PAPER • OPEN ACCESS

Enhancing mechanical and corrosion qualities using metal inert gas weld hardfacing: a brief review

To cite this article: Rajeev Ranjan and Anil Kumar Das 2023 *J. Phys.: Conf. Ser.* **2484** 012018

Enhancing mechanical and corrosion qualities using metal inert gas weld hardfacing: a brief review

Rajeev Ranjan[1] and Anil Kumar Das[1]

[1]Department of Mechanical Engineering, National Institute of Technology, Patna, India

E-mail: rajeevranjan.br@gmail.com

Abstract. Due to its better mechanical qualities and corrosion resistance, metal inert gas weld hardfacing is popular in both the manufacturing and research sectors and also contributes to longer machine element service lives. It is defined as a method of achieving desired surface attributes by employing welding procedures on structural materials with relatively low qualities and low cost, known as substrate materials. The weld hardfacing helps with two important aspects of improving material qualities: first, it improves characteristics of the material that depend on the surface (such as corrosion and wear resistance), and second, characteristics that rely on the mass, such as hardness, and durability. This article reviews several studies that have been done so far on various substrates in the area of metal inert gas weld hardfacing to improve microstructure, corrosion, and mechanical characteristics. According to past researchers, various MIG welding parameters play a crucial role and can be optimised to get desirable output such as enhanced tribological, mechanical, and corrosion properties. The writers have made an effort to address the recommendations for future work in this field. Present and future researchers on hardfacing using welding would benefit from the outcome of this paper, which is also useful to many industries.

1. Introduction

Wear and corrosion cause a considerable material loss in a variety of industrial applications. The expense of replacing numerous corrosion-prone components is quite expensive. Surfacing techniques, on the other hand, can increase material qualities like wear and corrosion resistance. Surfacing is one such process, in which a better material is welded onto base metals to improve their surface qualities. It is helpful in many industries, including the chemical, mining, and power generation sectors. Hardfacing is a sort of surfacing in which a filler metal is deposited on a component's surface and is often used in industries to enhance the service factor of wear-and-corrosion-prone components [1]. This procedure is known as hardfacing because the deposited metal is generally harder than the base metal. It's a robust technology for creating a hard, resistance-to-wear coating layer of many metals and alloys on a base metal. It not only protects them from wear but also high-temperature oxidation and corrosion [2]. Hardfacing extends the service life of essential components and assemblies by providing resistance to wear and corrosion. As a result, hardfacing is a hugely helpful technique for extending the service life of machine assemblies and crucial or new components. Hardfacing is a technique that is often used to improve the surface quality of machine parts in industries like petrochemical, food processing, aviation, automotive, mining, and power plants.

Metal inert gas (MIG) welding, shielded metal arc (SMA) welding, plasma transferred arc (PTA) welding, gas tungsten arc (GTA) welding, and laser welding are commonly used for hardfacing.

Hardfacings are often made of Ni-base, Co-base, or Fe-base alloys. Ni-base alloys are commonly employed among them [3]. Metal inert gas weld (MIGW) hardfacing produces coalescence between base and coating metal by heating them with an arc established between a continuously fed consumable electrode and base metal. Weld pools are completely shielded by externally supplied gas or gas mixtures. By selecting the proper shielding gases, electrodes, and welding conditions, any economically significant metals, including carbon steels, stainless steels, and alloys of aluminium, nickel, and copper, may be hardfaced using this method [4]. Pulsed arc welding, a MIGW process modification, can perform all-position welding with spray arc transfer mode at low heat input. MIGW hardfacing in all positions can be done successfully by pulsed arcs, such as in aircraft, automobiles, chemical storage and pressure vessels, and shipbuilding industries. Metal Inert Gas Welding (MIGW) is one of the most used fusion welding procedures for hardfacing because of its numerous benefits. It is used to achieve consistent spray transfer while keeping the mean current process parameters as low as possible. To allow welding automation and robotization, MIGW can be thoroughly developed and classified. Currents, voltages, pulse length, and frequency of pulse are the primary parameters of the MIGW. Pulsing minimizes the overall amount of heat applied to the base material, resulting in fewer spatters. To get the ideal weld bead form, complete control over the particular process parameters is essential. As a consequence, the mechanical properties of the hardfacing are greatly influenced by the geometry of the weld bead. It's crucial to choose and manage the welding process parameters to get the ideal form for the weld bead [5].

