the dies but after the number of units produced increases will drop with factories using the same die for hundreds of thousands of stampings before replacing (Baison, 2023). A metal stamping machine will continuously run as long as the sheet metal is fed allowing for large scale production of millions of parts using this process (Baison, 2023).

4.2 Injection Stretch Blow Moulding (ISBM)

Plastic water bottles manufactured from PET are formed from a process called ISBM as shown in Figure 6.

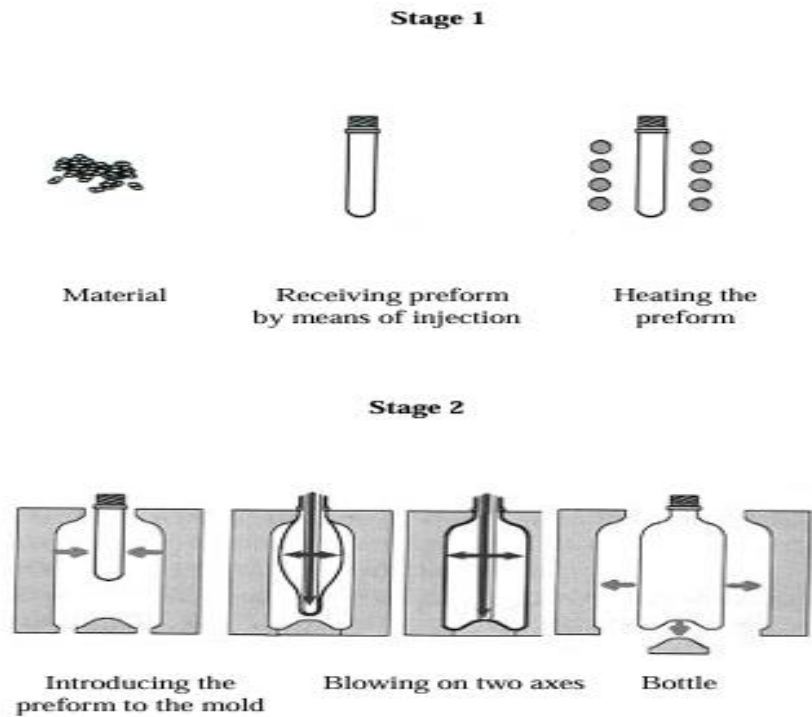


Figure 6: ISBM (W Kruszelnicka et al., 2018)

High production speed and automation make injection stretch blow moulding cost-effective for large-scale manufacturing (ISBM Machinery, 2025). Furthermore, the ISBM process has an initial cost and complexity of machines and moulds are high, so this method suits businesses with large production volumes (ISBM Machinery, 2025).

4.3 Slip Casting

Manufacturing a coffee mug from ceramics involves the process of Slip Casting as seen in Figure 7.

