ASEAN Journal for Science and Engineering in Materials 6(1) (2027) 57-78

ASEAN Journal for Science and Engineering in Materials

Journal homepage: https://ejournal.bumipublikasinusantara.id/index.php/ajsem

ASTM F75 Alloys: A Systematic Review of Microstructural Characteristics and Manufacturing Advances from Conventional to Laser-Based Techniques with Bibliometric Analysis

Raghad Ahmed Al-Aloosi[1], *Wisam T. Abbood*[1], *Enas A. Khalid*[1], *Wassan S. Abd Al-Sahb*[1], *Nazar Kais AL-Karkhi*[1], *Oday I. Abdullah*[1,2,3]*, *Somer Nacy*[4], *Adawiya J. Haider*[5], *M. N. Mohammed*[6]

[1]University of Baghdad, Baghdad, Iraq;
[2]Al-Naji University, Baghdad, Iraq;
[3]Al-Farabi Kazakh National University, Almaty, Kazakhstan.
[4]San Diego State University, San Diego, United States;
[5]University of Technology, Iraq;
[6]Gulf University, Sanad, Bahrain;
*Correspondence: E-mail: oday.abdullah@coeng.uobaghdad.edu.iq

ABSTRACT

This study provides a systematic and bibliometric review of ASTM F75 cobalt–chromium alloys, focusing on microstructure and the shift from conventional to laser-based manufacturing. Using combined analytical methods, it evaluates microstructure, mechanical properties, corrosion behavior, and biocompatibility. Results show that laser-based techniques such as LPBF and DMLS produce finer grain sizes (1–10 µm vs. 50–200 µm), leading to improved hardness (20–40%) and tensile strength (15–30%). Despite challenges like residual stress and process optimization, these methods show strong potential for high-performance and sustainable applications.

ARTICLE INFO

Article History:
Submitted/Received 10 Dec 2025
First Revised 19 Jan 2026
Accepted 12 Feb 2026
First Available online 05 May 2026
Publication Date 01 Mar 2027

Keyword:
Additive manufacturing;
ASTM F75 alloys;
Laser powder bed fusion;
Microstructural characterization;
Mechanical properties.

1. INTRODUCTION

ASTM F75 alloys have become a necessity in high-performance engineering applications, especially in situations where top-notch mechanical properties, corrosion resistance, and biocompatibility are most important [1]. These metals have been used extensively in surgical implants, dental prostheses, and aerospace components, where a material failure can trigger a disaster [2].

The superior performance of ASTM F75 alloys originates from the fact that they have the highest strength, the best wear resistance, and excellent corrosion stability in aggressive environments [1, 3]. The search for materials that can resist the harsh conditions of biological and high-temperature environments has been the main mover of the development of these metals throughout history [4, 5].

Several traditional manufacturing methods, such as investment casting, forging, and powder metallurgy, have been the main sources of ASTM F75 alloy production for many years [6]. But these methods have serious challenges, e.g., due to the refractory nature of these alloys, such as melting problems, microstructural inhomogeneities, and the inability to make complicated shapes [1].

The laser-based additive manufacturing technologies have changed the production industry of ASTM F75 alloys completely, and they allow unprecedented control of microstructural evolution and the creation of structures with very complicated shapes that were not possible before [7,8]. These include direct metal laser sintering (DMLS) & laser powder bed fusion (LPBF). They are high-productive methods for manufacturing parts that will meet demanding mechanical performance &/or other performance criteria [9, 10]. Tribocorrosion in biological environments of ASTM F75 alloys illustrates how the mechanical aspects of tribocorrosion are linked to electrochemical corrosion [1].

This effect is very hazardous in the case of metal-on-metal bearing surfaces of artificial joint implants. In such a case, the density of wear particles and metal ions goes beyond the necessary limit, which in turn causes adverse biological responses [2].

Besides, passive chromium oxide film formation has major significance in determining the corrosion resistance of the alloys, with the stability of this film being essential as it can be changed by different parameters such as alloy composition, microstructure, and environmental conditions [1]. Laser-based manufacturing technology has reached a new level with recent breakthroughs, thus allowing us to solve the problem of the old methods while also giving the possibility to create new alloy compositions and microstructures [11, 12].

In addition, the characteristic of the laser processing is that the solidification rate is very high; thus, it can prevent some unnecessary phase formation and also lead to the production of fine-grained microstructures with improved mechanical properties [13, 14]. The present review thoroughly examines a spectrum of achievements in ASTM F75 alloy production by both traditional and laser-based manufacturing methods. It sheds light on the advantages and disadvantages of each and pinpoints future research focus and technological openings for high-performance alloy manufacturing progress by summarizing extensive literature data.

This systematic literature review aims to thoroughly and methodically compare the traditional and laser-based manufacturing techniques for ASTM F75 alloys. It is a critical update of the existing literature, where most reviews have dealt with conventional or additive manufacturing techniques separately. The novelty of this work resides in the combination of bibliometric analysis with thematic synthesis to plot the research landscape, count the emerging trends, and give manufacturing process selection evidence-based recommendations. Moreover, this review is the only one that especially relates its results to the United Nations Sustainable Development Goals (SDGs).

SDG 3-Good Health and Well-being, ASTM F75 alloys are essential materials of medical implants such as hip and knee replacements, dental prosthetics, and spinal fixation devices. The development of laser-based manufacturing techniques can make more biocompatible implants, release fewer metal ions, and have improved tribocorrosion resistance. In this respect, implant durability and patient health benefit directly from the new implants.

SDG 9-Industry, Innovation, and Infrastructure, Laser-based additive manufacturing fundamentally changes the way things are made in industry as it allows digital manufacturing, introduces process optimization in machine learning-assisted manufacturing, and enables the production of complex geometries that were not possible with traditional methods.

This evolution of technology strengthens manufacturing infrastructure and promotes the development of sustainable industries. SDG 12-Responsible Consumption and Production, Laser-based manufacturing can be used to achieve a high material utilization rate of more than 95%, thus significantly lowering the waste of raw materials produced by the traditional subtractive methods.

The near-net-shape feature of these processes also serves to decrease the amount of post-processing, which is an important factor for more sustainable and resource-efficient production cycles. SDG 13-Climate Action, the energy saving of laser-based manufacturing, the combined factor of the reduced material waste, and the exclusion of widely post-processing activities together are contributing to the lowering of the carbon footprint of the manufacturing industry, hence, making it more compatible with the goals of climate change mitigation at a global level.

In this way, the paper is putting the progress made in the technology sector within a wider global sustainability context. This kind of multidisciplinary work is what sets the present review apart from the previous ones and is a source of practical knowledge points for biomedical and aerospace researchers, manufacturers, and policymakers.

2. METHODS

The systematic literature review (SLR) was performed in line with the standards of systematic reviews in engineering and materials science. The method of research consisted of four main stages:

(i) An extensive search of the database for relevant articles,
(ii) A shortlisting and further verification of the ones selected,
(iii) Bibliometric analysis,
(iv) Thematic synthesis and critical evaluation of the articles.

An extensive literature review was conducted on several scientific databases, The search was done with these key phrases: "ASTM F75" OR "CoCrMo alloy" OR "cobalt-chromium-molybdenum" in combination with "laser manufacturing" OR "additive manufacturing" OR "laser powder bed fusion" OR "selective laser melting" OR "DMLS" OR "casting" OR "forging" OR "powder metallurgy." The articles were restricted to the period of 2012 to 2025 to include fundamental as well as the latest developments in the field.

The initial search returned over 300 articles, which were screened through a multi-stage process. Inclusion criteria required that articles:

(i) Focus on ASTM F75 alloys or equivalent,
(ii) Address manufacturing processes (traditional or laser-based),
(iii) Report experimental or analytical results on microstructure, mechanical properties, corrosion behavior, or biocompatibility,
(iv) Be published in peer-reviewed journals or reputable conference proceedings.

Exclusion criteria eliminated studies that:

(i) Focused exclusively on non-cobalt alloy systems,
(ii) Lacked experimental validation,
(iii) Were duplicate publications. After full-text evaluation, 61 articles were selected for inclusion in the final review, forming the basis of the thematic analysis presented in subsequent sections.

An analysis of bibliometric data was carried out to understand the history of the topic in order to confirm that this review investigates a significant and growing area of research. Research output in the area of ASTM F75 alloys and the type/ form of laser manufacturing continues to demonstrate a clear upward trend in the number of publications.