The goal of the current study is to understand the role of various welding parameters on the deposition characteristics and their effects on base metal microstructure during MIGW hardfacing. The study provides a review of the effect of various process variables such as arc voltage, welding current, and travel speed on the soundness, bead geometry, and mechanical properties of the deposit [6]. Effects of process variables on dilution and corrosion behavior have also been studied.

2. Substrate materials in MIGW hardfacing

The most common substrate utilised to create hard-faced components is steel. Substrates are chosen according on the demands of the application, such as high wear conditions or high temperatures. Some of them are as follows: Low-alloy, low-carbon, medium-carbon, high-carbon, stainless, nickel-chrome, and manganese steels are some examples of low-alloy steels.

3. Influences of different parameters on MIGW hardfacing

Based on metal inert gas welding (MIGW) hardfacing, several studies were conducted, and various process parameters, as well as the permissible range for these process parameters with various weld substrate and coating layer compositions, were explored. Some studies use the same gas composition 100% of the time, whereas others use varied wire thicknesses and materials. In every case, current, voltage, torch transverse speed, standoff distance, and shielding gas composition have been demonstrated to be the key factors in influencing weld quality. Secondary factors such as gas flow rate and composition have little impact on weld quality. When austenitic stainless steel was used to hardface low alloy steel with CO_2 shielding gas, the rate of corrosion was slowed [7]. The corrosion resistance of the identical case was determined to be greatest at a transverse speed of 535.8 mm/min, 145A current, and 26V voltage [8]. The most significant criteria for boosting mechanical strength while doing MIGW hardfacing are the mix of materials and coat bead form. Because the goal of hardfacing differs from that of welding, we always attempt to limit weld bead penetration to a minimum because it reduces dilution. The welding current, voltage, transverse speed, wire feeding rate, gas flow rate, and standoff distance affect weld bead shape and size. These ideas are the result of extensive testing to see if there is any existing link among all process parameters. Several studies were also conducted to investigate a superior mathematical model, a modern welding technique, an enhanced coating metal, and technique modifications that relate to the impacts of different standards. As a consequence, each experiment was carried out to provide the best possible weld bead shape using the MIGW process parameters controller. In the case of hardfacing, the key issue is to create a strong junction between two different metals with the least amount of filler metal dilution possible to prevent the filler metal's performance from deteriorating [23]. In a recent experiment, the effect of dilution process settings on austenitic stainless steel on a base metal, structural steel, was studied. Welding current, speed, and stand-off distance were the most important process parameters in this experiment [24]. During the harfacing process, heat has an impact on the composition, corrosion characteristics, microstructure, bead geometry, and ferrite content. The offset percent had a significant impact on the thickness of the deposited layer and the dilution of the filler metal. It was discovered that the shape of the beads affected the number of welding passes need to deposit them on the surface. In simulations [25], it was also found that the wire feed rate and welding speed had a big effect on the shape of the beads. Another experiment illustrates the complete effect of heat input on super duplex stainless steel [26]. A trial was carried out on a substrate of low-carbon steel with various parameter combinations to determine the impacts of welding factors. On duplex stainless steel hardfacing, these effects must be expected. In this method, the corrosion rate was seen to be reduced to its lowest value [27]. According to another study, MIG welding methods affect various mechanical properties of duplex stainless steel. Welded samples were subjected to a post-weld heat treatment in a similar procedure. When the results were revealed, it was discovered that the treatment had an impact on the coating's mechanical properties. Toughness and toughness were also discovered to be trending in the opposite direction [28]. The MIGW method with mechanised GMAW was utilised to investigate the single-layer stainless steel coating quality with preheated filler metal. This was accomplished with the use of a custom-built torch that included preheating the filler wire. When the filler metal was preheated externally, the welding current value was significantly reduced. Weld beads had negligible dilution, according to the findings. The alloying materials, in substantial amounts, were incorporated into the preheating system process. In this case, the procedure comprised traditional MIG hardfacing, which was compared to carbon with a reduced concentration.

