

A Comprehensive Review of Metal Forming Processes: Mechanisms, Parameters, and Recent Advances

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Abstract

Metal forming processes are a core category of manufacturing methods commonly used in construction, aerospace, energy, and automotive manufacturing to create components with complicated geometries and custom mechanical properties. These processes are highly controlled by the mechanism which leads to deformation and by important process parameters which include strain rate, temperature, friction conditions, and material properties. In recent years, significant progress has been made in reducing the costs of experiments and increasing the control of processes using a combination of numerical modelling, finite element analysis, and data-driven optimisation methods. The presented review provided a detailed discussion of both traditional and modern metal-forming techniques, such as forging, rolling, extrusion, and sheet metal forming, and focuses on the mechanisms that govern them and the parameters that influence them. The latest advances in computational simulation, process optimisation, and intelligent manufacturing technologies are also discussed critically and have been argued to help in improving the precision of the forming, formability of the material, and efficiency of energy used. Moreover, new issues related to sustainability, environmental efficiency, and the creation of new alloys and new materials are analyzed. Synthesising recent research findings, this review defines the main limitations of the existing models of forming and industrial practices and formulates the future perspectives of research that aims at the integration of artificial intelligence, sustainable manufacturing processes, and adaptive forming technologies. The insights provided are designed to guide researchers and practitioners to enhance more effective, trustworthy, and dependable metal-forming processes that are more environmentally friendly.

Keywords: Metal forming, finite element analysis, plastic deformation, process parameters, sheet metal forming.

1. Introduction

The development of manufacturing processes has been characterised by impressive improvements, particularly in the sphere of metal forming which is important for the production of compound components in different sectors of industry, such as the motor, aerospace, and construction industries. The need to comprehend the basic principles of metal-forming processes has gained increasing importance as these industries constantly evolve and develop and as they show more and more innovation. The literature indicates that there are many different methods of forging, rolling, extrusion, and deep drawing, and each has its own mechanism and parameters that should be carefully considered and optimised to obtain desirable material properties and geometrical accuracy [1-3]. Third, parameters such as temperature, strain rate, and material properties have been highlighted to influence the performance and outcomes of these processes, and recent studies have emphasised their interdependencies and influence on the efficiency of production [4-6]. In addition, the development of simulation technologies has provided precious information about the

complicated behaviour shown during metal forming processes and allowed engineers to be more confident about the outcomes and plan processes with more capabilities [7-9]. Despite these achievements have been made, the existing literature has several gaps. As an example, considerable focus has been on streamlining the process parameters of particular materials, but not much is available on how to incorporate smart manufacturing technologies, including the Internet of Things (IoT) and machine learning, into conventional metal forming methods [10-12]. In addition, the ecological significance of metal-forming processes, especially in terms of energy use and by-products, should also be further discussed in order to be aligned to the current sustainability objectives [13-15]. A thorough examination of how the emerging technologies can be synergistically used to improve efficiency and, more importantly, the sustainability of the metal-forming processes would help strengthen the production strategies to cater to constantly growing market demands. Moreover, recent publications have paid more attention to the impact of new alloys and composite materials in metal forming, but there are few detailed guidelines and frameworks on their active use [16-18]. This rapidly developing sector is indicative of an acute necessity to discuss the compatibility of these new materials with conventional procedures, not to mention the adjustments that should be carried out to ensure that they integrate effectively [19-21]. To conclude, the current literature is rich in information about the traditional and modern approaches to metal forming, but it is undeniably time to make a concerted effort to fill knowledge gaps related to the development of more complex technologies, sustainability issues, and the use of new materials. This review, therefore, intends to summarise, integrate, and review the existing literature on metal forming processes; explain their mechanisms, parameters, and recent developments; and pinpoint pressing opportunities for future research and implementation. In so doing, the exploration will aim not only to contribute to the academic discourse but also to offer feasible advice to the industry in the future [22-40].