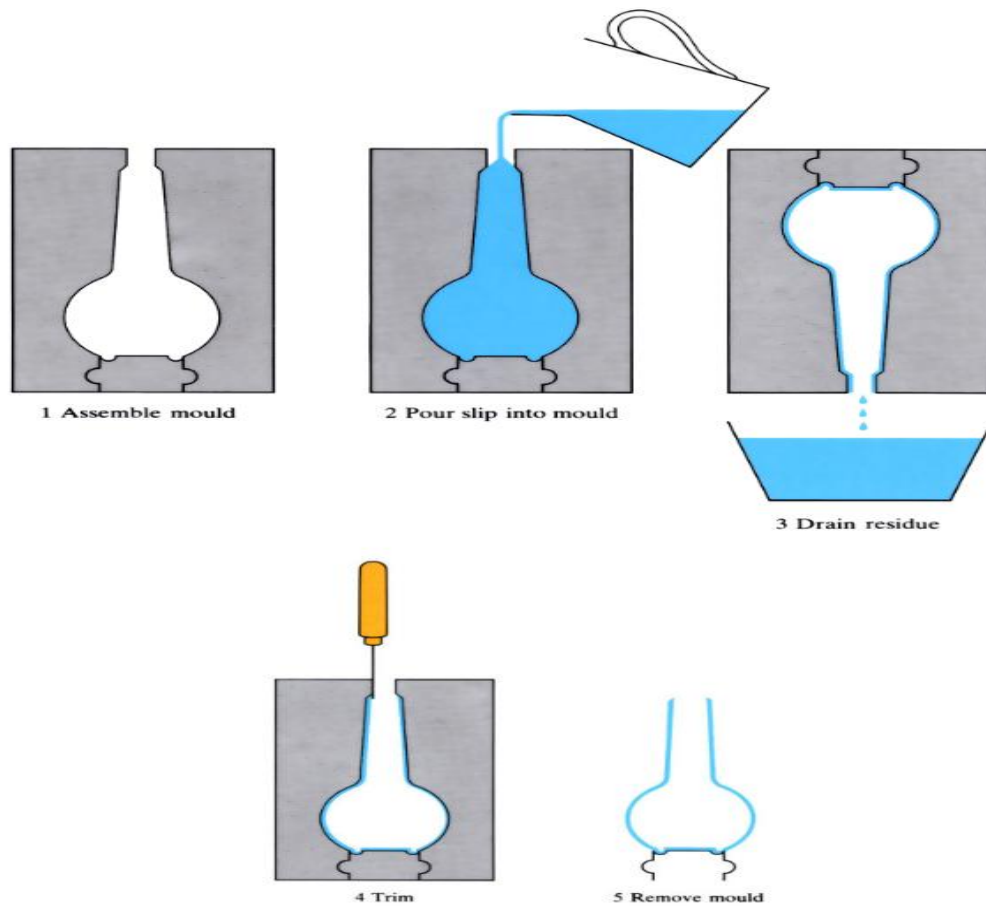


Figure 7: Slip Casting (The Open University, 2017)

In slip casting, modern methods employ resin moulds, automated mould-handling and filling equipment, pressurisation of the slip feed, heated slurry, air-assisted drying, vacuum dewatering of moulds, etc to reduce casting cycle time to as little as 20 minutes (Hansen, 2019). In addition, slip casting can produce complex shaped pieces but a simple manufacturing process, allowing production with low technical skills (Hansen, 2019).

5 Mechanical and Thermal Properties

5.1 Mechanical and Thermal Properties Comparison

Table 1: Mechanical and Thermal Properties

Property	Stainless-Steel Spoon (304 Grade) (Metal)	PET Water Bottle (Polymer)	Coffee Mug (Ceramic)
Strength	505MPa (Mat Web, n.d.)	65 MPa (Engineer calculator, 2026)	130 MPa (Compressive) (makeitfrom, n.d.)
Ductility	70% (Mat Web, n.d.)	100 % (Engineer calculator, 2026)	0% (makeitfrom, n.d.)
Modulus of Elasticity	193 GPa (Mat Web, n.d.)	3GPa (Engineer calculator, 2026)	67 – 150 GPa (makeitfrom, n.d.)
Melting Temperature	1400 – 1455 °C (Mat Web, n.d.)	250°C (Engineer calculator, 2026)	1170°C (Maximum Operating Temperature) (makeitfrom, n.d.)
Heat Resistance	Very High	Low (Engineer calculator, 2026)	High

The stainless-steel spoon has the highest strength, stiffness, and heat resistance, which makes it suitable to its intended use. In contrast, the PET water bottle has much lower stiffness and heat resistance but higher ductility, allowing it to deform without breaking, while the ceramic coffee mug has high heat resistance and compressive strength (Morgan Advanced Materials, 2024) but very low ductility outlining its brittle nature.

6 Lifespan, Cost and Environmental Analysis

6.1 Stainless Steel

Stainless steel exhibits high tensile strength and heat resistance allowing for continuous use in daily life for decades, even under demanding conditions. The World Stainless Association (2024) reports that water bottles manufactured from 304 stainless steel can have a lifespan of 20 years. Although stainless steel has high CO₂ emissions during its production process, further reductions in the production emissions for stainless steels will happen in the future, as the use of scrap or utilisation of renewable energy increases (World Stainless Association, 2024).

6.2 PET

PET plastic bottles are typically denoted for their single use properties, and their expected lifespan often do not exceed one year (Duan et al., 2024). This is reflected by the PET manufacturing process (Section 4.2) able to produce large production volumes due to its lifespan. According to (Duan et al., 2024), from 2020 usage of PET, 42% went to landfills and 35% was incinerated highlighting the negative impacts of PET use to the environment.