The trend in the total number of publications illustrates that the production of research output has shifted dramatically from only a few papers before 2019 to almost half (55%) of all the papers published between 2023 and 2025, indicating that there is now significant academic interest in this area of research. Keyword co-occurrence analysis demonstrated that there is considerable overlap between the fields of science/materials engineering and biomedical engineering.

It is further observed that most of the studies are published in high-impact journals and that the average number of citations per paper has increased annually in a similar manner. From this, we draw the conclusion that there is ample evidence that this systematic review is timely and significant.

Standardized templates were used to extract data from each chosen study. Extraction points included:

(i) The manufacturing process used,
(ii) Alloy composition and processing information,
(iii) Results of microstructure analyses,
(iv) Mechanical properties (hardness, tensile strength, yield strength, and fatigue limit),
(v) Material performance in terms of corrosion and tribocorrosion resistance,
(vi) Biocompatibility assessments,
(vii) Important facts and limitations of the study.

The compiled data will be synthesized by subject matter into the following thematic sections: ASTM F75 Scientific Characteristics (Section 3), Comparison Between Manufacturing Processes (Section 4), Manufacturing Challenges/Limitations (Section 5), Laser Processing as an Enabling Technology (Section 6), Technological Superiority of Laser-based Manufacturing Technologies (Section 7), Future Directions (Section 8). This structured approach enables a thorough, repeatable, and verifiable review of the material in accordance with the best practices for systematic reviews.

3. RESULTS AND DISCUSSION

3.1. Scientific Characteristics of ASTM F75 Alloys

ASTM F75 alloys forensic scientific features incorporate the setting of their microstructural performance, corrosion resistance, as well as biological response, which are the key factors that select the alloys' suitability for implantation purposes. The metal microstructural growth, which is most notably attributed to the manner of processing and the metal's thermal past, affects its mechanical strength, wear resistance, and its electrochemical stability in body fluids.

3.1.1. Microstructural Evolution and Phase Composition

The major microstructural properties of ASTM F75 alloys are mostly set by their thermal processing history and cooling rates, which have a very strong effect on the resulting mechanical and corrosion characteristics [15, 16]. The main constituents of the microstructure are a face-centered cubic (FCC) γ-Co matrix phase and carbon precipitates, especially M23C6 and M6C types, which are chromium and molybdenum-enriched [1, 17]. Generally, the distribution of the carbides and their shape are naturally dependent on the content of carbon and the thermomechanical processing of the material.

HC ASTM F75 alloys, as a rule, show significantly increased carbide formation, which in turn improves hardness via precipitation strengthening mechanisms; nevertheless, this operation may also be the cause of corrosion resistance reduction because chromium is being consumed in the adjacent matrix area [1, 18]. Contrary to that, LC variants turn out to be more balanced in terms of elements and their distribution and have better corrosion stability, albeit with limited hardness [19, 20]. The microstructural elements resulting from the laser-based manufacturing methods are the consequence of extremely high solidification rates (10^3-10^6 K/s) and high cooling rates, and thus lead to fine-grained or nanocrystalline structures [21, 22]. Microstructural features introduced by laser-based manufacturing processes are characterized by very high solidification rates (10^3-10^6 K/s) and high cooling rates, leading to fine-grained or nanocrystalline structures [21, 22]. Such conditions of processing bring about the occurrence of supersaturated solid solutions and also inhibit the formation of the brittle intermetallic phases, which are the major sources of the conventional process of slow cooling [23, 24].

The cellular or columnar dendritic structures frequently encountered in laser-processed materials have grain sizes generally falling within the range of 1-10 µm, which are significantly finer than those resulting from conventional casting (50-200 µm) [25, 6]. The specific laser processing parameters, such as laser power density, scanning velocity, hatch spacing, and layer thickness, had a great impact on the resulting microstructural characteristics [26, 27]. Energy density optimization through laser processing can indirectly manipulate grain size, crystallographic texture, and the distribution of the secondary phase, which in turn will decide the mechanical and corrosion properties of the part being produced [28, 29].

In a recent publication, it was pointed out the fact that nanoprecipitates discovered in coherent and semi-coherent states were formed in additively manufactured ASTM F75 alloys. These nanoprecipitates give the strength of the material along with several strengthening mechanisms [30]. Typically, 5-50 nm in size, these nanoscale features are quality articles that generate the strengthening effect beyond the grain boundary. **Figure 1** shows the Microstructural Evolution of ASTM F75 alloys.

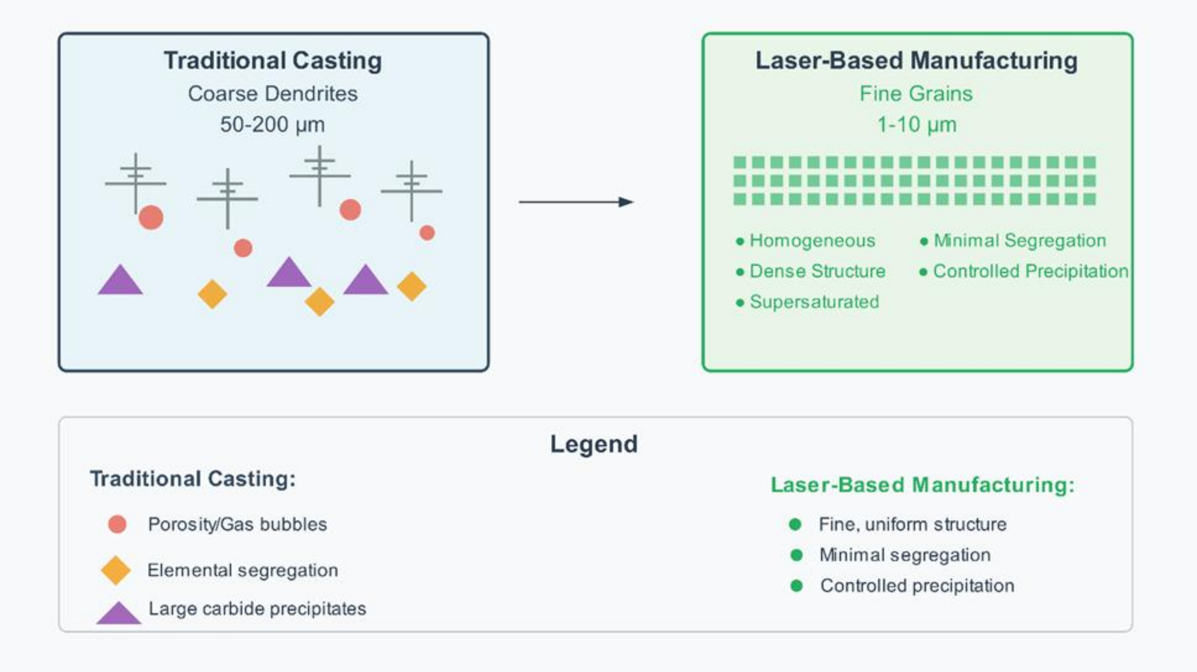


Figure 1. Microstructural evolution in ASTM F75 alloys.

3.1.2. Mechanical Properties and Performance Characteristics

The mechanical properties of ASTM F75 alloys are a one-to-one match with microstructural features and processing history, with laser-based production always yielding better results than traditional methods [31, 32]. The quick cooling from the high rate of solidification has led to the microstructure of the alloy being very fine-grained, which is the major factor in the strength increment due to the Hall-Petch mechanism, while the comixing of elements makes the deformation process more uniform [32, 33]. ASTM F75 alloys prepared via additive manufacturing generally possess hardness values in the range of 400-600 HV, which is much higher than that of conventionally cast ones (300-450 HV) [21,6].

This increase in hardness can be explained by the grain refinement effect and solid-state strengthening by precipitates, which are formed during the process of rapid solidification [34]. Laser-processed alloys have tensile strength values that can rise beyond 1200 MPa, and yield strengths of 800-1000 MPa are often reported, which means that they are far beyond those of traditional manufacturing methods [31]. Experimental results reveal that laser-fabricated ASTM F75 alloys' fatigue resistance is substantially upgraded, wherein the high-cycle fatigue frontier is regularly above 500 MPa at physiological loading conditions [32, 33].

The enhanced fatigue resistance is linked to the absence of casting defects, the reduction of grain size, and the improvement of surface integrity resulting from laser anisotropic behavior. A laser-based manufacturing technique may give directional dependence to mechanical properties owing to the nature of the process of building layer-by-layer and grains having a preferential orientation [35]. Nonetheless, the heat treatments carried out after processing can go a long way in eliminating this anisotropy due to recrystallization processes, hence providing the same mechanical behavior in all directions [35, 36]. Introducing reinforcing agents like TiN nanoparticles has proven to be highly effective in pushing the mechanical properties of ASTM F75 alloys that are constructed via additive manufacturing to a new level of performance, along with the efficiency of strength and wear resistance [37]. **Figure 2** shows the Hall-Petch plot of ASTM F75.