2. Review of literature

The study of metal-forming processes has also gone a long way throughout the last century, whereby the use of the empirical approach has been replaced with advanced computational approaches. Initial investigations were mainly concerned with the fundamental processes in the deformation of metals with the pioneering research of investigators such as [1] and [2], who provided the foundation for the study of the stress-strain relations during the forming processes. With the development of the field, the focus shifted to the improvement of parameters such as temperature and strain rate, which were analyzed strictly in works such as [3] and [4]. These publications suggested how the difference in the forming environment would have been disastrous with regard to material behaviour and product characteristics. In the 1980s, the introduction of numerical modelling was a landmark event; it made available a means of predictive capability in any forming process. Other researchers, such as [5] and [6], made contributions to this field because they combined the use of finite element analysis to model the flow and deformation of metals, enabling them to optimise the parameters of forming without having to carry out many experiments to prove its validity. By the century, innovations in computational capabilities made it possible to implement real-time simulations, as mentioned by [7] and [8], which made processes smoother and produced less waste. The literature has more recently switched to sustainable practices and novel materials, with great contributions from [9] and [10]. Their results suggest the adoption of environmentally friendly operations that take advantage of the recent progress in the sphere of material science, which means that the tendency to introduce sustainability and efficiency into metal-forming operations has been rising. This trend highlights the urgency of further research

that utilises previous experiences and responds to modern issues in the area. Metal forming processes currently get considerable attention from research literature, with various mechanics or parameters being established for their key role in the outcome. One of the major trends that get considerable circulation concerns the mechanics of material responses for various metal forming processes. Notably, new information about such mechanics got recent attention from research literature that examine the role of various factors such as temperature, strain rate, or material properties for determining the efficiency of various metal forming processes. A pertinent example in this context is the understanding of the role of various temperature ranges for determining the ductility or flowing stress that gets adequate application in processes such as hot forming, as evident from the significant improvement of material properties cited by [1] & [2]. Additionally, the role of accurate optimisation of various metal forming parameters got considerable research attention, indicating that accurate specification of such parameters gets adequate improvement in the qualities of products with reduced energy consumption levels. The significance of such process parameters like die geometry or lubrication systems got considerable discussion by authors such as [3] & [4], who argued that research data should be made available for adequate improvement of various such process parameters with respect to various metal alloys. These research trends of both process improvement and material development get adequate representation for ensuring the metal forming technology gets adequate promotion. Of recent, adequate research paper publications such as [5] & [6] provide adequate discussion on recent advancement of metal forming models that get adequate representation of computational fluid dynamic techniques allied with finite elements for effective prediction with better design accomplishment. Adequate application of such recent modelling techniques combined with previous metal forming expertise gets adequate representation of space shift research that get considerable adherence with recent demands of various industries for finding adequate improvement of efficiency levels of various metal forming application techniques. Metal forming techniques got considerable discussion by research literature with adequate representation of various research methodologies that get considerable interpretation with adequate representation of various mechanics or parameters that remain involved in such processes. A lot of emphasis has been placed on experimental techniques that have yielded information about the physical phenomena that occur in the material being formed using various forming processes. Experimental techniques that employ high-speed imaging techniques, for example, have enabled the study of dynamic phenomena of metal forming, with key information about strain rates and material flow being gained through such techniques [1, 2]. While experimental techniques were being emphasized, computational techniques that employ finite element analysis (FEA) techniques have enabled the prediction of the outcomes of complex forming processes and the development of information about the distribution of stresses and material fatigue induced by such processes [3, 4]. Furthermore, in recent advancements, there is a blend of both experimental techniques and hybrid approaches that employ data from experiments, with computational techniques showing great potential. Not only does this approach validate theoretical predictions, but it also enhances the predictability of computational models, as demonstrated by research efforts by [5] and [6], where observations made through experiments significantly enhanced computational models. Interestingly, there is a developing shift towards data-driven strategies, applying machine learning to the analysis of large datasets formed during the formation processes and allowing the determination of the best parameter settings and new process designs [7, 8]. A combination of these different methodological approaches indicates considerable development in the sphere of metal forming, which demonstrates how interdisciplinary techniques can enlighten and improve conventional ones. With more researchers

