Jurnal Semiotika-Q
Kajian Ilmu al-Quran dan Tafsir

Volume 6, Nomor 1, Tahun 2026
E-ISSN 2809-0500 P-ISSN 2809-6401
http://jurnal.radenfatah.ac.id/index.php/jsq

Iron Metallurgy as a Foundation of Civilization: A Qur'anic Analysis of QS. al-Hadid [57]: 25 and Saba' [34]: 10–11

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Abstrak

Penelitian ini bertujuan menganalisis kedudukan besi sebagai fondasi peradaban manusia melalui kajian tafsir terhadap QS. al-Hadid [57]: 25 dan QS. Saba' [34]: 10-11 dengan pendekatan ilmiah integratif. Studi ini menggunakan metode penelitian kualitatif berbasis studi kepustakaan (*library research*) dengan sumber data primer berupa karya tafsir klasik dan kontemporer, seperti *Tafsir al-Tabari, Tafsir al-Azhar,* serta karya tafsir ilmiah Zaghlūl an-Najjār, dan didukung oleh literatur ilmiah terkait metalurgi. Analisis dilakukan melalui teknik *content analysis* dengan pendekatan tematik untuk mengidentifikasi makna teologis, linguistik, dan saintifik terkait konsep besi. Hasil penelitian menunjukkan bahwa al-Qur'an memposisikan besi sebagai anugerah ilahi yang memiliki *ba'sun syadid* (kekuatan besar) dan *manafi' li al-nas* (manfaat bagi manusia), yang terefleksi dalam perkembangan teknologi dan peradaban sejak masa Nabi Dawud hingga revolusi industri modern. Besi tidak hanya berfungsi sebagai material struktural utama dalam bidang pertanian, militer, konstruksi, dan industri, tetapi juga menjadi simbol kemajuan teknologi yang menopang sistem sosial, ekonomi, dan infrastruktur modern. Temuan ini menegaskan adanya sinergi antara wahyu dan ilmu pengetahuan dalam memahami peran metalurgi sebagai instrumen kemaslahatan serta indikator kemajuan peradaban manusia dari era awal hingga Revolusi Industri 5.0.

Kata Kunci: *Metalurgi besi, Fondasi Peradaban, QS. al-Hadid [57]: 25, QS. Saba' [34]: 10-11*

Abstract

This study aims to analyze the position of iron as the foundation of human civilization through an interpretive study of QS. al-Hadid [57]: 25 and QS. Saba' [34]: 10-11 with an integrative scientific approach. This study uses a qualitative research method based on library research with primary data sources in the form of classical and contemporary exegetical works, such as *Tafsir al-Tabari, Tafsir al-Azhar*, and the scientific exegetical works of Zaghlūl an-Najjār, and supported by scientific literature related to metallurgy. The analysis was carried out using content analysis techniques with a thematic approach to identify theological, linguistic, and scientific meanings related to the concept of iron. The results of the study show that the Qur'an positions iron as a divine gift that has ba'sun syadid (great strength) and manafi' li al-nas (benefits for humans), which is reflected in the development of technology and civilization from the time of the Prophet David to the modern industrial revolution. Iron not only serves as a primary structural material in agriculture, the military, construction, and industry, but also serves as a symbol of technological progress that underpins modern social, economic, and

infrastructure systems. This finding confirms the synergy between revelation and science in understanding the role of metallurgy as an instrument of public welfare and an indicator of the progress of human civilization from the early era to the Industrial Revolution 5.0.
Keywords: *Iron metallurgy, Foundations of Civilization, QS. al-Hadid [57]: 25, QS. Saba' [34]: 10-11*

INTRODUCTION

The Qur'an, as the holy book of Muslims, functions not only as a source of spiritual and legal (*sharīʿah*) guidance, but also as a source of scientific inspiration.[1] It contains *qauliyah* (textual) verses that often correlate with *kauniyah* verses (natural phenomena).[2] The interaction between revelation and reason, as well as between sacred text and scientific discovery, has given rise to various scholarly approaches, including the scientific approach.[3] This study is situated within the framework of the scientific approach, focusing on iron as one of the most fundamental materials for human civilization.

Iron is a metallic element that has played a significant role in the history of human civilization. From the perspective of the history of science, the development of metallurgy—the science of processing and engineering metals—has been a key factor in social, technological, and economic transformations from prehistoric times to the modern industrial era. Human ability to extract, smelt, shape, and alloy iron has generated innovations in agriculture, military technology, construction, and heavy industry.[4] Therefore, mastery of iron technology serves as an important indicator of civilizational advancement.

The Qur'an gives particular attention to iron, as mentioned in QS. al-Hadid [57] and QS. Saba' [34]: 10–11. In QS. al-Hadid, iron is presented as a divine gift possessing great strength and strategic benefits for humanity. Meanwhile, QS. Saba' [34] depicts iron as a technological instrument utilized by Prophet David in crafting armor through metallurgical skills granted by God.[5] These verses indicate that iron

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[1] Anisa Nur Izzati Sukmaningtyas, et al., "Etika Komunikasi Al-Qur'an Dan Relevansinya Dengan Komunikasi Di Zaman Modern", *Jurnal Semiotika-Q: Kajian Ilmu al-Quran dan Tafsir* 4, no. 2 (2024): 556–576. https://doi.org/10.19109/jsq.v4i2.23981.