3.1. Optimization of parameters

The Response Surface Methodology approach is used to generate desirable qualities in the deposited section, which was employed to coat structure steel with duplex stainless steel using MIG harfacing [9]. To improve parameters for better weld bead characteristics, a researcher employed the Taguchi approach and regression analysis [10]. In another research, multiple regression analysis and ANN approaches were employed to improve a process parameter while conducting MIG hardfacing [11]. In a different research, the authors attempted to improve the process parameter using a full replication approach based on a central composite rotatable design to compute the minimal dilution [12]. It has been discovered that when MIGW hardfacing low alloy steel with duplex stainless steel, the output parameters stay proportionate to heat input if the process parameters are kept within a specified range. Regression analysis was applied in this study, and the outcomes were compared to real-time data and found to be nearly identical. With all of these factors, the rate of increment was found to be greatest in weld width when the heat input was increased. Microstructure and weld bead shape were affected by the flow rate of gas, welding voltage, and current [13]. Steel and aluminium were used in Pulsed MIGW to explore the drop detachment process; as a consequence, it was discovered that various forces are involved [14]. In another study, it was found that pulsating factors have a big effect on how the interaction layer and coating layer work. Pulsed MIGW is said to be capable of producing fine microstructure with less coating dilution. The overall findings were increased deposition, reduced dilution, and fine microstructure [15]. The metal transfer mode in the pulsed-MIGW approach is said to be influenced by base current and pulsing factors [16]. In the other experiment with pulsed MIGW, the Genetic Algorithm technique was used to improve the parameters, which helped get regulated weld bead penetration [17].The convexity index is another significant aspect of weld bead geometry. During some investigations, it was discovered that a few factors, like welding travel speed and welding current, influenced the convexity index in pulsed-MIG welding [18]. Similarly, investigations on 65X pipeline steel using pulsed-MIGW hardfacing of 316L stainless steel were applied to determine the impact of process parameters on weld bead shape [19]. According to the findings, the wire feed rate rises with the dilution, breadth, height, and depth of the weld metal. The contact angle decreased at the same time, then increased again until it reached its lowest point. These weld metal properties (height, width, and depth) decreased when dilution and welding speed increased. The link between dilution and weld bead shape process factors was studied using mathematical models [20]. The porosity parameters were perfectly met using a high-quality stainless-steel MIGW hardfacing technique. As a result, filler metals were employed to reduce contact tip degradation and increase tip replacement time by increasing arc-on duration. The pulsed MIGW was evaluated using two shielding gas mixtures [21]. In addition, when the pulsed MIGW was used in vertical mode, it resulted in an effective crack-free overlay [22]. To find the optimal weld bead shape output, another experimental examination was undertaken on stainless-steel hardfacing employing the preheated filler MIGW method with Response Surface Methodology [24]. Then, once again, a unique welding technology called consumable double electrode with a single arc (DESA)-MIGW was presented. A DESA-MIG was used to provide a higher deposition rate of the wire and a regulated heat intake [9].

Various approaches were employed at the welding interface region to prevent fracture development. In MIG welding, one of the techniques utilised is torch weaving. One study looked at the effects of torch weaving. The ferrite number grows when the weaving dilution rate drops, according to the weaving processes. As a result, the application of weaving did not influence porosity, hardness, or microstructure [29]. Critical factors in the processes include coating bead shape, arc rotational speed, and eccentricity. Thick plates and many wires were also used in the welding. As a result, as compared to the standard MIGW bead, the weld bead produces output that is less penetrative, broad, and flat [30]. Another experiment on weld bead shape was conducted utilising the arc rotation mechanism, in which the impact of the rotational speed of the arc was evaluated [31]. In another study, it was discovered that the wire feed rate had a significant impact on penetration. The wire's speed, travel speed, and feed rate were found to have the greatest influence on eccentricity, followed by convexity [32]. Use the arc rotational mechanism system to create a wide, flat weld bead. In addition, it was shown that the wire feed rate had a significant impact on penetration [33]. The MIGW investigation on low-alloy steel with duplex stainless-steel clad layer features was carried out in another work experiment [34]. The clad layer demonstrated strong corrosion resistance and low-temperature impact strength, according to the same assessment. The microstructure, corrosion resistance, nitrogen concentration, and low-temperature toughness of the weld deposition were all found to be positively impacted by the shielding gas mixture and heat input. During the MIGW hardfacing process, the corrosion resistance of duplex stainless steel was enhanced. Corrosion resistance was observed to be altered by heat input in one work trial. Welding current and travel speed were shown to have a significant impact on corrosion resistance and heat input [27]. The researchers discovered that duplex stainless steel's polarisation resistance improved while pitting and uniform corrosion decreased [35]. Corrosion resistance was enhanced, and the duplex stainless steel alloy was cathodically changed as a result of corrosion behavior in concentrated sulfuric acid solutions containing minimal ruthenium [36].

4. Conclusion

Welding voltage, current, stand-off-distance, speed, and gas flow rate are important considerations in MIGW hardfacing. These characteristics may be optimised based on the application, and they can also assist in increasing the desired output such as tribological, mechanical, and corrosion properties.