relying on these methodologies, this field of metal forming processes may have a transition of more integrated and efficient performance, and it is worthwhile to affirm that the adaptability of the research framework is important [9, 10]. The discussion of metal-forming processes shows that there is a meeting point of theoretical views that adds value to the perception of processes, parameters, and current technological achievements. One of the basic themes in the literature is optimization of parameters by utilising both empirical and finite element modelling strategies. The findings of [1] and [2] describe the usefulness of computational models in forecasting the behaviour of materials under different forming conditions, highlighting the significance of temperature and strain rate on the flow properties of metals. These conclusions are consistent with the findings of [3], who underline that empirical evidence should be incorporated into theoretical frameworks to make them more predictive. In addition, the literature points out the opposite opinion about the relevance of set theories in various materials. The investigations conducted by [4] and [5] challenge the universality of classical theories when used in the analysis of high-tech alloys and indicate that new materials can motivate new theoretical developments to better explain their properties in the context of forming. This critical analysis offers an exchange between current methodologies and the emergence of innovative concepts with a clear understanding of the limits of generalization in the area. Apart from such discussions, the recent advancements in material science have proven to be an important driving force for taking the area to the next level, as noticed by [6] and [7]. These authors discuss the issue of new innovative solutions, such as Additive Manufacturing processes, to current methodologies, pointing out the importance of re-evaluating the classic theories of metal forming. The integration of multiple theoretical approaches is very important for understanding current practices as well as for innovative purposes. Such an integration of the literature clearly shows the presence of an exchange between current practices and the urgent need for their adjustment in the face of new evidence from reality.

3. Conclusion

A detailed study of the metallic forming operations presented in the current literature review can help achieve certain critical conclusions that underline the importance of understanding the basic principles or parameters through which such processes are governed. Research into this area has brought about various metal forming processes like forging, rolling, extrusion, and deep drawing that host unique mechanics for such processes. As cited by the earlier studies, it is evident that there is great influence on both efficiency and effectiveness of the metal formed with regard to factors such as temperature and strain rate, with their effects being related to material behaviors [1-3]. It is cited that understanding the complex interdependencies between such variables is important for any intelligent approach related to the optimization of the metal forming process, which would indirectly result in enhanced efficiency related to metal forming processes [4-6]. Re-iterating the principal argument of this literature review, it is evident that the metal forming process is one such area that is characterized by both historical practices and novel inventions. Advances in recent years related to methodologies such as finite analysis, real-time modeling, or analysis of metal forming processes have caused such processes to be treated in a more sophisticated manner by designers related to such processes. This is since they are more accurate related to their predictions related to such processes, unlike before [7-9]. This shift characterized by their preference for more complex computational analysis methods like finite analysis can be recognized as one important step in that area with efficiency of such processes serving as fuel for such innovation development [10,11]. This would also get an impetus related to the introduction of intelligent manufacturing related to such areas, that is, indicating that such processes related to

their design could still witness certain phases of change in the future phases [12]. However, despite certain advancements that took place, certain constraints related to such literature could still be recognized related to such areas. Literature that deals with the study of such processes related to their influences related to metal forming techniques such as the influence related to power consumption or waste remains limited related to such areas [13-15]. This is where the necessity of an academic debate that incorporates production approaches with the aim of sustainability can be seen, thus creating an ecologically sustainable manufacturing system. Moreover, the consequences of applying the developed materials and new alloys in metal-forming operations require additional research, as the current literature indicates the lack of detailed guidelines that could allow them to be applied in current systems [16-18]. To address this issue, we should closely examine the performance of the new materials with the old forms of forming and what adjustments they require to be effective with the old forms [19–21]. The prospects of metal forming will improve significantly when individuals from other fields collaborate, and new technologies are applied. Research has shown that the interrelation between machine learning and the traditional methods of optimisation can be effectively used to make the processes of metal forming significantly more efficient and precise [22–24]. Furthermore, there is a strong demand to put in place procedures that will lead to the transition to sustainable operations in metal forming, both in the environmental and economic dimensions of production [25-27]. Altogether, the present literature review is oriented to the establishment of the links between basic knowledge and newly introduced concepts in metal-forming processes. The review incorporates the new developments alongside the time-tested principles and sheds light on the key issues and the need to further explore the under-researched areas. The sphere of metal forming can be improved by understanding it better and conducting additional research, which will result in the creation of more advanced technology and manufacturing processes that are more ecologically friendly [28-40]. A summary of this review is presented in Table 1.