[2] Alya Mardatillah B, Eva Dewi, and Khairil Anwar, "Ayat-Ayat Kauniyah dan Qur'aniyah Dalam Perspektif Epistemologi Ilmu" 3, no. 1 (2025): 22–31.

[3] Taufik Mukmin, Yesi Arikarani, "Filsafat Sebagai Sarana Transformasi Pendidikan Islam: Perspektif Ayat-Ayat Kauniyah", *Edification Journal : Pendidikan Agama Islam* 8, no. 1 (2025): 53–64. https://doi.org/10.37092/ej.v8i1.1247.

[4] Tech Agus Pramono, Rois Syuriah, "Eksistensi Ilmu Metalurgi Dalam Perspektif Islam", *Jurnal Pendidikan Karakter "JAWARA" (JPKJ)* 4, no. 1 (2018): 75–83.

[5] Melisa Humairoh, "Konsep Besi Dalam Q.S. Al-Hadid Ayat 25 Berdasarkan Teori Verifikasi Alfred Jules Ayer", *Amsal Al-Qur'an: Jurnal Al-Qur'an dan Hadis* 2, no. 3 (2025), 412-430. https://doi.org/10.63424/amsal.v2i3.500.

technology carries not only material value but also a theological dimension in supporting social welfare and the development of civilization.

This study aims to integrate Qur'anic exegesis with scientific findings in modern metallurgy. It not only examines the linguistic and theological meanings of iron in the Qur'an but also analyzes its relevance to technological developments from the prophetic era to the age of Technological Revolutions 1.0 to 5.0. Accordingly, this research seeks to provide a comprehensive perspective on iron as a foundation of civilization and as evidence of the synergy between revelation and scientific knowledge.[6]

This study is important due to the limited number of works that directly relate QS. al-Hadid and QS. Saba' through a scientific approach. Most previous studies focus on a single verse, particularly QS. al-Hadid, which highlights the distinction between Islamic and conventional production concepts. Conventional production emphasizes efficiency and profit maximization, whereas Islamic production incorporates spiritual, ethical, and social dimensions, oriented toward worship and public welfare. The study by Anggara et al. examines the perspective of Zaghlūl Rāghib Muḥammad an-Najjār and validates the concept of *anzalnā* through an astrophysical approach, demonstrating that iron originates from cosmic processes. However, the study primarily focuses on the origin and natural functions of iron, leaving room for further research on technological aspects and their impact on human civilization.[7]

This study, however, focuses on the scientific meaning of iron and its relationship with metallurgy and the development of human civilization. Iron is positioned as a fundamental element in civilizational progress from early societies to the era of Technological Revolutions 1–4. In QS. al-Hadid [57], the concept of *anzalnā* signifies iron as a divine gift endowed with strength and strategic benefits, while QS. Saba' [34]: 10–11 presents iron as a symbol of technological advancement and civilizational skill. Therefore, this research not only continues but also expands previous studies through a comparative and integrative approach to both verses.

The novelty of this research lies in its integrative framework that connects Qur'anic exegesis, scientific understanding of iron, and the historical trajectory of metallurgical development within a unified analytical model. Unlike prior studies that tend to emphasize either theological interpretation or scientific correlation in isolation, this study systematically bridges textual interpretation (*tafsir*), material science, and the evolution of technological revolutions, thereby offering a

[6] Hasan Husaini, Badruddin, "Produksi Dalam Tafsir Al-Qur'an", *Jurnal Riset Multidisiplin Edukasi* 1, no. 2 (2025), 65-75. https://doi.org/10.71282/jurmie.v1i2.14.

[7] Deki Ridho Adi Anggara, Aqdi Roqif Asnawi, and Alhafidh Nasution, "Mengungkap Rahasia Besi Dalam Al-Qur'ān Menurut Zaǵlul Rāǵib Muḥammad An-Najjār (Pendekatan At-Tafsīr Al-'Ilmī)," *MAGHZA: Jurnal Ilmu Al-Qur'an Dan Tafsir* 8, no. 2 (2023): 192–206.

multidimensional reading of iron as both a symbolic and functional foundation of civilization. In addition, this research extends the discussion beyond conventional industrial phases by situating iron within the broader continuum of technological transformation and civilizational dynamics.

The research gap addressed in this study emerges from the limited scholarly attention to the intersection between Qur'anic discourse on iron and the scientific-historical development of metallurgy in a comprehensive manner. Existing literature often treats QS. al-Hadid [57] in relation to cosmological or theological themes, while QS. Saba' [34]: 10–11 is primarily examined within prophetic narratives without further technological contextualization. Moreover, few studies attempt to synthesize these verses within the framework of modern scientific knowledge and industrial evolution. This study, therefore, fills this gap by providing a holistic analysis that integrates scriptural interpretation, scientific insight, and civilizational history, positioning iron as a key conceptual bridge between revelation and the advancement of human knowledge.

RESEARCH METHOD

This study employs a qualitative method with a library research approach.[8] This approach is chosen because all data required to address the research problem are derived from literature and written documents rather than fieldwork. Methodologically, this study is situated within a scientific approach that seeks to correlate Qur'anic verses with modern scientific phenomena. The data are classified into two main categories: primary and secondary sources. The primary data sources include *Tafsir al-Azhar* by Hamka, *Tafsir al-Tabari* by Abu Ja'far Muhammad bin Jarir al-Tabari, and *Tafsir al-Ayat al-Kauniyyah fi al-Qur'an al-Karim* by Zaghlūl Rāghib Muḥammad an-Najjār as a representation of scientific exegesis. These sources serve as the main foundation for analyzing the meaning of iron and its relationship with metallurgy and human civilization from theological, semantic, and scientific perspectives.