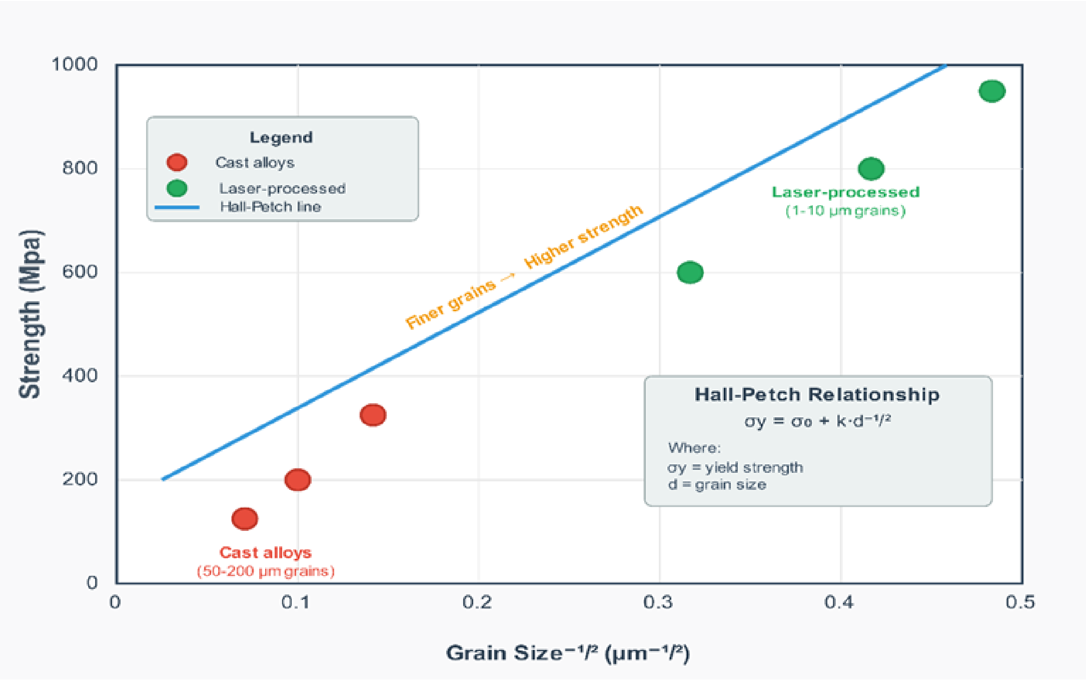


Figure 2. Hall-Petch relationship for ASTM F75 alloys.

3.1.3. Corrosion Resistance and Electrochemical Behavior

The corrosion resistance of ASTM F75 alloys is largely determined by the formation and stability of chromium oxide films, which act as a shield from electrochemical attack in corrosive environments [38, 39]. The electrochemical behavior of those materials is to a great extent affected by their microstructure, surface condition, and environment [20, 40]. The passive film, which is mainly constituted of Cr2O3, is generated by nature upon contact with oxidizing atmospheres, and it is also instrumental in corrosion prevention [41]. The protection ability of this passive film is highly dependent on the chromium concentration level and its homogeneity across the microstructure [18].

Coatings processed by a laser technique generally have a better passive film stability since their microstructure is more uniform and their segregation is less in comparison with cast materials [19]. ASTM F75 alloys corrosion in biological media is a very complicated issue because the consort with proteins, ions, and other organic substances is part of the process [42]. Various experiments have been reported to prove that the involvement of albumin may change the corrosion rate drastically depending on the solvents and pH of the media [1]. In phosphate-buffered saline (PBS) solutions, both high and low carbon alloys increase corrosion rates when proteins are present. This is a good indication of how the surface and biological environment are interacting [19].

Laser-based manufacturing can also affect the corrosion behavior of alloys in a very small way due to microstructure differences and residual stress states [39, 40]. On the other hand, additively manufactured ASTM F75 alloys generally exhibit similar or better corrosion resistance to the materials of wrought, but the presence of sub-cellular structures and possible defects caused by the process can change the local electrochemical behavior [19, 37]. Corrosion tests over a long period of time done in a simulated physiological environment have shown that laser-processed ASTM F75 alloys still keep their passive properties after quite a long time, and also, they give out very little metal ions compared to the traditional cast alloys [20, 43].

3.1.4. Biocompatibility and Biological Performance

Biocompatibility reflects an important feature for ASTM F75 alloys that are intended as orthopedic implants, covering the mechanical compatibility as well as biological tolerance of the alloys [8, 44]. The cellular response to these materials is basically carried by their surface features, metal ion release dynamics, and the matching of mechanical properties with the environment. The metal ion release of the cobalt and chromium ions is the most significant issue for the biocompatibility of the ASTM F75 implants that will last for a long time [42].

The laser manufacturing methods signify diminished metal ion release rates due to improved surface integrity and enhanced corrosion resistance [44, 45]. The in vitro cytotoxicity tests have proven that ASTM F75 alloys, additively made, reveal similar or even higher biocompatibility than those materials that are made by conventional methods [18, 46]. The updating of the surface of the material by means of a number of the most modern methods, including laser-induced nano-structuring of the surface, is a very promising step in the direction of increasing biocompatibility and promoting osseointegration [44].

At the same time, these surface treatments can highly increase osteoinductivity without sacrificing the mechanical properties of the underlying alloy [44]. The mutual impact on the mechanical wear and electrochemical corrosion in biological environments is a great challenge for the durability of the implant performance [47, 45]. Laser-processed ASTM F75 alloys have exhibited better tribocorrosion resistance in comparison to investigations of calcium phosphate-reinforced ASTM F75 composites via laser-based techniques, which have demonstrated that they possess excellent bio-tribological properties and biocompatibility for load-bearing implants [8, 21]. Such composite avenues signify a substantial progress in the development of biomedical alloys.

3.2. Comparative Analysis of Manufacturing Processes

The way the manufacturers use to make the ASTM F75 alloys essentially decides the microstructure, the mechanical properties, and the clinical performance of the biomedical components. It has been found that the optimization of the process parameters is very important, especially in the case of energy density, scanning strategies, and thermal management, as it becomes very critical for the utilization of the performance advantages offered by these advanced manufacturing techniques, as well as ensuring the medical device applications are reproducible and reliable.

3.2.1. Traditional Manufacturing Methodologies

For many decades, industrial production of ASTM F75 alloys relied on established traditional manufacturing methods, which included investment casting, forging, and powder metallurgy techniques [10, 48]. These traditional methods have proven to be quite reliable and have processing protocols established, but they are running into limitations when applying high-performance alloy systems. One of the most common methods for making complicated-shaped ASTM F75 parts in the dental and orthopedic sectors is still investing casting [6, 49]. The technique consists of producing a wax model, then a ceramic shell, and finally, after the wax has been melted, the metal is poured into the cavity. Nevertheless, cast CoCr alloys usually have a microstructure that is coarser, formed of primary dendrites, and may have gas entrapment that causes the mechanical properties to be worse, but advanced manufacturing techniques are better [6]. The SEM images of the fracture surface of the cast samples reveal the interdendritic zones with dendritic structures clearly visible, and also indicate that the technique is not very suitable [6].

Powder metallurgy techniques are advantageous in terms of material utilization and near-net-shape capability [50]. Although reaching full density and growth control of grains are still very serious problems, especially for refractory alloys like ASTM F75, the mechanical properties of the parts produced with powder metallurgy are weakest if the processing parameters are not well decided among other production methods [50]. The forging techniques do generally enhance mechanical properties by means of grain refinement and texture development. Unfortunately, the high strength and small ductility of ASTM F75 alloys at room temperature still require high-temperature processing with special equipment, which leads to more complex production and higher costs [5].

3.2.2. Advanced Laser-Based Manufacturing Technologies

Laser additive manufacturing is set to change the way the ASTM F75 alloy is produced, a material that for the first time has been controlled so precisely in terms of microstructural change and geometric complexity [4, 9, 10]. These kinds of machines use concentrated laser energy to selectively heat and join the metallic powders, thus enabling a layer-by-layer build of complex 3D parts. (LPBF). Technology is certainly a way that uses intense lasers to achieve complete melting and fusing of metallic powder particles, thereby resulting in dense, metallurgically bonded structures [4, 9, 21]. Process parameters such as laser power, scanning speed, hatch spacing, and layer thickness are of great importance in determining the microstructure and properties of the alloy [9, 26, 27].