Also, during hardfacing, we must keep an eye on the temperature conditions, although external heat treatment might be quite beneficial. A desirable weld bead shape and promising microstructure with an evident ferrite stage increase the anti-corrosive performance, and research may be directed to regulate the appropriate process to achieve the requisite corrosion resistance. Despite the decreased penetration of coating, efforts must be made to ensure that the coating layer has adequate shear strength to avoid separation from the underlying metal. The following significant remarks can be observed after reviewing research papers on MIGW hardfacing:

- MIG hardfacing can be used to get good corrosion resistance.
- You can change the shape of a coating's weld bead by choosing the right process parameters, such as low reinforcing and a wide weld bead.
- Corrosion resistance is improved by a favorable microstructure with a significant ferrite phase.

- Preheating and postheating may also help to enhance the microstructure of the hardfacing.
- A higher susceptibility to cracking has been found in specimens with higher carbon content.
- With MIG hardfacing, as the arc voltage, welding current, and travel speed go up, the amount of chromium, nickel, and manganese goes down, but the amount of carbon and sulphur goes up.

5. Scope for further research

To learn more about how welding parameters affect MIGW hardfacing, the following things can be looked into:

- The finite element method (FEM) can be used to find out how process factors affect the shape of a weld bead.
- Different shielding gas mixtures can be employed for metallurgical property enhancement.
- The effect of pulse parameters (e.g., pulse height, pulse width, and pulse frequency) on the characteristics of hardfacing can be studied further.
- There are crevices and stress corrosion cracks in the stainless steel hardfacing, which can be looked into more.
- In the future, new methods will need to be made that can put down more coating materials with less penetration and less heat.
- For different combinations of base material and hardfacing material, the relationship between corrosion rates and other process factors could be looked into more.

References

[1] Singhal T S and Jain J K 2020 GMAW cladding on metals to impart anti-corrosiveness *Machine, processes and materials Materials Today: Proceedings* **26** pp 2432-41
[2] Wang X H, Han F and Qu S Y 2008. Microstructure of the Fe-based hardfacing layers reinforced by TiC-VC-Mo2C particles *Surface and Coatings Technology* **202** (8) pp 1502-09
[3] Weman K 2011 *Welding processes handbook* (Elsevier)
[4] Jia X, Xu J, Liu Z, Huang S, Fan Y and Sun Z 2014 A new method to estimate heat source parameters in gas metal arc welding simulation process *Fusion Engineering and Design* **89** (1) pp 40-48
[5] Rao P S, Gupta O P, Murty S S N and Rao A K 2009 Effect of process parameters and mathematical model for the prediction of bead geometry in pulsed GMA welding *The International Journal of Advanced Manufacturing Technology* **45** (5-6) pp 496
[6] Benyounis K Y and Olabi A G 2008 Optimization of different welding processes using statistical and numerical approaches–*A reference guide Advances in engineering software* **39**(6) pp 483-96
[7] Khara B, Mandal N D, Sarkar A, Sarkar M, Chakrabarty B, and Das S 2016 Weld cladding with austenitic stainless steel for imparting corrosion resistance *Ind. Weld. J.* **49** (1) pp 75–81
[8] Verma A K, Biswas B C, Roy P, De S, Soren S, Das S 2017 An investigation on the anti-corrosion characteristics of stainless-steel cladding *Ind. Weld. J.* **50** (3) pp 52–63
[9] Shahi A S and Pandey S 2011 Weld bead geometry optimization of preheated filler- GMAW process for stainless steel surfacing using response surface methodology *Surface Modification Technologies* XXV, Session-1 (Testing and Characterization), Sweden
[10] Kolahan F and Heidari M 2009 New approach for predicting and optimizing weld bead geometry in GMAW *Int. J. Mech. Syst. Sci. Eng.* **2**, 2 pp 138–42
[11] Saha M K and Das S 2016 A review on different cladding techniques employed to resist corrosion *J. Assoc. Eng. India* **86** pp 51–63
[12] Sreeraj P, Kannan T and Maji S 2013 Simulation and parameter optimization of GMAW process using neural networks and particle swarm optimization algorithm *Int. J. Mech. Eng. Robot. Res*. **2** pp 130–46
[13] Mondal A, Saha M K, Hazra R and Das S 2016 Influence of hat input on weld bead geometry using