The secondary data sources consist of scholarly works such as journal articles, undergraduate theses, and prior studies related to scientific exegesis, particularly concerning QS. al-Hadid [25] and QS. Saba' [34]: 10–11. The scientific approach in this study aims to uncover the scientific dimensions of Qur'anic verses by relating them to contemporary scientific findings. The data analysis technique employed is content analysis with a thematic approach, focusing on verses about iron QS. al-Hadid [57] and QS. Saba' [34]: 10–11. The analysis involves identifying key terms,

[8] Ashila Uhnul Nafisa, Yeti Dahliana, "The Scientific Meaning of Fingerprints as Identity and Punishment in QS Al-Qiyamah (4) and Al-Anfal (12)", *Mauriduna: Journal of Islamic Studies* 6, no. 4 (2025), 698-717. https://doi.org/10.37274/mauriduna.v6i4.23.

comparing interpretations of various exegetes, and interpreting theological and scientific meanings. The findings are then critically correlated with modern scientific discoveries in metallurgy and human civilization to produce a systematic synthesis within a qualitative library-based research framework.[9]

RESULTS AND DISCUSSION

Meaning of Iron in QS. al-Hadid [57]: 25 and Saba' [34]: 10–11

The concept of iron in QS. al-Hadid [57]: 25 and QS. Saba' [34]: 10–11 demonstrates a correspondence between Qur'anic textual meaning and modern scientific understanding. In QS. al-Hadid [57]: 25, it is stated:

لَقَدۡ أَرۡسَلۡنَا رُسُلَنَا بِٱلۡبَيِّنَٰتِ وَأَنزَلۡنَا مَعَهُمُ ٱلۡكِتَٰبَ وَٱلۡمِيزَانَ لِيَقُومَ ٱلنَّاسُ بِٱلۡقِسۡطِۖ وَأَنزَلۡنَا ٱلۡحَدِيدَ فِيهِ بَأۡسٞ شَدِيدٞ وَمَنَٰفِعُ لِلنَّاسِ وَلِيَعۡلَمَ ٱللَّهُ مَن يَنصُرُهُۥ وَرُسُلَهُۥ بِٱلۡغَيۡبِۚ إِنَّ ٱللَّهَ قَوِيٌّ عَزِيزٞ

"Indeed, We have sent Our messengers with clear proofs and revealed with them the Scripture and the Balance so that people may uphold justice. And We sent down iron, in which there is great might and benefits for humanity, so that Allah may make evident those who support Him and His messengers unseen. Indeed, Allah is Powerful and Exalted in Might."

The *asbāb al-nuzūl* of QS. al-Hadid relates to the condition of the Muslim community in Medina, where a sense of comfort led some individuals to neglect their religious responsibilities. The revelation thus serves as a reminder to remain committed to righteous deeds and the struggle for truth. Within this framework, iron is also associated with instruments such as weapons used to defend justice and protect the community.

Meanwhile, QS. Saba' [34]: 10–11 states:

وَلَقَدْ اٰتَيْنَا دَاوٗدَ مِنَّا فَضْلًاۗ يٰجِبَالُ اَوِّبِيْ مَعَهٗ وَالطَّيْرَ ۚوَاَلَنَّا لَهُ الْحَدِيْدَۙ

"Indeed, We granted David a bounty from Us, (saying), 'O mountains and birds, echo praises with him.' And We made iron pliable for him."

اَنِ اعْمَلْ سٰبِغٰتٍ وَّقَدِّرْ فِى السَّرْدِ وَاعْمَلُوْا صَالِحًاۗ اِنِّيْ بِمَا تَعْمَلُوْنَ بَصِيْرٌ

"(Commanding), 'Make full coats of armor and measure precisely the links, and do righteousness. Indeed, I am Seeing of what you do.'"

These verses illustrate iron as a technological resource, where Prophet David is granted the ability to manipulate and utilize it in the production of armor. This depiction reflects the role of metallurgy as a form of technical skill that contributes to the advancement of human civilization.

[9] Qomariyah Qomariyah, Ilyas Ilyas, "Pemahaman Al-Dākhil Dalam Tafsir Saintifik: Sebuah Tinjauan Umum", *Jurnal Semiotika-Q: Kajian Ilmu al-Quran dan Tafsir* 3, no. 2 (2023): 387–399. https://doi.org/10.19109/jsq.v3i2.26738.

According to *Lisān al-'Arab*, the term *al-ḥadīd* derives from the root ح–د–د, which conveys meanings of sharpness, hardness, and durability. Iron is named based on these characteristics, as it is hard, sharp, and functions as an instrument of delimitation and protection. The dictionary also records its derivatives, such as *ḥadīdah* (a piece of iron) and *ḥaddād* (blacksmith), indicating that in the Arab intellectual tradition, iron is understood not merely as a metal but also as a symbol of strength and firmness.[10] Raghib al-Asfahani, in *Mufradāt Alfāẓ al-Qur'ān*, defines *al-ḥadīd* as something hard, sharp, and strong, used for القوة (power), protection, and boundary-setting. Its meaning extends beyond the physical object (iron) to include a symbolic dimension associated with strength and the enforcement of law.[11]

In the development of science and technology, iron is no longer understood solely as a specific metallic element but as a broader representation of metallic materials that sustain modern life.[12] Other metals such as aluminum, copper, nickel, and potassium possess distinct characteristics and functions that complement the role of iron, whether as structural materials, electrical conductors, or components in industrial and energy processes. Therefore, iron may be positioned as the primary foundation of metallic materials, while other metals expand its technological functions in accordance with the needs of scientific and civilizational development.