LPBF-processed ASTM F75 alloys display the best mechanical properties when compared to cast materials, showing increased hardness, tensile strength, and fatigue resistance [9]. LPBF technology is similar to LASER POWDER BED FUSION but places more emphasis on controlling the powder bed and laser scanning strategies in a precise manner [28]. Goal-oriented machine learning-assisted process optimization has brought vast improvements in the trust and repeatability of LPBF processing of ASTM F75 alloys [28]. The technology makes it possible to fabricate parts with densities well beyond 99.5% and mechanical properties that are better than those of conventional methods [5, 41].

Direct Metal Laser SDMLS technology facilitates high component densities in the as-printed state, which can thus be hot isostatic pressing (HIP) free [6]. The fast solidification associated with DMLS allows for small microstructural features; however, heat treatments after fabrication might be needed to get the mechanical properties to be optimal [5, 15]. LENS™ is a method of directed energy deposition that allows the creation of complex structures and coatings by continuously supplying the powder into the laser-generated molten pool [3]. This technique has been proven to be particularly appropriate for the production of porous structures that are biocompatible due to the inherent properties of materials for bone implant application [7].

3.2.3. Process Parameter Optimization and Control

Parameter optimization of laser processing is the most important part of obtaining better material properties in ASTM F75 alloys [26, 27, 29]. Laser power is a major control parameter that affects density, microstructure, and mechanical properties [9, 27]. Laser energy density is the ratio of power to the product of the speed of scanning and the distance between two adjacent tracks, which is the main control parameter influencing density, microstructure, and mechanical properties [9, 27]. Several studies have found the main control parameter influencing density, microstructure, and mechanical properties [9, 27].

The energy densities of states obtained by experiments span mostly from 50 to 120 J/mm^3 for the densest microstructure and the best mechanical properties [9, 27]. On the other hand, too low energy density causes insufficient melting and porosity, while too high energy density may result in overheating, elimination of alloying elements, and the appearance of unwanted microstructures [27, 29]. The laser scanning pattern has a major impact on thermal gradients, residual stress, and the microstructure changes at the local level [33]. Innovative scan patterns, such as rotation and island approaches, can be very helpful in minimizing residual stresses and enhancing surface quality [33].

Table 1 shows a quantitative comparison of the material properties produced by traditional manufacturing methods like casting and those obtained by laser-based additive manufacturing techniques, in particular Laser Powder Bed Fusion, demonstrating considerable improvements in a wide range of essential parameters.

Table 1. Mechanical and corrosion properties comparison.

PROPERTY	TRADITIONAL METHODS (E.G., CASTING)	LASER-BASED METHODS (E.G., LASER POWDER BED FUSION)	IMPROVEMENT
Hardness (HV)	300-450	400-600	20-40%
Tensile Strength (MPa)	800-1000	1200+	15-30%
Yield Strength (MPa)	500-700	800-1000	15-30%
Fatigue Limit (MPa)	300-400	500+	50-100%
Wear Resistance	Variable, can be lower depending on microstructure	Improved due to fine microstructure and surface integrity	2-5x improvement
Corrosion Resistance	Can be compromised by segregation and carbide formation	Generally good, influenced by process parameters and residual stresses	Comparable or superior
Grain Size (µm)	50-200	1-10	5-50x refinement
Density (%)	95-98	>99.5	1-4% improvement

3.3. Manufacturing Challenges and Limitations

The fabrication of ASTM F75 alloys for use in the human body is a primary problem that is technically hard to solve. Nevertheless, these various methods have their own limitations, which are intimately related to the characteristics of the safe components and the favorable outcome of the treatment.

3.3.1. Traditional Manufacturing Challenges

The slow cooling rates that are typical for casting can lead to macro-segregation of the alloying elements, thus creating microstructural inhomogeneities and property variations [6]. The presence of brittle intermetallic phases during slow cooling may also lead to a decrease in mechanical properties. The fact that ASTM F75's thermal expansion coefficients are high and the limited ductility at elevated temperatures make it very prone to stress due to thermal changes during processing [5]. Solidification hot cracks during solidification are a significant problem in casting, which is often the reason for the need to use special molds and controlled cooling protocols. The emissive behavior of chromium and other elements of the alloy is responsible for the propensity of ASTM F75 alloys towards oxidation during high-temperature processing [1]. Keeping the purity of the atmosphere is vital to maintain the purity of the alloy.

3.3.2. Laser-Based Manufacturing Challenges

Laser-based manufacturing provides a lot of benefits, but it also creates new problems that need to be solved to get the best result [23, 36, 51]. One of the problems is thermal stress, which results from a very short period of high temperatures in one certain area and a cooling next to it. Extreme temperature differences cause thermal stresses, which are very high in value at the spot. The thermal stress can be a reason for product distortion, breaking, and early failure if it is not eliminated through process optimization and after-treatment. [36] Laser processing can be the reason for the creation of different defects such as porosity, voids, and surface roughness [36, 39].

Insufficient laser power, wrong scan strategy, or the gas trapped in the powder bed can be the sources of the porosity formation. The defects serve as stress concentrators and can greatly decrease mechanical properties, especially fatigue strength. Because of the layer-by-layer method of additive manufacturing, anisotropic properties can be developed, and the mechanical characteristics may change depending on the build direction [18, 35]. This anisotropy must be considered in the design of the component, and it can be reduced by the heat treatment procedures that are appropriate [35]. Laser-based manufacturing requires a substantial capital investment, and the specialized powder feedstocks can be expensive compared to conventional raw materials [9]. These economic factors must be considered in the total cost-benefit analysis during the process of choosing the manufacturing strategy.

3.3.3. Quality Control and Standardization

Strong quality control protocols implementation poses a key challenge to traditional and laser-based manufacturing of ASTM F75 alloys [46, 52]. The setting up of standards and the creation of test methodologies that are suitable for the development of performance that is consistent and obtaining regulatory compliance are particularly important for biomedical applications. As an example, advanced nondestructive testing techniques like X-ray tomography and ultrasonic inspection give a crucial opportunity to reveal inner flaws and verify the integrity of the part [39].

These techniques are primarily applicable to safety-critical situations, that is, the cases where a failure of the component can cause a chain of unfortunate events. Instant tracking of laser processing parameters as well as melt pool features opens the way for a feedback-control system and thus defect elimination [28]. Methods rooted in machine learning are increasingly implicated in the determination of optimal process parameters and in the evaluation of component quality [28].

3.4. Laser Processing as an Enabling Technology

One of the major changes that has impacted the entire material production field to a great extent is the advent of laser-based manufacturing that produces materials according to the ASTM F75 standard. In fact, this new technology not only has the capability of reproducing the same products as conventional methods, but it also offers a plethora of features that are not confined to the old ones.

3.4.1. Microstructural Engineering Capabilities

Laser-based manufacturing technologies provide microstructural engineering possibilities that are unmatched in ASTM F75 alloys, hence making it feasible to adjust their properties for the requirements of a particular application [14, 24, 30]. The rapid solidification rates normal to the laser processing can eliminate unwanted phase formations while at the same time providing microstructural features that are more beneficial. The microstructures that are fine-grained and obtained by means of laser processing make a significant contribution to the improved mechanical properties through Hall-Petch strengthening mechanisms [24].

The grain sizes that are normally in the range of 1-10 µm are a substantial refinement compared to those from conventional casting (50-200 µm), which is the main reason for improved strength and toughness [44, 6]. The rapid solidification of phases of supersaturated solid solutions provides opportunities for the controlled precipitation of the strengthening phases through the following heat treatment [30]. The production of coherent and semi-coherent nanoprecipitates can give a combination of strength-ductility that is not achievable through conventional processing [30]. Laser processing parameters could be used for maximum benefit to control the crystallographic texture as well as the grain orientation, hence allowing the development of the anisotropic properties, if these are preferred, or isotropic properties, when needed [35].

3.4.2. Geometric Freedom and Design Innovation

Laser geometrical freedom of the manufacturing process allows innovation in component design by using the exceptional properties of ASTM F75 alloys [7, 8, 21]. Such a facility is very much in demand for biomedical and aerospace applications, where complex geometrical parts can provide functional advantages. The laser is a tool that makes the fabrication of extremely fine internal features and complex geometrical figures, such as lattice structures, cooling channels, and optimal material allocation, possible [7]. These features are, in particular, very important for the reasons of weight reduction and functional integration. By means of this method, a huge breakthrough in personalized medicine can be achieved by the fabrication of patient-specific implants with the geometrical features and surface properties being optimized [44]. In addition, the laser fabrication technique is a method that leads to the development of porous structures, which, apart from giving better osseointegration, can also provide mechanical integrity, which is a must for load-bearing applications [7]. High-tech laser processing techniques give unlimited opportunities, such as combining various materials within one component that can lead to the creation of functionally graded structures and composite materials [8, 21]. The inclusion of bioactive phases, such as calcium phosphate, may increase biocompatibility without the loss of mechanical performance [21].