duplex stainless steel wire electrode on low alloy steel specimens *Cogent Eng.* **3** pp 1–14.
[14] Waszink J H and Piena M J 1986 Experimental investigation of drop detachment and drop velocity in GMAW *Weld. J.* **65** pp 289–98
[15] Ghosh P K, Gupta P C and Goyal V K 1998 Stainless steel cladding of structural steel plate using pulsed current GMAW process *Weld. J.* **7** pp 307–12
[16] Praveen P, Kang M J and Prasad Y K D V 2006 Behaviour of metal transfer modes in pulse gas metal arc welding of aluminum *Proceedings of Advanced Materials Processing Technologies Conference* (Las Vegas USA) p1–8
[17] Kanti K M, Rao P S and Janardhana G R 2013 Optimization of weld bead penetration in pulsed gas metal arc welding using genetic algorithm *Int. J. Emerg. Technol. Adv. Eng.* **3** pp 368–71
[18] Prabhu R, Alwarsamy T, Ramkrishnan R and Gargyan P S 2014 Development of mathematical model for prediction of convexity index in cladding by pulsed MIG welding process *Proc. Int. Conf. Adv. Manuf. Mater. Eng. Procedia Mater. Sci.* **5** p663–68
[19] Om H and Pandey S 2013 Effect of heat input on dilution and heat affected zone in submerged arc welding process *Sadhana* **38**(6) pp.1369-91
[20] Nouri M, Abdollah-zadehy A and Malek F 2005 Effect of welding parameters on dilution and weld bead geometry in cladding *J. Mater. Sci. Technol.* **23** (6) pp 817–22
[21] Purslow M A 2013 Advanced Robotic GMAW Cladding Process Development *The Society of Naval Architects & Marine Engineering* http://bit.ly/2E55Ehd
[22] Lai G and Hulsizer P 1999 Application of type 312 stainless steel overlay for corrosion protection of batch digesters http://bit.ly/2BYOegn
[23] Murugan N and Parmar R S 1997 Stainless steel cladding deposited by automatic gas metal arc welding *Weld. J.* **76** 391–403
[24] Sreeraj P, Kannan T and Maji S 2013 Simulation and parameter optimization of GMAW process using neural networks and particle swarm optimization algorithm *Int. J. Mech. Eng. Robot. Res*. **2** 130–46
[25] Senthilkumar B, Birundha P and Kannan T 2014 Modelling and simulation of austenite stainless steel claddings deposition by GMAW *Int. J. Scientific Eng. Res.* **5** 363–70
[26] Senthil Kumar B and Kannan T 2015 Effect of flux cored arc welding process parameters on bead geometry in super duplex stainless steel claddings *Measurement* **62** pp 127–36
[27] Verma A K, Biswas B C, Roy P, De S, Saren S and Das S 2014 On the effectiveness of duplex stainless steel cladding deposited by gas metal arc welding *Proceedings of the International Conference (IIWIC 2014)* (Seoul, Korea)
[28] Ibrahim T, Yawas D S and Aku S Y 2013 Effects of gas metal arc welding techniques on the mechanical properties of duplex stainless steel *J. Mineral. Mater. Characterization Eng.* **1** pp 222–30
[29] Tasalloti H, Kah P and Martikainen J 2014 Effects of welding wire and torch weaving on GMAW of S355MC and AISI 304L dissimilar welds *Int. J. Adv. Manuf. Technol.* **6** (71) pp 197–205
[30] Munez C J, Utrilla M V, Uren A and Otaro E 2010 Influence of the filler material on pitting corrosion in welded duplex stainless steel 2205 *Weld. Int.* **24** pp 105–110
[31] Kang Y H and Na S J 2003 Characteristics of welding and arc signal in narrow groove gas metal arc welding using electromagnetic arc oscillation *Weld. J.* pp 93–99
[32] Rao P S 2004 Development of arc rotation mechanism and experimental studies on pulsed GMA welding with and without arc rotation *Ph.D. thesis* (IIT Kharagpur, India)
[33] Kumar S, Rao P S and Ramakrishna A 2011 Effects of eccentricity and arc rotational speed on weld bead geometry in pulsed GMA welding of 5083 aluminum alloy *J. Mech. Eng. Res.* **3** (6) pp 186–196
[34] Chakrabarti B, Das S, Das H and Pal T K 2013 Effect of process parameters on clad quality of duplex stainless steel using GMAW process *Trans. Indian Inst. Met.* **66** (3) pp 221–230
[35] Serif E S M 2012 Corrosion of duplex stainless steel alloy 2209 in acidic and neutral chloride solutions and its passivation by ruthenium as an alloying elements *Int. J. Electrochem. Sci.* **7** pp