Scholarly Interpretations of the Concept of Iron

In the context of QS. al-Hadid [57]: 25, the term *anzalnā* serves as a key concept for understanding how the Qur'an represents iron as part of divine will and governance. In al-Tabari's exegesis, the phrase *wa anzalnā al-ḥadīd* is interpreted as indicating that iron contains immense strength and various benefits for humanity, both in warfare and in everyday needs. Thus, the term *anzalnā* is not understood as a literal physical descent from the sky, but rather as the provision and bestowal of a divine blessing.[13]

Raghib al-Asfahani, in *Mufradāt Alfāẓ al-Qur'ān*, explains that the term *ba's* is associated with hardship, suffering, and strength in warfare. This concept is relevant to QS. al-Hadid [57]: 25, which describes iron as possessing *ba'sun shadīd* (great

[10] Abu Fadl Jamaluddin Muhammad bin Mukrim Ibnu Mandzur, *Lisan al-Arab* (Beirut: Dar Shadar, 1985), jilid 3.

[11] Muhammad Raghib al-Ashfahani, *Al-Mufradat fi Gharibil Qur'an,* terj. Ahmad Zainal Dahlan (Depok: Pustaka Khazanah, 2017), 43-44.

[12] Tety Sudiarti, Gina Giftia A. Delilah, Rohmanur Aziz, "Besi Dalam Al Qur'an Dan Sains Kimia (Analisis Teoritis dan Praktis Mengenai Besi Dan Upaya Mengatasi Korosi Pada Besi)", *Al-Kimiya: Jurnal Ilmu Kimia dan Terapan* 5, no. 1 (2018), 7-16.

[13] Abu Ja'far Muhammad bin Jarir Ath-Thabari, *Jami' Al-Bayan Fi Ta'wil Al-Qur'an Jilid 24*, (Jakarta: Pustaka Azzam, 2013), 638.

might) and numerous benefits.[14] The use of this term emphasizes that iron carries not only material value but also a symbolic dimension, representing strength, protection, and resilience in difficult circumstances. Al-Tabari interprets the "sending down of iron" as its presentation as a substance endowed with great strength and wide-ranging benefits, particularly in warfare and daily life. This interpretation is reinforced by QS. Saba' [34]: 10–11, which illustrates the utilization of iron through the skill of Prophet David as a means of social benefit.[15]

In al-Tabari's tafsir, metals are not discussed within a modern scientific framework, but rather in accordance with the Qur'anic context in which iron is mentioned. Iron is understood as a divine gift possessing great strength and utility, especially for tools, protection, and daily needs. This interpretation is grounded in linguistic analysis and reports from the Companions and the tabi'in, indicating that iron was regarded as a crucial material for human life and civilization.

Regarding QS. Saba' [34]: 11, Hamka cites the views of Hasan al-Basri, Qatadah, and al-A'mash, who state that Prophet David was granted the ability to soften iron without the use of tools such as hammers or fire. The iron became pliable instantly, enabling him to produce armor with ease and precision. This phenomenon is understood as a prophetic miracle. The interpretation also shows that David's abilities encompassed both spiritual and technical dimensions, as a leader, artist, and metallurgical practitioner.[16]

In *Tafsir al-Azhar*, Hamka does not elaborate on types of metals in technical detail, but instead offers a contextual interpretation of "iron" as a general representation of metals essential to human life. Iron is positioned as a symbol of strength, justice, and civilizational progress.

According to a narration from Qatadah, before the time of Prophet David, armor was not known as a form of warfare equipment, and shields were primarily used. Therefore, the innovation of armor-making by Prophet David represents not only a miracle but also a technological contribution with social and military significance. Furthermore, David's activity in producing and distributing armor reflects a strong work ethic, as the proceeds were used for family needs, assisting the poor, and social welfare. The verse concludes by emphasizing that professional and technical activities can constitute acts of worship when performed in obedience to God.[17]

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[14] Dede Suhendar, "Meninjau Bukti Ilmiah Kekuatan Besi Menurut Cara Pandang Ilmu Kimia Dan Sains Yang Berkaitan Beserta Beberapa Konsekuensinya Sebagaimana Disebut Dalam Al Quran Qs. Al Hadiid: 25", *Jurnal Istek* 4, no. 1 (2011).

[15] Md. Mamunur Rashid, "Scientific Findings on Origin and Attributes of Iron Mentioned in Al-Qur'an", *Journal of Quranic Sciences and Research* 5, no. 1 (2024), 1-11.

[16] Hamka, *Tafsir Al-Azhar*, (Jakarta: Pustaka Panjimas, 2003), Jilid 8, 5934.

[17] Hamka, *Tafsir Al-Azhar,* Jilid 8, 5934.