3.4.3. Surface Engineering and Modification

Laser-powered technologies are the most advanced concept of applying ASTM F75 alloys to produce new surfaces, which in turn open the door to designing the optimized surface properties of the materials that depend on the surface, such as the resistance to wear, the corrosion behavior, and the biocompatibility [44, 53]. Laser surface treatment is one of the ways a laser-modified surface layer with improved characteristics can be formed while, at the same time, the bulk properties of the initial material are retained [53]. Such treatments can become sources of new corrosion resistance, low surface roughness, and changed surface chemistry [53]. Surface nano-structuring triggered by laser dramatically improves biocompatibility and, at the same time, restimulates a cellular response [44]. These modifications of the surface can be very effective in improving both osteoinductivity and osseointegration while at the same time they allow the mechanical properties of the alloy to be retained [44]. Laser cladding allows for the transfer of protective or functional layers with metallurgical bonding to the recipient. TiN layers applied on ASTM F75 substrates that were laser-processed have proven to be more corrosion and wear-resistant.

Table 2 is a comprehensive comparison that examines the fundamental differences between traditional manufacturing methods (casting, forging, and powder metallurgy) and advanced laser-based manufacturing techniques (LASER POWDER BED FUSION, DMLS, LENS™) for producing ASTM F75 (cobalt-chromium-molybdenum-tungsten) alloys, which are critical materials in biomedical and high-performance engineering applications.

Table 2. Comparison of manufacturing methods for ASTM F75 alloys.

FEATURE/METHOD	TRADITIONAL METHODS (CASTING, FORGING, POWDER METALLURGY)	LASER-BASED MANUFACTURING (LASER POWDER BED FUSION, DMLS, LENS™)
Microstructure	Coarser grains, potential for segregation and defects (e.g., gas bubbles, interdendritic structures)	Finer grains, homogeneous, dense microstructure, potential for supersaturated solid solutions
Mechanical Properties	Generally lower hardness, tensile strength, and yield strength compared to AM, though sometimes higher fatigue strength	Superior hardness, tensile strength, and yield strength due to fine-grained structure; properties highly dependent on process parameters and post-processing
Corrosion Resistance	Can be compromised by chromium depletion in HC alloys due to carbide formation; susceptible to segregation	Generally good, but can be influenced by microstructural variations and residual stresses; comparable to wrought alloys
Biocompatibility	Generally good, but concerns exist regarding metal ion release due to wear and corrosion.	Enhanced biocompatibility through improved surface integrity and reduced ion release; potential for surface modification
Geometric Complexity	Limited in producing complex geometries; often requires extensive post-machining	High ability to fabricate complex and near-net-shape geometries; reduced need for post-machining
Material Waste	Can involve significant material waste, especially in subtractive processes	Lower material waste due to the additive nature and efficient material utilization
Process Control	Less precise control over microstructure and properties	High precision and control over process parameters, allowing for tailored properties
Challenges	Melting difficulties, segregation, cracking, porosity, residual stress, oxidation	Residual stresses, potential for build defects (e.g., porosity), &high equipment cost
Applications	General industrial components, some medical implants (e.g., dental prosthetics)	High-performance biomedical implants, aerospace components, & customized parts

3.5. Technological Superiority of Laser-Based Manufacturing

One of the main pieces of evidence of the technological superiority of laser-based production for ASTM F75 alloys over other production methods is the radical changes in performance, efficiency, and economic metrics that are beyond the reach of traditional production methods. In fact, the laser-processed products show that the mechanical properties have been strengthened, the corrosion resistance improved, the biocompatibility increased, and the service life extended, thus resulting in a performance level that is easily convertible into clinical and operational advantages.

3.5.1. Performance Advantages

The superiority of a laser-based technology in materials that are ASTM F75 alloys is beyond doubt, as it has been consistently demonstrated by the continuous performance improvements in various properties over those made by traditional manufacturing methods [9, 7, 46]. The reasons for these advantages are the fundamental differences in processing mechanisms and the different microstructural characteristics that result from the process. Comparative studies reveal that the mechanical properties of laser-treated ASTM F75 alloys have been improved, the values of hardness, tensile strength, and fatigue resistance increasing by 20-40%, 15-30%, and 50-100%, respectively, as compared to the cast materials [9, 6]. Grain microstructures of a fine nature, together with the lower defect population, support these improvements [6]. Laser-fabricated parts also display improved corrosion resistance and better wear properties owing to the fact that surface condition is improved and microstructural distribution is homogeneous [20, 37, 38]. Tribocorrosion tests indicate that wear rates are considerably lowered, and electrochemical stability is improved during sliding contact conditions [37, 45]. Lower metal ion emission rates and better biocompatibility have been repeatedly found in laser-treated ASTM F75 alloys, which have led to increased long-term durability in biological media [18, 42, 44]. The better surface properties and fewer defect populations are the reasons for these improvements. **Figure 3** shows the manufacturing radar of ASTM F75 alloys.

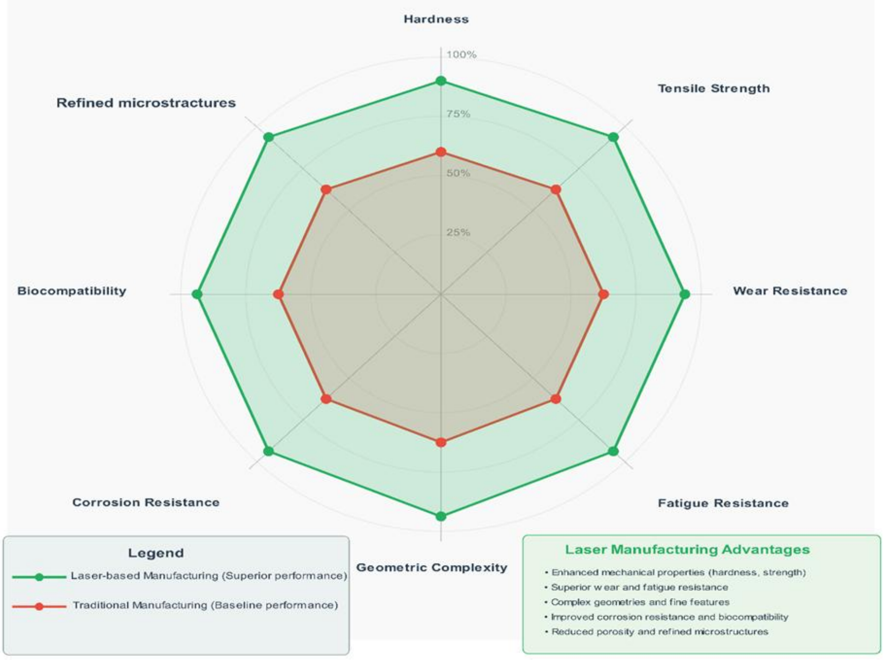


Figure 3. Performance comparison radar chart of ASTM F75 alloys.

3.5.2. Manufacturing Efficiency and Sustainability

Laser-based manufacturing has major benefits related to manufacturing efficiency and environmental sustainability, which are sustainable from the perspective of manufacturing, compared to traditional methods [9]. Material utilized for the laser processing phase of additive manufacturing principles is practically directly proportional to the utilization rate of the process, which generally exceeds 95%, whereas subtractive manufacturing is only 30-60% [9]. This effectiveness is mainly geared towards costly high-performance alloys.

Moreover, the local heating characteristics of the laser operation can result in more energy savings than the conventional melting and forming methods, particularly if it is a case of complicated shapes. The reduction in energy consumption is further facilitated by the elimination of the extensive machining operations that have been removed. Laser-based manufacturing enables quick prototyping and small-batch production, which can be done without the need for significant tooling [9]. The mentioned flexibility finds a very suitable application in the personalized biomedical sector and a low-volume aerospace [54].

3.5.3. Economic and Strategic Considerations

Economic benefits of laser-based manufacturing are most clear when one considers full ownership costs such as material prices, processing efficiency, and performance incentives [9, 46]. The near-net-shape feature of laser processing significantly reduces the number of machining operations that are required, which is, in particular, a great result for the hard-to-machine ASTM F75 alloys [9]. The reduction in post-processing is thus directly linked to both the cost savings and shorter lead times. Higher quality and more reliable laser-fabricated parts may result in lower maintenance costs and longer service life, thus providing long-term economic benefits [46, 45].