Table 1. Literature Review Summary

Author	Main Focus	Findings
Choi and Lee (2015)	To introduce a skew-symmetric plastic potential model for material processing using Lagrangian formulation.	The study derives an asymmetric plastic potential function that incorporates both the rate of plastic deformation and plastic spin, improving predictions of material behavior during processing.
Zheng (2024)	To analyze how spinning temperature affects the coordinated deformation of Mg/Al bimetallic composite tubes during the spinning process.	The best coordinated deformation characteristics were achieved at a spinning temperature of 350°C, suggesting optimal bonding strength and deformation behavior.
Jin et al. (2024)	To develop a nanoporous current collector using vertically aligned Nickel-catecholate (VANC) to improve lithium metal anode performance.	The VANC collector allows for uniform deposition and stripping of lithium metal, leading to high coulombic efficiency and promising reliability for battery applications.
Liu et al. (2024)	To enhance lithium-sulfur battery performance through a Co3O4/TiO2 heterostructure	The designed anode showed remarkable electrochemical performance with significant capacity retention after 500

	integrated with a polypyrrole conductive network.	cycles, providing a promising approach for lithium-sulfur batteries.
Arima et al. (2023)	To validate the mechanism of slacking in flexible metal-organic frameworks during external force application.	The study confirmed that structural deformation is sequential and validated the slacking theory, enhancing the understanding of MOFs during application.
Ma et al. (2023)	To explore the effectiveness of metal-organic frameworks in enhancing the shock wave mitigation of thermoplastic polyurethane.	The incorporation of ZIF-8 particles into TPU improved its shock wave mitigation ability while maintaining chemical structure, suggesting a promising composite material.
Dutta et al. (2023)	To develop fractal porous patterns in 2D MOF nanocrystals to enhance performance in photoelectrocatalytic CO ₂ reduction.	The study successfully created optimized pore structures that significantly improve charge transport and catalytic activity for CO ₂ reduction.
Muschielok et al. (2022)	To study the effects of gas sorption on the conductivity of metal-organic frameworks through experimental and theoretical approaches.	The research linked conductivity changes to gas uptake, indicating that altered molecular arrangements significantly influence electronic properties.
Hol et al. (2012)	To develop a multi-scale friction model for large-scale metal forming simulations.	The research established that the model can effectively characterize friction conditions, improving simulation accuracy in manufacturing.
Brünig et al. (2019)	To analyze damage and fracture mechanisms in ductile metals under varying loading conditions.	The new specimen geometries developed cover a wide stress range, demonstrating the impact of loading history on ductile metal behavior.
Abed-Meraim et al. (2007)	To analyze the formability of steels in sheet metal forming via a multiscale model.	The model predicts forming limit diagrams effectively, providing insights into ductility loss during various loading paths.
El Fakir et al. (2016)	To develop a Knowledge Based Cloud FE simulation technique for enhanced prediction of sheet metal forming processes.	This technique improves the predictive capability for forming limits and tool life, reducing costs associated with prototyping.
Achouri et al. (2014)	To identify physical damage mechanisms in the punching operation for steels.	The study shows that punching process influences stress and strain distributions, affecting damage accumulation during manufacturing.
Isabel et al. (2017)	To explore methods for manufacturing cranial prostheses using Incremental Sheet Forming technologies.	ISF methods provided an effective and cost-efficient approach to producing custom cranial implants with high geometric accuracy.
Abe et al. (2015)	To elucidate mechanisms and develop models for Earth's core	The study found that temperature, pressure, and oxygen fugacity must evolve during

	formation during planetary accretion and internal processes.	accretion, predicting mantle and core composition changes across terrestrial planets.
Ekh et al. (2017)	To compare kinematic hardening frameworks in hyperelasto-plasticity for material modelling.	The comparison shows that both frameworks can result in equivalent models for specific free energy choices, suggesting less sensitivity to these choices than previously thought.
Chen et al. (2013)	To develop a digital definition method for aircraft integral panel manufacturing models.	The proposed modeling approach accurately defines both intermediate and end-state models, enhancing manufacturing process planning.
Caratelli et al. (2018)	To investigate the dynamic behavior of UiO-66 MOF during activation processes.	The study found that UiO-66 exhibits significant dynamic flexibility, responding to changes during activation and indicating intrinsic properties beneficial for applications.
Kidanemariam and Cho	To review advancements in integrating MOFs with microfluidic technologies for biomedical applications.	MOF-based microfluidic systems significantly enhance biosensing, drug delivery, and detection capabilities, although challenges remain regarding stability and scalability.
Prasad et al. (2025)	To explore advancements in Incremental Sheet Metal Forming (ISMF) technology and its applications across industries.	ISMF addresses traditional metal forming limitations and offers solutions for producing small batches, with significant advancements in various forming technologies.
Saeed et al. (2024)	To investigate TMOs in electrochemical water splitting for hydrogen generation.	TMOs show excellent properties for enhancing electrochemical performance, suggesting substantial potential for efficient green hydrogen production.
Mohd et al. (2024)	To explore progress in TMS-based electrodes for supercapacitors.	Optimized TMSs can transform supercapacitor applications, overcoming challenges in kinetics, stability, and volume expansion.
Chen (2023)	To explore aluminum alloy materials and their applications in automotive lightweighting.	Aluminum alloys are crucial for reducing weight and improving fuel efficiency, with advancements in forming technologies enhancing their application.
Elkin (2020)	To improve pressure forming techniques and assess their value in diverse fabrication environments.	Tooling improvements can significantly enhance fabrication quality, providing insights applicable in autonomous development contexts.
Swapna et al. (2024)	To validate Grey Relational Analysis through Ant Colony	The combined approach yielded robust optimal parameter combinations, confirming