6.3 Ceramic

Ceramics to produce coffee mugs are suitable due to ceramics straightforward manufacturing method and their high heat resistance. The lifespan of a ceramic coffee mug is typically reported from approximately 5 to over 30 years (Curvd, 2026). However, the lack of ductility means it's a brittle material and more prone to fracture when under impact which can reduce the expected lifespan. Ceramics are primarily made from natural raw materials such as clay which lowers its environmental impact when compared to PET.

7 Material Selection and Alternative Choices

7.1 Stainless Steel

An alternative material for the manufacture of spoons is polypropylene (PP) due to its lower production requirement and its heat resistance of up to 104 °C without warping which can extend its lifespan when compared to other polymers (Martinez, 2026). Although, compared with PP, stainless steel provides significantly higher strength and stiffness which is essential for a spoons' intended use, highlighting the preferred choice of stainless steel.

7.2 PET

A PET water bottle can be manufactured from glass instead. However, when comparing glass to PET, glass is a brittle material compared to the ductility of PET (Table 1) making it less suitable for a water bottles daily use and more prone to fracture under impact. Although, glass is more sustainable due to its recyclable properties (The Cary Company, n.d.), it cannot compete with PETs high production efficiency (Section 3.1.2).

7.3 Ceramics

Stainless steel can be used as the material in the manufacturing of coffee mugs. When comparing ceramics to stainless steel (Table 1), stainless steel exhibits higher tensile strength and ductility. As a result, using stainless steel instead provides improved resistance to fracture when under impact whilst safely being used for storing hot liquids. This data indicates that stainless steel is the preferred material of choice.

8 Conclusion

Understanding mechanical properties and manufacturing process of materials is essential for an engineer when selecting materials for products. Comparing materials against criteria such as strength, ductility and heat resistance allows for informed decision making, ensuring a product is manufactured to correct specifications. For the manufacture of cutlery such as spoons, stainless steel's high tensile strength, heat resistance (Table 1) and its large-scale volume production (Section 4.1) indicate it as the most suitable material after comparison (Section 7.1). Despite glass being a more sustainable option (Section 7.2), the higher ductility property of PET (Table 1) and large-scale manufacturing (Section 4.2) justify its selection over glass for water bottles. Ceramics demonstrate high compressive strength and heat resistance (Table 1) making them a suitable choice of material for manufacture. However, when compared with stainless steel (Section 7.3), stainless steel provides improved resistance to fracture under impact due to its mechanical properties making it more suitable to a coffee mug's daily operating conditions.

9 References

9.1 Reference list

AdornThemes (2026). *Coffee Cup – Ceramic – Drip Glaze Finish*. [online] Hale & Beck. Available at: https://haleandbeck.com/products/drip-glaze-ceramic-coffee-cup?variant=56550613614965&utm_medium=cpc&utm_source=bing&utm_campaign=Bing%20Shopping&msclkid=c4861077ada31261650579f01cdf652d&utm_term=4577198196842999&utm_content=Ad%20group%20%231 [Accessed 10 Jan. 2026].

Baison (2023). *Laser Cutting vs. Metal Stamping: The Ultimate Showdown - Baison*. [online] Baison. Available at: <https://baisonlaser.com/blog/laser-cutting-vs-metal-stamping/>.

Britannica (n.d.). *Industrial ceramics*. [online] Encyclopedia Britannica. Available at: <https://www.britannica.com/technology/ceramics>.

British Stainless Steel Association (n.d.). *Cutlery Stainless Steel Grades – British Stainless Steel Association*. [online] British Stainless Steel Association. Available at: https://bssa.org.uk/bssa_articles/cutlery-stainless-steel-grades/.

Curvd (2026). *Securly - Geolocation sharing*. [online] Curvd.com. Available at: https://www.curvd.com/blogs/news/how-long-do-ceramic-mugs-last?srltid=AfmBOor9ZUfDSjFmZmU6OtY2B6R3dlRTkNMiprdPv3g9_KADvWnG8maR&utm [Accessed 17 Jan. 2026].

Duan, C., Wang, Z., Zhou, B. and Yao, X. (2024). Global Polyethylene Terephthalate (PET) Plastic Supply Chain Resource Metabolism Efficiency and Carbon Emissions Co-Reduction Strategies. *Sustainability*, 16(10), pp.3926–3926. doi:<https://doi.org/10.3390/su16103926>.