Interpretations of iron in QS. al-Hadid [57]: 25 and QS. Saba' [34]: 10–11 reveal an integrative tendency that combines theological, symbolic, and functional meanings, while also exposing certain tensions within contemporary scientific approaches. On the one hand, classical exegetes such as al-Tabari and Hamka successfully position iron as a divine gift possessing both strength (*ba's*) and social utility, without reducing it to a purely material entity. On the other hand, modern readings that associate the concept of *anzalnā* with the cosmic origin of iron or the development of metallurgy risk exceeding the textual intent if not grounded in clear methodological limits. This suggests that the scientific exegetical approach must exercise caution to avoid over-interpretation by imposing scientific validation onto the scriptural text. Therefore, a more balanced position is to understand these verses as a theological framework that invites dialogue with science, rather than as literal scientific explanations, thereby maintaining equilibrium between normative, symbolic, and empirical dimensions in contemporary Qur'anic studies.

The Relationship between Iron Metallurgy and Human Civilization

Metallurgy is a field of science and technology that studies metals, encompassing processes from ore extraction and purification to alloy formation, as well as the analysis of their properties and applications. This discipline has been known since prehistoric times, when humans began utilizing metals such as gold, silver, and copper. Over time, metallurgy has developed into a significant field integrating principles of physics, chemistry, and engineering in material design. Its branches include physical, mechanical, chemical, powder, and engineering metallurgy, all of which focus on the structure, properties, and processing of metals. Iron, as an alloy primarily composed of Fe and C, holds a central role in civilization, as its carbon content determines its properties and forms the basis of modern steel production.[18]

The mastery of iron metallurgy serves as a key indicator of advancement in material technology, as it enables the production of steel with superior mechanical properties. Innovations in iron processing enhance strength, ductility, and durability, making it a primary material for manufacturing tools, construction, and industrial machinery. Therefore, iron metallurgy has made a fundamental contribution to the development of modern infrastructure and technology.[19]

The role of iron in human civilization is evident in its capacity to drive social, economic, and cultural transformations. The mastery of iron technology has

[18] Mishbah Khoiruddin Zuhri, "Analisis Metalurgi Menurut Ilmu Kimia Dan Perspektif Al-Quran: Tinjauan Surat Al-Kahfi Ayat 96-97," *Prosiding Konferensi Integrasi Interkoneksi Islam Dan Sains* 4 (2022): 364–369.

[19] Zuhri, "Analisis Metalurgi Menurut Ilmu Kimia Dan Perspektif Al-Quran: Tinjauan Surat Al-Kahfi Ayat 96-97.

produced agricultural tools, weapons, and construction equipment that increase productivity and accelerate development. Societies that controlled iron technology tended to advance more rapidly, establishing stronger economic and political systems, as well as forming settlements and centers of civilization. Thus, iron functions not only as a technological material but also as a catalyst for civilizational development.

Historically, the use of iron can be observed in several domains. *First*, in early periods, civilizations such as the Hittite Empire in Anatolia utilized iron to produce tools and weapons, including swords, spears, and agricultural implements. *Second*, the use of iron-based agricultural tools increased food production by enabling more effective land cultivation, leading to population growth and greater social complexity. *Third*, in the military domain, iron weapons provided superior strength and durability compared to earlier materials, granting strategic and defensive advantages. *Fourth*, in construction and infrastructure, iron was used to produce structural components such as nails, frames, and other elements, facilitating the development of cities, fortifications, and bridges, and promoting urbanization.

The role of iron in technological and civilizational development corresponds with the Qur'anic assertion in QS. al-Hadid [57]: 25, which states that iron possesses great strength and benefits for humanity. Iron is understood as a divine endowment that supports life, development, and the establishment of justice. Its utilization across various sectors reflects its strategic function in the history of civilization, while also illustrating human efforts to understand and utilize the signs of divine power wisely.

Iron and Strategic Metals in the Perspective of Modern Science and Technology

From the perspective of modern science and technology, iron occupies a central position as a primary foundation for the development of industrial civilization and technological systems. Functionally, however, its role is not autonomous, as it operates within an integrated system of strategic metals that includes elements such as aluminum, copper, silver, and certain alkali metals, each contributing specific functions within the contemporary technological ecosystem. Accordingly, iron may be understood as a representative symbol of the broader metallic system that underpins human life and progress.[20]

Materially, iron and its alloys (steel) serve as the principal structural framework for most technological infrastructures, ranging from industrial buildings and production machinery to transportation systems and energy devices. Its superior mechanical properties, including high tensile strength, load resistance, and

[20] Gunnar Haaland, Randi Haaland, Suman Rijal, "The Social Life of Iron. A Cross-Cultural Study of Technological, Symbolic, and Social Aspects of Iron Making", *Anthropos* 97, no. 1 (2002), 35-54.

adaptability in engineering processes, establish iron as the foundational framework of technology, while other metals complement functions that cannot be fulfilled by iron alone.

Aluminum functions as a strategic complementary metal in modern technologies that require lightness, energy efficiency, and corrosion resistance. Its low density makes it essential in the automotive and aerospace industries, where weight reduction directly enhances efficiency and performance.[21] Furthermore, its electrical and thermal conductivity supports its application in cooling systems, electronic components, and modern construction, thereby extending the functional capacity of iron through lighter yet technically effective material solutions.[22]

Copper and silver play critical roles in sustaining modern technologies based on electricity, electronics, energy systems, and chemical industries. Copper, characterized by high electrical and thermal conductivity, is widely utilized in electrical wiring, energy distribution networks, electric motors, transformers, and communication devices, making it fundamental to electrical and data transmission systems.[23] Silver, although used more selectively due to its economic value, possesses the highest electrical conductivity among metals and is therefore applied in precision electronics, high-performance electrical contacts, sensors, solar panels, and renewable energy technologies requiring optimal efficiency and stability. [24]