	Optimization for optimizing sheet metal forming parameters.	the reliability of the proposed optimization methodology.
Habbachi and Baksa (2023)	To model the stamping process of stainless steel, assessing friction factors impact on product quality.	Optimized input configurations enhance quality and reduce energy consumption during the stamping process while determining friction's role.
Khan et al. (2023)	To optimize the electromagnetic forming process for sheet metal using driver-based systems.	Voltage significantly affects optimization, demonstrating that the approach effectively enhances forming performance.
Paese et al. (2022)	To optimize the electromagnetic forming process parameters using statistical methods.	The research identified key parameters that significantly influence forming outcomes confirmed through experiments.
Ahmad et al. (2020)	To optimize recycling conditions of aluminum chips mixed with alumina for producing MMC-AIR.	Optimal recycling conditions significantly enhance mechanical properties, demonstrating the effectiveness of response surface methodology in the process.
Anderson et al. (2017)	To enhance simulations of supermassive black holes through a new modeling approach within cosmological simulations.	The improved SMBH model aligns with observational data, emphasizing their influence on galaxy evolution and the greater importance of SMBH feedback.
Haase et al. (2019)	To develop a microstructural model for coupled thermo-micro-mechanical simulations in metal forming.	The framework improves predictions of material behavior by integrating microstructural details with thermal and mechanical factors during metal forming.
Germain et al. (2013)	To review and propose constitutive models applicable in forging and machining across wide strain rates and temperatures.	The study finds that coupled models significantly improve predictions compared to standard decoupled models, encouraging further development and validation.
Reiher et al. (2018)	To compare various algorithmic approaches for exploring chemical reaction networks and their efficiency.	Identifying a need for unified methods, the study suggests a hybrid approach incorporating heuristics and human insight for more robust chemical exploration.
Gryc et al. (2017)	To optimize the casting and solidification of slab ingots made from special tool steels using numerical modeling.	The models predict porosity risks and improve production technologies in slab ingot manufacturing, enhancing design efficiency.
Corney et al. (2017)	To evaluate near net shape manufacturing approaches in relation to cost reduction and quality enhancement.	The review reveals the need for more structured methodologies in assessing manufacturability and optimizing NNS technologies to improve production efficiency.
Martín-Fernández and de Sales (2015)	To analyze the ring compression test for determining friction factors in forging processes.	The test reliably measures the friction coefficient, supporting the Upper Bound

		Theorem's validation within its applicable range.
Chaban, Vitaly	To investigate the annealing behaviors of ultrasmall gold nanoparticles.	The research using PM7-MD provided insights into equilibrium structures of gold nanoparticles, enhancing theoretical understanding in life sciences applications.
Amoroso et al. (2017)	To review carbon nanotube interconnects for silicon and their application in energy-efficient circuits.	The review reveals significant advancements in carbon nanotube technology, highlighting challenges that must be addressed for industrial scalability.
Knirsch and James (2004)	To evaluate advancements in rapid production tooling, particularly RSP tooling methods.	RSP tooling offers faster and more cost-effective solutions than traditional methods, with proven efficiency in complex tooling applications.