The improved resistance to fatigue and the better corrosion performance are the reasons for these lifecycle benefits. Unlimited design possibilities resulting from laser manufacturing enable the creation of innovative and competitive products that can be the basis of differentiation from the market [44, 55]. Simultaneously, the possibility to integrate several functions in one component can thus simplify the assembly process, and, at the same time, it is a way to reduce system complexity.

3.6. Future Perspectives and Research Directions

That future path of laser-based manufacturing for ASTM F75 alloys is going to be characterized by the fast progress of the technology, "innovation driven by application," and the rising necessity for more comprehensive standardization frameworks. The new and additional technologies, mostly artificial intelligence and machine-learning methods, will significantly influence process optimization and quality control. Moreover, they will help in the development of new alloy compositions, functionally graded materials, and multi-material architectures with unprecedented properties.

3.6.1. Emerging Technologies and Innovations

Innovations in laser-based manufacturing technologies continuously pave the way for numerous new methods of processing and using ASTM F75 alloy [50, 51]. The implementation of AI and ML-powered methods is a significant game-changer that can radically optimize processes and quality control [46]. These machines can also lead to parameter setting adjustments on the fly and reactive quality control; thus, the manufacturing trust and efficiency are further enhanced. With the aid of laser technology, energy can be deposited very accurately, thus resulting in a wide range of possibilities for novel alloy compositions and microstructural modifications [50]. For example, nitrogen doping and other alloying strategies not only make the material properties better but are still compatible biologically [50]. In addition, modern laser techniques open up the possibility of manufacturing functionally graded substances and multi-material parts whose property distribution is more optimal than the previous one [51]. These abilities, therefore, come with the prospect of designing the next generation of components.

3.6.2. Application-Specific Developments

Additional breakthroughs in the manufacturing of ASTM F75 alloy will probably be a result of application and new market conditions changes in the next period [51, 52]. The shift to personalized medical devices will probably result in the further development of customization capabilities and patient-specific optimization [36].

The advanced imaging and modeling will be tools that will allow more complicated implants to be designed. Innovations in high-temperature performance and lightweighting capabilities will, therefore, be mostly driven by aerospace applications, which have extremely strict requirements [51]. The production of such components with integrated cooling and structural functions is, therefore, a huge opportunity. Sustainability will be the main focus and, therefore, more efficient processing techniques and recycling strategies for ASTM F75 alloys will be developed as a result [51]. Additive manufacturing has a low wastage rate, which is very compatible with the principles of a circular economy.

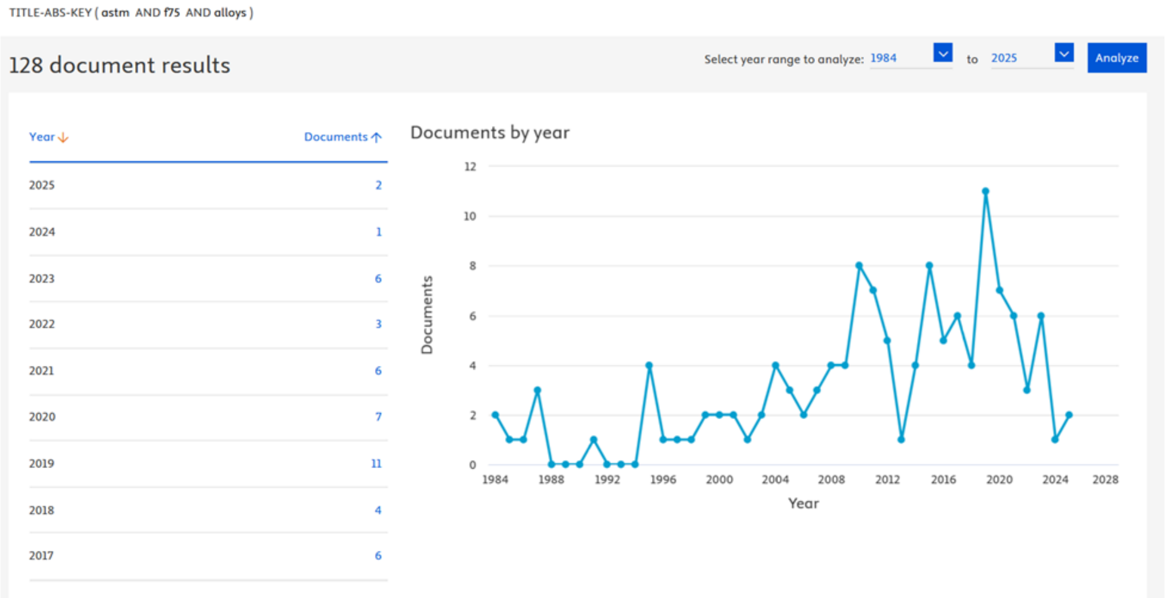
3.6.3. Standardization and Regulatory Development

It should be noted that to continue laser-based manufacturing of ASTM F75 alloys, the development of suitable standards and regulatory frameworks will be indispensable [38, 48]. The creation of sector-specific quality standards for additively manufactured ASTM F75 parts is a must for the greater acceptance of the technology [48]. These standards should be designed in such a way that they consider the properties of the materials, the ways of laser processing, and the typical failures of the laser-processed parts.

On the other hand, the main thing for the biomedical field is the clear regulatory path for additively manufactured implants, which is the only way for such products to be accepted on the market [31, 48]. Besides, biocompatibility and performance of the laser-processed materials that are proven will be among the aspects considered during the licensing process. The proper application of laser technology in the manufacturing sector needs people with high expertise and skills [51]. Educational programs and training initiatives have to be the means through which the required workforce capabilities are achieved.

3.7. The results for bibliometric analysis

Figure 4 illustrates the annual distribution of publications related to ASTM F75 alloys obtained from the Scopus database in April 2026 based on a TITLE-ABS-KEY search query. Data was extracted until 2025. The data indicate a gradual increase in research output over time, with a notable acceleration after 2015 and a peak around 2019, followed by fluctuating but sustained interest in recent years. This trend reflects the growing scientific and industrial relevance of ASTM F75 alloys, particularly in advanced manufacturing and biomedical applications. The increase in publications is strongly associated with the emergence of laser-based manufacturing technologies, which have attracted significant research attention due to their ability to enhance microstructural control and material performance. Bibliometric analysis plays a crucial role in this context, as it enables the identification of research trends, emerging topics, and knowledge gaps within the field. By providing a quantitative overview of publication patterns, bibliometric insights support evidence-based evaluation of technological progress and guide future research directions in ASTM F75 alloy development.



TITLE-ABS-KEY (astm AND f75 AND alloys)

128 document results

Select year range to analyze: 1984 to 2025

Year ↓	Documents ↑
2025	2
2024	1
2023	6
2022	3
2021	6
2020	7
2019	11
2018	4
2017	6

Figure 4. Bibliometric analysis obtained from the Scopus database taken in April 2026.

An in-depth analysis discloses that the implementation of laser-based production methods can be largely termed as a revolutionary change in the processing of ASTM F75 alloy in the mechanical engineering industry. These new technologies are the main agents of change as they combine and push the limits of traditional manufacturing methods to achieve efficiency in different performance metrics. They are the first choice in high-performance applications due to such factors as gaining superior corrosion resistance, as geometric freedom becomes possible by the better microstructural control made available by these technologies.

The main points are as follows:

(i) Laser treatment of material allows the achievement of microstructures that are fine-grained, homogenous, and have better precipitation characteristics, which are unattainable by conventional methods of processing.

(ii) Several records of continuous mechanical characteristic improvement, like hardening increase of 20-40%, tensile strength rise of 15-30%, and fatigue resistance development of 50-100% for laser-modified ASTM F75 alloys, have been acknowledged.

(iii) Environmentally, economically, and socially, laser-driven processes fingerprint positive impacts in the form of efficient resource utilization (>95%), fewer subsequent operations, and more design freedom, resulting in substantial savings of money, energy, and other resources.

(iv) Excellent biocompatibility, small amounts of released metal ions, and increased tribocorrosion resistance are among the most important.

(v) The continuous progress in laser processing technologies, the efficient utilization of machine learning, and the creation of new alloys have opened enormous opportunities for us to not only improve performance but also to increase the area of application.