Elmardi, M. (2024). The Importance of Studying Mechanical Properties of Engineering Materials. *ResearchGate*. [online] doi:<https://doi.org/10.13140/RG.2.2.22654.60489>.

engineer calculator (2026). *Glossary | EngineerCalculator*. [online] Engineercalculator.com. Available at: <https://engineercalculator.com/glossary/#percent-elongation> [Accessed 7 Jan. 2026].

Hansen, T. (2019). *Slip Casting*. [online] Digitalfire.com. Available at: <https://digitalfire.com/glossary/slip%2Bcasting>.

ISBM Machinery (2025). *Understanding the Benefits and Drawbacks of Injection Stretch Blow Molding - ISBM Machine*. [online] ISBM Machine Manufacturer. Available at: <https://isbmmachine.net/understanding-the-benefits-and-drawbacks-of-injection-stretch-blow-molding/>.

Jagannatha Guptha, V.L. (2023–2024) *Engineering materials*. Lecture notes. RV College of Engineering, Bengaluru. Available at: <https://www.scribd.com/document/892297584/UNIT-1-Engineering-Materials> (Accessed: 13 Jan 2026).

Kumar, R. (2024). *Understanding Metal Tasting Spoons: A Comprehensive Guide*. [online] SciVast. Available at: <https://scivast.com/articles/metal-tasting-spoons-guide/> [Accessed 12 Jan. 2026].

Kutz, M. (ed.) (2002) *Handbook of materials selection*. New York: John Wiley & Sons. Available at: <https://catalogimages.wiley.com/images/db/pdf/Z0471359246.01.pdf> (Accessed: 10 Jan 2026).

makeitfrom (n.d.). *Engineering Porcelain :: MakeItFrom.com*. [online] www.makeitfrom.com. Available at: <https://www.makeitfrom.com/material-properties/Engineering-Porcelain>.

Martinez, S. (2026). *Understanding The Plastic Composition Of Modern Flatware Materials | ShunPoly*. [online] Shunpoly.com. Available at: <https://shunpoly.com/article/what-type-of-plastic-are-flatware-made-from> [Accessed 12 Jan. 2026].

MatWeb (n.d.). *MatWeb - The Online Materials Information Resource*. [online] matweb.com. Available at: <https://matweb.com/search/datasheet.aspx?matguid=abc4415b0f8b490387e3c922237098da&ckck=1>.

Morgan Advanced Materials (2024). *Compression and Creep in Ceramics*. [online] Morgan Advanced Materials. Available at: <https://www.morgantechnicalceramics.com/en-gb/ceramics-101/mechanical-properties-of-ceramics/compression-and-creep/>.

Robert Dyas (2026). *Tala Performance Stainless Steel Set Of 4 Latte Spoons*. [online] @RobertDyas. Available at: <https://www.robertdyas.co.uk/tala-performance-stainless-steel-set-of-4-latte-spoons> [Accessed 15 Jan. 2026].

The Cary Company (n.d.). *Glass vs Plastic: 7 Factors to Consider for Packaging your Product*. [online] www.thecarycompany.com. Available at: <https://www.thecarycompany.com/insights/articles/glass-vs-plastic-packaging>.

The Open University (2017). *Slip-casting*. [online] OpenLearn. Available at: <https://www.open.edu/openlearn/science-maths-technology/engineering-technology/manupedia/slip-casting>.

Vivian (2025). *Why Is PET The Go-To Material For Water Bottles Over HDPE*. [online] Bottle Blowing Machine And Mold. Available at: <https://ibottler.com/why-pet-is-the-preferred-material-for-water-bottles-over-hdpe/>.

W Kruszelnicka, P Bałdowska-Witos, J Flizikowski, Tomporowski, A., P Ropińska and Ignaczak, P. (2018). THE BLOWING PROCESS OF A PET BOTTLES. *Machines. Technologies. Materials.*, 12(8), pp.313–315.

World Stainless Association (2024) *Stainless steel CO₂ emissions report*. Available at: https://worldstainless.org/wp-content/uploads/2025/02/worldstainless_CO2_Emissions_Report.pdf (Accessed: 8 Jan 2026).