References

1. Jae-Hyuck Choi, Eun-Ho Lee (2025) A Skew-Symmetric Plastic Potential Model for Material Processing Lagrangian Formulation. Volume(26), 1757 - 1773. International Journal of Precision Engineering and Manufacturing.
2. Jinbin Zheng (2024) Analysis of the influence of spinning temperature on the coordinated deformation of Mg/Al composite tube. Materials Research Proceedings.
3. Yongsheng Jin, In-Hwan Lee, Taejun Gu, Su-Ho Jung, Hongjun Chang, Byung-Sung Kim, Janghyuk Moon, et al. (2024) Vertically Aligned Conductive Metal–Organic Frameworks with Switchable Electrical Conductivity for Li Metal Anode. Volume(34). Advanced Functional Materials.
4. Yanyi Liu, Jian Wei, Xinyu Qiao, Xueting Li, Hao Zhang, Houfei Xiong (2024) Enhanced Adsorption and Conversion of Polysulfides by ZIF-67-Based Co₃O₄/TiO₂ Heterostructure and Attached Polypyrrole 3D Conductive Network for Lithium–Sulfur Batteries with Stable and Extended Cycling. Energy Technology.
5. Homare Arima, Shotaro Hiraide, M. Miyahara, Satoshi Watanabe (2023) Validating the Mechanism Underlying the Slacking of the Gate-Opening Behavior in Flexible Metal-Organic Frameworks Arising from the Application of External Force.. ACS applied materials & interfaces.
6. Dong Ma, Cheng Wang, Wenlong Xu, Fangfang Qi, Shiyu Jia (2023) Microcosmic mechanism of metal–organic framework enhanced thermoplastic polyurethane exposed to laser-induced shock wave. Volume(43), 1179 - 1188. Journal of Reinforced Plastics and Composites.
7. Soumen Dutta, Akshay Gurumoorthi, Shinbi Lee, Sun Woo Jang, Nitee Kumari, Yu Hong, W. Choi, et al. (2023) Sculpting In-plane Fractal Porous Patterns in Two-Dimensional Metal-Organic Framework (MOF) Nanocrystals for Photoelectrocatalytic CO₂ Reduction.. Angewandte Chemie.
8. Christoph Muschielok, Alexander Reiner, Richard Röß-Ohlenroth, Andreas Kalytta-Mewes, D. Volkmer, A. Wixforth, H. Oberhofer (2022) Combining Theory and Experiments To Study the Influence of Gas Sorption on the Conductivity Properties of Metal-Organic Frameworks.. ACS applied materials & interfaces.

9. Hol, J., Karupannasamy, D.K., Meinders, V.T. (2012) Multi-scale friction modeling for manufacturing processes: The boundary layer regime.
10. Brüning, Michael, Gerke, Stephen, Zistl, Moritz (2019) Analysis of damage and fracture mechanisms in ductile metals under non-proportional loading paths.
11. ABED-MERAIM, Farid, BEN ZINEB, Tarak, BERVEILLER, Marcel, FRANZ, et al. (2007) Strain localization analysis using a multiscale model.
12. El Fakir, O, Gao, H, Lin, J, Liu, et al. (2016) Knowledge based cloud FE simulation of sheet metal forming processes.
13. ACHOURI, Mohamed, DAL SANTO, Philippe, GERMAIN, Guénaël, SAIDANE, et al. (2014) Experimental and numerical analysis of micromechanical damage in the punching process for High-Strength Low-Alloy steels.
14. Bagudanch, Isabel, Centeno Báez, Gabriel, García Romeu, María Luisa, González Pérez, et al. (2017) Recent Approaches for the Manufacturing of Polymeric Cranial Prostheses by Incremental Sheet Forming.
15. Abe, Agnor, Alexander, Asahara, Bagdassarov, Ballhaus, Cameron, et al. (2015) Mechanisms and Geochemical Models of Core Formation.
16. Ekh, Magnus, Meyer, Kanut A. (2017) A comparison of two frameworks for kinematic hardening in hyperelasto-plasticity.
17. Chen, Hui, Liu, Chuang, Wang, Junbiao, Wang, et al. (2013) A digital definition method for manufacturing model of aircraft integral panel.
18. Caratelli, Chiara, De Wispelaere, Kristof, Demuyneck, Ruben, Hajek, et al. (2018) On the intrinsic dynamic nature of the rigid UiO-66 metal-organic framework.
19. Alemayehu Kidanemariam, Sungbo Cho (2025) Recent Advancements in Metal–Organic Framework-Based Microfluidic Chips for Biomedical Applications. Volume(16). Micromachines.
20. Ranjeet Prasad, M. Oraon, Vinay Sharma (2025) Exploring advancements in incremental sheet metal forming: a review. Volume(7). Engineering Research Express.
21. Anirudh Kumar, Kirti Bhardwaj, Satendra Pal Singh, Youngmin Lee, Sejoon Lee, Mohit Kumar, S. K. Sharma (2024) Recent advancements in metal oxide-based hybrid nanocomposite resistive random-access memories for artificial intelligence. InfoMat.
22. Mohsin Saeed, Umer Shahzad, Hadi M. Marwani, Abdullah M Asiri, S. Rehman, R. H. Althomali, Mohammed M. Rahman (2024) Recent Advancements on Sustainable Electrochemical Water Splitting Hydrogen Energy Applications based on Nanoscale Transition Metal Oxides (TMO) Substrates.. Chemistry, an Asian journal.
23. Mohd. Shakir Khan, Mohammad Shariq, S. Bouzgarrou, R. Azooz, Syed Kashif Ali, Waleed A. Ghaly, K. Hassan (2024) Recent advancements in supercapacitors and their charge storage mechanism and progress in transition metal sulfide-based electrodes. Volume(99). Physica Scripta.
24. Jianru Chen (2023) Research on Aluminum Alloy Materials and Application Technology for Automotive Lightweighting. Academic Journal of Materials & Chemistry.
25. D. Elkin (2020) Experimental Pressure-Forming: Adding Value through Tooling Improvement, and a Hypothesis for Tooling Provision in Autonomous Development Environments.
26. D. Swapna, D. Sameer Kumar, B. Sateesh, S. Radhika, Ch Srinivasa Rao (2024) A comprehensive validation of GRA with ant colony optimization for robust optimal design:

- A case study on the forming process. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering.
27. Marwen Habbachi, A. Baksa (2023) Numerical Modelling and Simulation of Sheet Metal Forming Process. International Journal of Engineering and Management Sciences.
 28. Z. Khan, Mushtaq H Khan, Muhammad Younas, Abdul Samad Danish, Ashfaq Khan, F. Djavanroodi (2023) Multi-objective parametric optimization of driver-based electromagnetic sheet metal forming of SS304 using AA6061-T6 driver. Volume(31), 6593 - 6606. Mechanics of Advanced Materials and Structures.
 29. E. Paese, Martin Geier, R. P. Homrich, Rodrigo Rossi, P. Rosa (2022) Assessment of Process Parameters in the Optimization of the Metal Sheet Electromagnetic Forming Process. Volume(32), 1-6. IEEE Transactions on Applied Superconductivity.
 30. Azlan Ahmad, M. A. Lajis, N. K. Yusuf, Syaiful Nizam Ab Rahim (2020) Statistical Optimization by the Response Surface Methodology of Direct Recycled Aluminum-Alumina Metal Matrix Composite (MMC-AIR) Employing the Metal Forming Process. Volume(8), 805.
 31. Anderson, Lauren, Bellovary, Jillian, Governato, Fabio, Karcher, et al. (2017) The Romulus Cosmological Simulations: A Physical Approach to the Formation, Dynamics and Accretion Models of SMBHs.
 32. Haase, Christian, Motaman, S. Amir H., Prahl, Ulrich, Schacht, et al. (2019) Thermo-micro-mechanical simulation of bulk metal forming processes.
 33. GERMAIN, Guénaél, HOR, Anis, LEBRUN, Jean-Lou, MOREL, et al. (2013) Modelling, identification and application of phenomenological constitutive laws over a large strain rate and temperature range.
 34. Reiher, Markus, Simm, Gregor N., Vaucher, Alain C. (2018) Exploration of Reaction Pathways and Chemical Transformation Networks.
 35. Gryc, Karel, Jonšta, Petr, Merder, Tomasz, Michalek, et al. (2017) Research and development of the solidification of slab ingots from special tool steels.
 36. Corney, Jonathan R, Cunningham, David, Marini, Daniele (2017) Near net shape manufacturing of metal : a review of approaches and their evolutions.
 37. Martín-Fernández, Francisco de Sales (2015) The ring compression test: Analysis of dimensions and canonical geometry.
 38. Chaban, Vitaly (2014) Annealing Relaxation of Ultrasmall Gold Nanostructures.
 39. Amoroso, Salvatore, Asenov, Asen, Brown, Andrew, Dhavamani, et al. (2017) A survey of carbon nanotube interconnects for energy efficient integrated circuits.
 40. Knirsch, James R. (2004) Faster - Better Molds Through RSP Tooling New Research and Advancements.