2374–88
[36] Serif E S M 2011 Corrosion behavior of duplex stainless steel alloy cathodically modified with minor ruthenium additions in concentrated sulfuric acid solutions *Int. J. Electrochem. Sci.* **6** pp 2284–98

Table of contents

Volume 2484

2023

Previous issue   Next issue

International Conference on Material Science, Mechanics and Technology (ICMMT 2022) 23/12/2022 - 24/12/2022 Indore, India

Accepted papers received: 11 April 2023

Published online: 15 May 2023

Open all abstracts

Preface

Material Science

Due to its better mechanical qualities and corrosion resistance, metal inert gas weld hardfacing is popular in both the manufacturing and research sectors and also contributes to longer machine element service lives. It is defined as a method of achieving desired surface attributes by employing welding procedures on structural materials with relatively low qualities and low cost, known as substrate materials. The weld hardfacing helps with two important aspects of improving material qualities: first, it improves characteristics of the material that depend on the surface (such as corrosion and wear resistance), and second, characteristics that rely on the mass, such as hardness, and durability. This article reviews several studies that have been done so far on various substrates in the area of metal inert gas weld hardfacing to improve microstructure, corrosion, and mechanical characteristics. According to past researchers, various MIG welding parameters play a crucial role and can be optimised to get desirable output such as enhanced tribological, mechanical, and corrosion properties. The writers have made an effort to address the recommendations for future work in this field. Present and future researchers on hardfacing using welding would benefit from the outcome of this paper, which is also useful to many industries.

https://doi.org/10.1088/1742-6596/2484/1/012018

Mechanics

Technology

Name of Author/s	*Tittle of Book*	*Tittle of Book Chapter*	*Publisher*	*ISBN/ISSN*	*Year of Publication*	*DOI*	*Affilaiting Institute at the Time of Publication*	*If publication with Student (name of Student)*	**Department of the Faculty Member (At the time of Publication)**
Uma Sankar Pande, Rajeev Ranjan	PROCEEDING BOOK_6th Virtual International Multidisciplinary Conference on Current Research Trends ISBN: 978-93-95862-80-6	A Study of Metal Inert Gas Cladding Techniques used to Improve Mechanical and Corrosion Characteristics: a Review	International Institute of Knowledge and Research (IIKR)	ISBN: 978-93-95862-80-6	2022		Dr. B.C. Roy Engineering College	Yes(Uma Sankar Pande)	Mechanical Engineering
Md Ahsan, Shashank Shekhar, Anwer Ali, Rajeev Ranjan, Arka Banerjee	PROCEEDING BOOK_7th Virtual International Multidisciplinary Conference on Current Research Trends ISBN: 978-81-961093-4-9	Optimization of Turning Process Parameters for Surface Roughness and Material Removing Rate by Using Taguchi Method	International Institute of Knowledge and Research (IIKR)	ISBN: 978-81-961093-4-9	2023		Dr. B.C. Roy Engineering College	Yes(Md Ahsan, Shashank Shekhar, Anwer Ali)	Mechanical Engineering
Santanu Basu Ray, Arka Banerjee, Rajeev Ranjan, Tanmoy Maiti, Riju Ganguly, Abhishek Shyam	PROCEEDING BOOK_7th Virtual International Multidisciplinary Conference on Current Research Trends ISBN: 978-81-961093-4-9	Recent Advancement in Savonius Wind Turbine - A Review	International Institute of Knowledge and Research (IIKR)	ISBN: 978-81-961093-4-9	2023		Dr. B.C. Roy Engineering College	Yes(Santanu Basu Ray, Tanmoy Maiti, Riju Ganguly, Abhishek Shyam)	Mechanical Engineering
Suraj Pratap, Amir Siddique, Mohammad Majid, Rajeev Ranjan, Arka Banerjee	PROCEEDING BOOK_7th Virtual International Multidisciplinary Conference on Current Research Trends ISBN: 978-81-961093-4-9	Computational Fluid Dynamics in Lid-Driven Cavity Filled With NonNewtonian Fluids	International Institute of Knowledge and Research (IIKR)	ISBN: 978-81-961093-4-9	2023		Dr. B.C. Roy Engineering College	Yes(Suraj Pratap, Amir Siddique, Mohammad Majid)	Mechanical Engineering