Even though there remain issues with residual stress control, standardizing the process, and reducing costs, the benefits revealed and the ongoing technological progress are strong indications that laser-assisted fabrication is the way forward to producing high-performance ASTM F75 alloy. The special nature of these technologies is what makes the development of innovative solutions possible, which, though they become the most demanding requirements of the biomedical and aerospace sectors, do not lose their economic and environmental character. Follow-up studies should concentrate primarily on figuring out the perfect process by means of the best monitoring and regulating instruments, investigating new alloy compositions made possible by fast solidification, and coming up with multi-material and functionally graded structures. The establishment of complete standards and regulatory frameworks will be essential to enable the large-scale industrial implementation of the technology and the ongoing innovation in the field.

4. CONCLUSION

This review concludes that ASTM F75 cobalt–chromium alloys are highly suitable for biomedical and high-performance engineering applications due to their strength, corrosion resistance, wear resistance, and biocompatibility. Compared with conventional manufacturing methods, laser-based techniques such as LPBF, SLM, and DMLS provide clear advantages by producing finer and more homogeneous microstructures, which improve hardness, tensile strength, fatigue resistance, corrosion behavior, and biological performance. Although challenges such as residual stress, porosity, anisotropy, high cost, and process standardization remain, these limitations can be reduced through optimized processing parameters, post-heat treatment, and advanced quality control. Overall, laser-based manufacturing offers a promising and sustainable route for producing high-performance ASTM F75 alloys, especially for customized implants and aerospace components. Future research should focus on improving process reliability, long-term biocompatibility, and regulatory standards to support wider industrial and clinical application.

5. ACKNOWLEDGMENTS

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

7. REFERENCES

[1] Muñoz, I. A., and Mischler, S. (2011). Effect of the environment on wear ranking and corrosion of biomedical CoCrMo alloys. *Journal of Materials Science: Materials in Medicine*, *22*(3), 437-450.

[2] Hedberg, Y., and Wallinder, O. I. (2014). Metal release and speciation of released chromium from a biomedical CoCrMo alloy into simulated physiologically relevant solutions. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, *102*(4), 693-699.

[3] Mantrala, K. M., Das, M., Balla, V. K., Rao, C. S., and Rao, V. K. (2014). Laser-deposited CoCrMo alloy: Microstructure, wear, and electrochemical properties. *Journal of Materials Research*, *29*(17), 2021-2027.

[4] Guoqing, Z., Yongqiang, Y., Hui, L., Changhui, S., and Zimian, Z. (2017). Study on the quality and performance of CoCrMo alloy parts manufactured by selective laser melting. *Journal of Materials Engineering and Performance*, *26*(6), 2869-2877.

[5] Bawane, K. K., Srinivasan, D., and Banerjee, D. (2018). Microstructural evolution and mechanical properties of direct metal laser-sintered (DMLS) CoCrMo after heat treatment. *Metallurgical and Materials Transactions A*, *49*(9), 3793-3811.

[6] Song, C., Zhang, M., Yang, Y., Wang, D., and Jia-Kuo, Y. (2018). Morphology and properties of CoCrMo parts fabricated by selective laser melting. *Materials Science and Engineering*: A, *713*, 206-213.

[7] Guoqing, Z., Junxin, L., Jin, L., Chengguang, Z., and Zefeng, X. (2018). Simulation analysis and performance study of CoCrMo porous structure manufactured by selective laser melting. *Journal of Materials Engineering and Performance*, *27*(5), 2271-2280.

[8] Bandyopadhyay, A., Shivaram, A., Isik, M., Avila, J. D., Dernell, W. S., and Bose, S. (2019). Additively manufactured calcium phosphate reinforced CoCrMo alloy: Bio-tribological and biocompatibility evaluation for load-bearing implants. *Additive manufacturing*, *28*, 312-324.

[9] Li, J., Ren, H., Liu, C., and Shang, S. (2019). The effect of specific energy density on microstructure and corrosion resistance of CoCrMo alloy fabricated by laser metal deposition. *Materials*, *12*(8), 1321.

[10] Tonelli, L., Fortunato, A., and Ceschini, L. (2020). CoCr alloy processed by selective laser melting (SLM): Effect of laser energy density on microstructure, surface morphology, and hardness. *Journal of Manufacturing Processes*, *52*, 106-119.

[11] Santos, C. D., Habibe, A. F., Simba, B. G., Lins, J. F. C., Freitas, B. X. D., and Nunes, C. A. (2020). CoCrMo-base alloys for dental applications obtained by selective laser melting (SLM) and CAD/CAM milling. *Materials Research*, *23*(2), e20190599.

[12] Zhao, F., Guo, T., Li, Q., Yin, Y., Zhang, R., and Nan, X. (2022). Effect of solution aging treatment on microstructure and properties of Fe-0.5 C-11Cr corrosion resistant alloy by laser cladding. *Journal of Alloys and Compounds*, *922*, 166142.

[13] Li, H., Wang, M., Lou, D., Xia, W., and Fang, X. (2020). Microstructural features of biomedical cobalt–chromium–molybdenum (CoCrMo) alloy from powder bed fusion to aging heat treatment. *Journal of Materials Science & Technology*, *45*, 146-156.

[14] Miyake, M., Matsuda, T., Sano, T., Hirose, A., Shiomi, Y., and Sasaki, M. (2020). Microstructure and mechanical properties of additively manufactured CoCrW alloy using laser metal deposition. *Welding in the World*, *64*(8), 1397-1407.

[15] Viderščak, D., Schauperl, Z., Šolić, S., Ćatić, A., Godec, M., Kocijan, A., Paulin, I., and Donik, Č. (2021). Additively manufactured commercial Co-Cr dental alloys: Comparison of microstructure and mechanical properties. *Materials*, *14*(23), 7350.

[16] Kosec, T., Leban, M. B., Kurnik, M., and Kopač, I. (2021). Comparison of the corrosion properties of cocrmo dental alloys in artificial saliva. *Materials and Technology*, *55*(6), 819-824.

[17] Wai Cho, H. H., Takaichi, A., Kajima, Y., Htat, H. L., Kittikundecha, N., Hanawa, T., and Wakabayashi, N. (2021). Effect of post-heat treatment cooling conditions on microstructures and fatigue properties of cobalt chromium molybdenum alloy fabricated through selective laser melting. *Metals*, *11*(7), 1005.

[18] Hu, Y., Dong, C., Kong, D., Ding, J., He, X., Ni, X., Zhang, L., and Li, X. (2021). Effects of post-production heat treatment on the mechanical and corrosion behaviour of CoCrMoW

alloy manufactured through selective laser melting. *Materials Today Communications*, *29*, 102994.

[19] Saini, J. S., Dowling, L., Trimble, D., and Singh, D. (2021). Mechanical properties of selective laser melted CoCr alloys: A review. *Journal of Materials Engineering and Performance*, *30*(12), 8700-8714.

[20] Sahasrabudhe, H., Traxel, K. D., and Bandyopadhyay, A. (2021). Understanding wear behavior of 3D-printed calcium phosphate-reinforced CoCrMo in biologically relevant media. *Journal of the mechanical behavior of biomedical materials*, *120*, 104564.

[21] Mace, A., Khullar, P., Bouknight, C., and Gilbert, J. L. (2022). Corrosion properties of low carbon CoCrMo and additively manufactured CoCr alloys for dental applications. *Dental Materials*, *38*(7), 1184-1193.

[22] Dong, X., Li, N., Yu, J., Qu, Y., Wu, M., Zhou, Y., Shi, H., Peng, H., Zhang, Y., and Yan, J. (2022). Effect of grain boundary character on isothermal phase transformation and mechanical properties of Co-Cr-Mo alloy fabricated by selective laser melting. *Journal of Alloys and Compounds*, *903*, 163904.

[23] Reimann, L., Brytan, Z., and Jania, G. (2022). Influence of filler metal on electrochemical characteristics of a laser-welded Co-Cr-MoW alloy used in prosthodontics. *Materials*, *15*(16), 5721.

[24] Hu, Y., Yao, J., Ao, M., and Dong, C. (2022). Nanoscale precipitate in PBF-LB-manufactured CoCrMoW alloy and its effect on passive behaviour. *Materials Letters*, *319*, 132295.

[25] Liu, Y., Mace, A., Lee, H., Camargo, M., and Gilbert, J. L. (2022). Single asperity sub-nano to nanoscale wear and tribocorrosion of wrought CoCrMo and additively manufactured CoCrMoW alloys. *Tribology International*, *174*, 107770.

[26] Saini, J. S., Dowling, L., Trimble, D., and Singh, D. (2021). Mechanical properties of selective laser melted CoCr alloys: A review. *Journal of Materials Engineering and Performance*, *30*(12), 8700-8714.