Nickel constitutes another strategic metal with significant relevance in contemporary technology, particularly in energy and storage systems. It is a key component in nickel-based batteries, such as nickel–metal hydride (NiMH) batteries, which are recognized for their stability, durability, and safety. These batteries are widely employed in electronic devices, hybrid vehicles, and industrial applications. In addition, nickel serves as an efficient electrode material in electrochemical systems, reinforcing its importance in advancing sustainable and efficient energy technologies. [25]

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[21] Andika Wisnujati, Chirtian Sepriansyah, "Analisis Sifat Fisik Dan Mekanik Paduan Aluminium Dengan Variabel Suhu Cetakan Logam (Dies) 450 Dan 500 Derajat Celcius Untuk Manufaktur Poros Berulir (Screw)", *Turbo* 7, no. 2 (2018): 159–165.

[22] Pooya Parvizi, Milad Jalilian, and Pedram Sorouri, "Mechanical and Physical Properties of Aluminum and Its Alloys for Electrical Conductors : A Review," *Next Materials* 9, no. August (2025): 101090, https://doi.org/10.1016/j.nxmate.2025.101090.

[23] Eva Anggraini, Muhib Rosyidi, "Karakteristik Metalurgi Pada Zaman Zulkarnain Dalam Kajian Sains", *JISTech (Journal of Islamic Science and Technology)* 8, no. 1 (2023): 12–19. http://dx.doi.org/10.30829/jistech.v8i1.14627.

[24] Daffa Abdul Malik, *Pengaruh Variasi Massa Logam Perak Pada Ekstraksi Perak Nitrat (Agno3) Dengan Menggunakan Metode Reduksi Kimia Evaporasi*, (Lampung: Universitas Lampung, 2023).

[25] Botagoz Amanyazova, Moldir Sailaukhanova, and Indira Kurmanbayeva, "Advances in Battery-Grade Nickel Sulfate Production," *Separation and Purification Technology* 382, no. P1 (2026): 135672, https://doi.org/10.1016/j.seppur.2025.135672.

In sum, iron and other strategic metals operate synergistically in establishing the foundation of modern technology, enabling the development of systems that are structurally robust, functionally efficient, and technologically sustainable.

Iron as a Symbol of Civilization

Iron has long been regarded as a principal symbol of human civilization due to its substantial role in shaping technological advancement, economic development, and social organization.[26] The transition from stone and bronze to iron marked a transformative historical phase that enhanced capacities in production, agriculture, defense, and industry. Mastery of iron-processing technology enabled the creation of more efficient agricultural tools, stronger weaponry, and more durable infrastructure, positioning iron as a fundamental basis for societal progress. Within cultural and historical frameworks, iron also represents human intellectual capacity to transform natural resources into high-value technology, thereby functioning not only as a physical material but also as a symbol of creativity, strength, and civilizational resilience.

This symbolic significance is further reinforced by the long historical trajectory of iron utilization spanning millennia. Around 1500 BCE, iron became known to human societies, although its use remained limited. A major development occurred around 1100 BCE when the Hittites of ancient Anatolia, who had preserved iron-smelting techniques for centuries, began disseminating this knowledge across West Asia, facilitating the wider spread of metallurgy.[27] By 1000 BCE, civilizations such as the Greeks, Egyptians, Hebrews, Romans, Carthaginians, and Assyrians had adopted iron technology for daily use. By 800 BCE, India developed iron production through interactions with Indo-Aryan cultures, while China advanced iron-making techniques between 700–600 BCE. Europe entered a new phase with the emergence of steel production in the 5th–4th centuries BCE, followed by further developments in India around 250 BCE. The advancement of metallurgy reached a notable peak with the production of Damascus steel around 1000 CE, although its techniques were lost by the 14th century. Renewed progress in iron and steel research during the 18th century in Europe paved the way for the Industrial Revolution and the rise of modern technology. Collectively, these developments indicate that mastery of iron and steel has served as a key indicator of civilizational advancement and technological superiority.

[26] Nathaniel L Erb-satullo, "The Innovation and Adoption of Iron in the Ancient Near East", *Journal of Archaeological Research* 27 (2019), https://doi.org/10.1007/s10814-019-09129-6.

[27] Aries Abbas, Alfian Ady Saputra, *Material Teknik* (Padang: Gemilang Press Indonesia, 2025), 1-17.

From a theological perspective, Qur'anic references—particularly in QS. Saba' [34]: 10–11—depict the miracle granted to Prophet David in softening iron and shaping it into protective armor. These verses not only highlight a divine endowment but also illustrate that the ability to master iron technology carries social and civilizational significance. The command to produce armor with precision reflects the role of iron in strengthening defense systems, structuring social order, and reinforcing collective resilience. Thus, the Qur'an presents iron not merely as a material substance but as a vital instrument underpinning technological development, social stability, and civilizational growth.[28] The integration of historical and theological dimensions underscores that mastery of iron constitutes a central factor in the trajectory of human progress and forms part of the divine order governing civilization.

The Role of Iron in the Technological Revolution

The verse in QS. al-Hadid [25] affirms that iron is a divine endowment possessing "great might (*ba'sun shadīd*)" and "various benefits for humankind (*manāfi' li al-nās*)." This meaning can be contextually interpreted through the trajectory of technological revolutions across history. The strength of iron is evident in its function as a primary material shaping industrial civilization, beginning with its use in steam engines during the First Industrial Revolution, railway systems, mechanical frameworks, factory structures, and production equipment in the Second Industrial Revolution. In the Third and Fourth Industrial Revolutions, iron and its alloys remain fundamental to modern technological infrastructure, including industrial robots, data centers, servers, electric vehicles, and advanced architectural systems. In the era of the Fifth Industrial Revolution, which emphasizes harmonious collaboration between humans and intelligent technology, iron-based materials continue to play a crucial role in collaborative robotics, precision manufacturing, and sustainable energy infrastructure. Thus, iron not only represents *ba'sun shadīd* as a symbol of strength and resilience but also reflects *manāfi' li al-nās* as a means of public benefit enabling the advancement of science, technology, and increasingly complex and sustainability-oriented human life.[29]

1. *Ba'sun Shadīd* (Industry 1.0)

The First Industrial Revolution in the 18th century was marked by the invention of the steam engine, transforming production from manual systems to mechanization. In this phase, iron played a fundamental role as the primary material in steam engine construction, particularly in boilers, cylinders, shafts, gears, and

[28] Rashid, "Scientific Findings on Origin and Attributes of Iron Mentioned in Al-Qur'an".

[29] Tundjung and Rani Noviyanti, "Revolusi Industri Dan Pengaruhnya Pada Penelitian Sejarah," *Alur Sejarah: Jurnal Pendidikan Sejarah* 4, no. 2 (2020).

structural frames capable of withstanding high-pressure steam safely.[30] Iron also became essential in railways, locomotives, steamships, and early industrial infrastructure such as factories, bridges, and mining equipment. Mastery of iron technology enabled the conversion of steam energy into mechanical power, making it the backbone of early industrialization. This aligns with the Qur'anic notion of iron as *ba'sun shadīd*, denoting immense strength capable of sustaining extreme mechanical stress.

2. *Manāfi' li al-Nās* (Industry 2.0)

The Second Industrial Revolution in the 19th century was characterized by the discovery of electricity, which reduced production costs and enabled mass manufacturing.[31] In this phase, large-scale iron and steel production significantly strengthened heavy industry, automotive sectors, and mass manufacturing systems.[32] Iron was widely used in production machinery, assembly lines, factory buildings, and electrical infrastructure such as generators, transformers, and electric motors due to its magnetic properties. The mass production of vehicles, ships, and industrial equipment depended heavily on steel as a metallurgical advancement of iron. In this context, iron functioned as a driver of efficiency, speed, and production scale, corresponding to the concept of *manāfi' li al-nās* as tangible benefits for human welfare and civilizational progress.

3. Divine Determination (Industry 3.0)

The Third Industrial Revolution represents not only a technological leap based on electronics and information systems but also a manifestation of divine determination (*taqdīr ilāhī*) in the development of human intellect and capability. Computer-based automation, enabling machines to operate autonomously, reflects the directed potential of human intelligence in managing natural resources with precision and efficiency.[33] Iron and steel are utilized in CNC machine frames, industrial robots, automation systems, servers, and smart factory infrastructure. Although electronic devices rely on silicon, they remain dependent on iron structures for mechanical stability, heat dissipation, and electromagnetic shielding. Semiconductor industries also require high-precision steel equipment to ensure

[30] Umi Trisyanti and Banu Prasetyo, "Revolusi Industri Dan Tantangan Revolusi Industri 4.0," *Prosiding SEMATEKSOS* 3 (2018), 22-27.

[31] Nadise Putri et al., "Pancasila Sebagai Landasan Etika Dalam Mengatasi Tantangan Cyberbullying : Menumbuhkan Empati Pada Generasi Z", *Nasywa - Maliki Interdisciplinary Journal* 2, no. 4 (2024): 489–498.

[32] Tundjung and Noviyanti, "Revolusi Industri Dan Pengaruhnya Pada Penelitian Sejarah."

[33] Maya Yunus, Margono Mitrohardjono, "Pengembangan Tehnologi Di Era Industri 4.0 Dalam Pengelolaan Pendidikan Sekolah Dasar Islam Plus Baitul Maal" *Jurnal Tahdzibi: Manajemen Pendidikan Islam* 3, no. 2 (2020): 129–38, https://doi.org/10.24853/tahdzibi.3.2.129-138.

accuracy and durability. This phase demonstrates that advancements in information technology are grounded in metallurgical foundations, with iron bridging the physical and digital realms.

4. Ethics and Public Benefit (Industry 4.0)

The Fourth Industrial Revolution, emerging in the 2010s, is characterized by the integration of artificial intelligence, the Internet of Things, and cyber-physical systems relying on high-speed data processing through semiconductor technologies. The development of artificial intelligence depends on advanced processors, data centers, and servers supported by physical infrastructures composed of iron and other metals.[34] Steel structures play a crucial role in mechanical stability, cooling systems, and hardware protection, while metallization layers in chips enable efficient signal transmission and thermal management. This indicates that digital and AI-driven advancements remain fundamentally dependent on metallurgical systems as their structural basis.