[27] Qin, P., Chen, L. Y., Liu, Y. J., Zhao, C. H., Lu, Y. J., Sun, H., and Zhang, L. C. (2023). Corrosion behavior and mechanism of laser powder bed fusion produced CoCrW in an acidic NaCl solution. *Corrosion Science*, 213, 110999.

[28] Jiang, W., An, X., Xiao, C., Ni, S., and Song, M. (2023). Effects of heat treatment on the microstructure and properties of a face-centered cubic CoCrMoW alloy prepared via laser powder bed fusion. *Journal of Alloys and Compounds*, *963*, 171212.

[29] Shang, R., Yang, B., and Li, Y. (2023). Enhanced anti-corrosion performance of co-cr-mo alloy in molten Al by prior oxidation treatment. *Materials*, *16*(23), 7449.

[30] Zhang, Y., Lin, W., Zhai, Z., Wu, Y., Yang, R., and Zhang, Z. (2023). Enhancing the mechanical property of laser powder bed fusion CoCrMo alloy by tailoring the microstructure and phase constituent. *Materials Science and Engineering: A*, *862*, 144449.

[31] Atapour, M., Sanaei, S., Wei, Z., Sheikholeslam, M., Henderson, J. D., Eduok, U., Hosein, Y. K., Holdsworth, D.W., Hedberg, Y. S., and Ghorbani, H. R. (2023). In vitro corrosion and biocompatibility behavior of CoCrMo alloy manufactured by laser powder bed fusion parallel and perpendicular to the build direction. *Electrochimica Acta*, *445*, 142059.

[32] Al-Aloosi, R. A., Comakli, O., Yazici, M., and Taha, Z. A. (2023). Influence of scanning velocity on a CoCrMoW alloy built via selective laser melting: Microstructure, mechanical, and tribological properties. *Journal of Materials Engineering and Performance*, *32*(15), 6717-6724.

[33] Preda, L., Leau, S. A., Donath, C., Neacsu, E. I., Maxim, M. E., Sătulu, V., Paraschiv, A., and Marcu, M. (2023). Investigation of long-term corrosion of CoCrMoW alloys under simulated physiological conditions. *Metals*, *13*(11), 1881.

[34] Mace, A., and Gilbert, J. L. (2023). Low cycle fretting and fretting corrosion properties of low carbon CoCrMo and additively manufactured CoCrMoW alloys for dental and orthopedic applications. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, *111*(9), 1600-1613.

[35] Mohamed, L. Z., Elsayed, A. H., Elkady, O. A., and Abolkassem, S. A. (2023). Physico-mechanical, microstructure, and chemical properties of Si/Ti/Nb additions to CoCrMoW medium entropy alloys. *Journal of Materials Research and Technology*, *24*, 9897-9914.

[36] Man, K., Mazumder, S., Dahotre, N. B., and Yang, Y. (2023). Surface nanostructures enhanced biocompatibility and osteoinductivity of laser-additively manufactured CoCrMo alloys. *ACS Omega*, *8*(50), 47658-47666.

[37] Klimek, L., Bułhak, B., and Śmielak, B. (2024). A comparison of the structure and selected mechanical properties of Cr/Co alloys obtained by casting and selective laser melting. *Journal of Functional Biomaterials*, *15*(3), 61.

[38] Mani, G., Porter, D., Collins, S., Schatz, T., Ornberg, A., and Shulfer, R. (2024). A review on manufacturing processes of cobalt-chromium alloy implants and its impact on corrosion resistance and biocompatibility. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, *112*(6), e35431.

[39] Pellegrini, A., Lavecchia, F., Guerra, M. G., and Galantucci, L. M. (2024). Analysis of microstructure and mechanical properties of CoCrMo alloys processed by metal binder jetting multi-step technique. *Journal of Manufacturing and Materials Processing*, *8*(6), 292.

[40] Chen, J., Ding, X., Wang, J., Xie, Z., and Wang, S. (2024). Corrosion behavior, metal ions release and wear resistance of TiN coating deposited on SLM CoCrMo alloy by magnetron sputtering. *Journal of Alloys and Compounds*, *1002*, 175319.

[41] Alaloosi, R. A., Çomakli, O., Yazici, M., and Taha, Z. A. (2024). Effect of scan speed on corrosion and tribocorrosion properties of cobalt-chromium alloy in situ produced by selective laser melting. *Rapid Prototyping Journal*, *30*(3), 405-414.

[42] Sing, S. L., Huang, S., and Yeong, W. Y. (2020). Effect of solution heat treatment on microstructure and mechanical properties of laser powder bed fusion produced cobalt-28chromium-6molybdenum. *Materials Science and Engineering: A*, *769*, 138511.

[43] Vidyasagar, K. C., and Kalyanasundaram, D. (2024). Enhanced corrosion resistance of CoCrMo by laser-based surface modification. *Surface Engineering*, *40*(1), 100-111.

[44] Varol, T., Aksa, H. C., Yıldız, F., Akçay, S. B., Kaya, G., and Beder, M. (2024). Influence of post processing on the mechanical properties and wear behavior of selective laser melted Co-Cr-Mo-W alloys. *Tribology International*, *192*, 109336.

[45] Al-Aloosi, R. A., Taha, Z. A. T., and Çomakli, O. Ç. O. (2024). Influence of scanning velocity on Co24. 7Cr5Mo5. 4W alloy built via selective laser melting on roughness properties. *Iraqi Journal of Laser*, *23*(1), 24-37.

[46] Li, H., Song, B., Wang, Y., Zhang, J., Zhao, W., and Fang, X. (2024). Laser powder bed fusion process optimization of CoCrMo alloy assisted by machine-learning. *Journal of Materials Research and Technology*, *33*, 3901-3910.

[47] De La Cruz, L. G., Alvaredo, P., Torralba, J. M., and Campos, M. (2024). Material extrusion: A promising tool for processing CoCrMo alloy with excellent wear resistance for biomedical applications. *Materials & Design*, *244*, 113089.

[48] Ma, L. Y., Sun, F. Y., Li, Y., and Yu, H. (2024). Mechanical property, corrosion behavior and cytocompatibility of CoCrMo for dental application: A comparative study of cast and laser powder bed fusion. *Journal of the Mechanical Behavior of Biomedical Materials*, *160*, 106788.

[49] Al Jabbari, Y. S., Dimitriadis, K., Sufyan, A., and Zinelis, S. (2024). Microstructural and mechanical characterization of six Co-Cr alloys made by conventional casting and selective laser melting. *The Journal of Prosthetic Dentistry*, *132*(3), 646-e1.

[50] Jiang, W., Li, R., He, J., Ni, S., Wang, L., Chen, Z., Huang, Y., Li, C., Yi, J., and Song, M. (2024). Nitrogen-doping assisted local chemical heterogeneity and mechanical properties in CoCrMoW alloys manufactured via laser powder bed fusion. *Advanced Powder Materials*, *3*(5), 10027.

[51] Mazumder, S., Boban, J., and Ahmed, A. (2025). A comprehensive review of recent advancements in 3D-printed Co-Cr-based alloys and their applications. *Journal of Manufacturing and Materials Processing, 9*(5), 169.

[52] Aktürk, D., Yildiz, M. T., Yurtkuran, E., and Babacan, N. (2025). Microstructural and fatigue properties of dental structures produced via selective laser melting: Comparing Co-Cr-Mo, Co-Cr-Mo-W and Co-Cr-W alloys. *Rapid Prototyping Journal*, *31*(6), 1280-1290.

[53] Dai, L., Song, C., Fu, H., Chen, H., Yan, Z., Liu, Z., Li, R., Wang, A., Yang, Y., and Yu, J. K. (2025). Recrystallization induced by heat treatment regulates the anisotropic behavior of CoCrMo alloys fabricated by laser powder bed fusion. *Materials Futures*, *4*(2), 025001.

[54] Nothnagel, R. M., Vukonic, L., Bauer, C., Váradi, T., Linhardt, P., Franek, F., Nehrer, S., and Ripoll, R. M. (2025). Tribocorrosion performance and cytotoxicity of additive manufactured CoCrMo: A benchmark against wrought CoCrMo. *Journal of Bio-and Tribo-Corrosion*, *11*(1), 2.

[55] Avanzini, A., Petrogalli, C., and Cornacchia, G. (2025). Tribological behavior of a selective laser melted CoCrMo alloy under different heat treatment, loading, and sliding conditions. *Tribology Transactions*, *68*(3), 613-19.