5. Human Values and Technology (Industry 5.0)

The Fifth Industrial Revolution may be understood as a scientific and ethical responsibility to direct technological advancement toward human welfare.[35] Iron, as a primary industrial material, represents a form of strength that must be managed through responsible scientific innovation.[36] Industry 5.0 integrates artificial intelligence, robotics, and sustainable systems to enhance quality of life while minimizing environmental impact. For instance, the use of AI in manufacturing to optimize energy consumption and reduce waste reflects the alignment of technological progress with social responsibility. Although AI operates in a digital domain, its functionality depends on robust physical infrastructure, including steel-based components in robots, servers, data centers, and industrial machinery. Thus, iron remains a fundamental material underpinning modern technological development and the evolution of Industry 5.0.[37]

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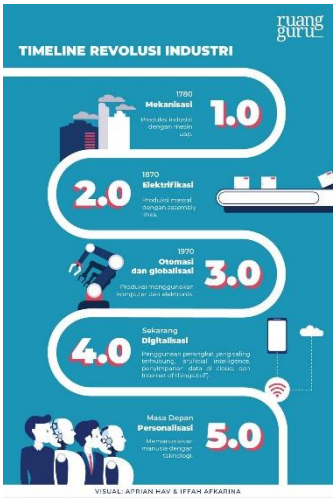
[34] Hoedi Prasetyo, Wahyudi Sutopo, "Industri 4.0: Telaah Klasifikasi Aspek Dan Arah Perkembangan Riset", *J@ti Undip: Jurnal Teknik Industri* 13, no. 1, (2018), 17-26, https://doi.org/10.14710/jati.13.1.17-26.

[35] Imaduddin Imaduddin, et al., "Pengaruh Teknologi Industri 5.0 Terhadap Efisiensi Manajemen Produksi Di Perusahaan Manufaktur", *EKOMA: Jurnal Ekonomi, Manajemen, Akuntansi* 4, no. 1 (2024): 2376–2384.

[36] Gianmaria Di Lorenzo, Antonio Formisano, Giusy Terracciano, Raffaele Landolfo, "Iron alloys and structural steels from XIX century until today: Evolution of mechanical properties and proposal of a rapid identification method", *Construction and Building Materials* 302 (2021), 124132. https://doi.org/10.1016/j.conbuildmat.2021.124132.

[37] Ina Kayser, "ScienceDirect Industry 5.0 – Past , Present , and Near Future," *Procedia Computer Science* 219 (2023): 778–88, https://doi.org/10.1016/j.procs.2023.01.351.



Gambar 1: Perkembangan Revolusi Industri
(https://www.ruangguru.com/blog/revolusi-industri-4-0)

The scientific framework concerning iron aligns with Qur'anic guidance, particularly in QS. al-Hadid [25], which states that God "sent down iron" endowed with great strength. Classical exegesis, such as that of al-Tabari, emphasizes iron's function as an instrument of defense and its practical benefits in human life, while *Tafsir al-Azhar* interprets this "sending down" as the endowment of technological potential to humankind. From a scientific perspective, the term *anzalnā* corresponds to the understanding that iron originates from supernova explosions and is partially delivered to Earth through meteoritic material.

This correlation is further reinforced by QS. Saba' [34]: 10–11, where God "softened iron" for Prophet David to produce armor. Al-Tabari interprets this as an extraordinary facilitation in shaping iron, whereas *Tafsir al-Azhar* highlights metallurgical skill as an indicator of civilizational advancement. Scientifically, the processes of softening and shaping iron constitute the foundation for the development of tools, weaponry, and early technologies.[38]

According to Zaghlūl an-Najjār, QS. al-Hadid [57] underscores iron as a fundamental element in the strength of human civilization, while QS. Saba' [34]: 10–11 illustrates its practical utilization through metallurgical technology in the era of Prophet David.[39] Together, these verses signify the strategic role of iron in the evolution of civilization—from simple tools to the foundation of modern technology and infrastructure—as part of divine guidance for humanity.

[38] Theodore A. Wertime, "Man's First Encounters With Metallurgy : Man's discovery of ores and metals helped to shape his sense of science, technology, and history", *Science* 146, no. 3649 (1964), 1257-1267, https://doi.org/10.1126/science.146.3649.1257.

[39] Zaghlūl Rāghib Muḥammad an-Najjār, *Tafsīr al-Āyāt al-Kauniyyah fī al-Qurʾān al-Karīm*, (Kairo: Maktabah as-Syurūq ad-Dawliyah, 2007), Juz 3.

CONCLUSIONS

This study demonstrates that iron constitutes a fundamental basis of human civilization, which the Qur'an presents not merely as a physical material but as a divine endowment possessing immense strength and strategic benefits for human life. QS. al-Hadid [57] emphasizes iron as a symbol of power, justice, and social welfare within both ancient civilizational structures and the trajectory of industrial revolutions. Meanwhile, QS. Saba' [34]: 10–11 illustrates the practical application of iron technology through the expertise of Prophet David in shaping it into armor, contributing to societal defense and well-being. From scientific and historical perspectives, mastery of iron metallurgy has served as a key indicator of technological advancement, driving social, economic, and cultural transformations from antiquity to the eras of Industrial Revolutions 1.0–5.0.

From an academic standpoint, references to iron in the Qur'an should not be construed as precursory scientific explanations preceding modern science. Rather, the Qur'an functions as a guidance text that highlights signs of divine power manifested through the natural world. Accordingly, verses concerning iron are more appropriately understood as reflections on its utility and potential for humanity, rather than as technical descriptions of metallurgy. Their correspondence with scientific knowledge may thus be viewed as a point of convergence between revelation and empirical inquiry, while also underscoring the ethical imperative that technological development be directed toward human welfare and responsibility.

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