International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 11-No.3 (2025) pp. 6576-6590
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

An Impact of reinforcement on Aluminum metal matrix composites: A critical Review

Kapil S. Banker[1], Anand B. Dhruv[2*], Jeetendrakumar A. Vadher[3], Utkarsh A. Patel[4]

[1]PhD Scholar, Gujarat Technological University, Chandkheda, Ahmedabad, Gujarat.
Email: 219999919024@gtu.edu.in - **ORCID:** 0000-0002-5247-7840

[2]Government Engineering College, Patan. Gujarat.
* **Corresponding Author Email:**dhruv_30@rediffmail.com , utkarsh12345@rediffmail.com - **ORCID:** 0000-0002-5247-7850

[3]Government Engineering College, Modasa. Gujarat.
Email: javadher1@gmail.com - **ORCID:** 0000-0002-5247-7830

[4]Government Engineering College, Patan. Gujarat.
Email: *dhruv_30@rediffmail.com , utkarsh12345@rediffmail.com - **ORCID:** 0000-0002-5247-7820

Article Info:

DOI: 10.22399/ijcesen.3128
Received : 20 June 2025
Accepted : 21 August 2025

Keywords

Advance hard to cut material
Stir Casting
AMC
Reinforcement
SiC
B_4C

Abstract:

Now a days in many of the industries adopted advanced material for long lasting and efficient product and this can be possible by some advanced material such as composites made by matrix material and reinforcement. Metal matrix composite (MMC) is a revolutionary and novel material with good mechanical properties, higher specific stiffness, decent tribological property, better strength, lighter in weightiness, high creep resistance, higher thermal conductivity, improved toughness, high corrosion resistance, low thermal expansion coefficient, low density. MMCs are known as nascent material due to its excellent and improved properties over parent matrix material. Applications of MMCs in various field such as automobile industries, aviation industries, agricultural industries, manufacturing industries, Pharma industries, structural industries and defense sector. These materials can be machined by various machines such as conventional machines with some constraints such as tool wear, tool worn out, machined with lower surface finish, less material removal rate, more time consumed and higher vibrations. These type of MMCs could be machined efficiently with unconventional machines such as laser beam machine, Electro discharge machining, Abrasive jet machining, Electro chemical machining, Electron beam machining, and Wire electro discharge machining (WEDM). The review article aims to explore various criteria of advanced hard to cut materials. This review article focused on various types of MMCs, types, manufacturing methods, process parameters, research methodology, and research findings. The article revealed that aluminum metal matrix with SiC and B_4C reinforcement are most prominent material in terms of its excellent mechanical properties and application in the various industries.

1. Introduction

Day by day Application of lighter and harder materials have been increased. Now a days in many of the industries adopted advanced material for long lasting and efficient product and this can be possible by some advanced material developed by the researchers, industries and manufacturer[1]. MMCs are the materials having upright wear resistance property, advanced specific strength, lighter in weight, high creep resistance, higher thermal conductivity, improved toughness, high corrosion resistance, low thermal expansion coefficient, low density, good mechanical properties. Generally, composites materials are known as advanced hard to cut material because of their enormous and

pioneered application in various industries such as automobile parts (piston, piston rods, break drum, connecting rods, car body structures.), aircraft parts, agriculture industries, structural industries, defense industries, manufacturing industries, infrastructure development industries.

Composite materials are the material in which one parent material and other reinforcement are combined by various techniques. So composite materials are using property of two different material combinedly and developed newer advanced material which are having improved properties for today's fast-growing industries. MMCs are emerging composites in which one matrix material combined with another reinforcement constituent such as B_4C (Boron Carbide), S_iC (Silicon carbide), Al_2O_3 (aluminum oxides / alumina), WC (Tungsten carbide). T_iB_2 (Titanium Boride), T_iC (titanium carbide), fly ash, ZrO_2 (Zirconium dioxide/ Zirconia). MMCs are used in the outer cell of the aircraft toward withstand higher temperature and resistance to fracture. MMC developed with boron carbide reinforcement gives 27 % higher hardness than silicon carbide reinforcement[2]. Hardness and other mechanical properties were increased with boron carbide reinforcement in AA6061 Aluminum alloy however impact strength was decreased[3]. It has also been detected that tensile strength, hardness and impact strength were significantly increased by boron carbide reinforced LM24 aluminum composite[4]. Reinforcement with variable particle size also effect the physical properties. Different wt. % of reinforcement significantly effects on the morphological assets of composite. It has been observed that Silicon carbide reinforcement with 37-54 µm in Al4032 was improved mechanical properties of composite[5]. Mechanical properties were increased as reinforcement wt % increase in composite[6]. It has been noticed that mechanical properties enhanced greatly by boron carbide reinforcement than silicon carbide reinforcement in AA6061 alloy[7].

2. Manufacturing methods of Composites

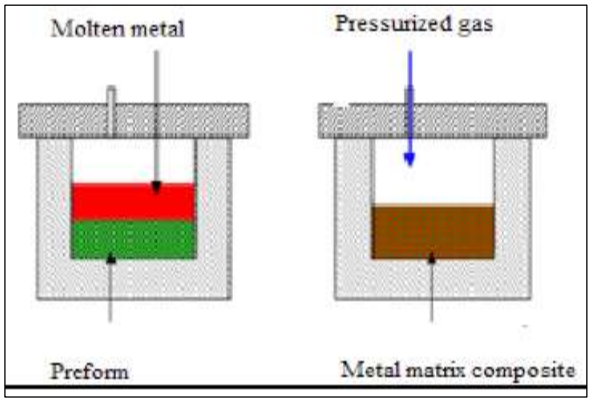

Figure 1. *Gas pressure infiltration (Chandra Kandpal et al.)*

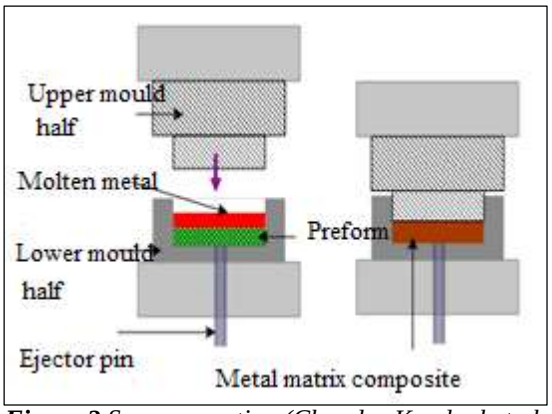

Figure 2 *Squeeze casting (Chandra Kandpal et al.,)*

It has been described from most of research paper that various techniques are available for manufacturing composites material such as Liquid state processing (In which matrix material are being melted in furnace and added reinforcement), Liquid solid state processing (In which reinforced material are added in the stage of mushy phase) and Spark plasma sintering (It is resemble sintering process) and powder metallurgy (In which powder form of matrix material and reinforced material are being added and sintered in die[8]. In addition to this process another process shown in

Figure ***1*** and Figure 2 used by some researcher such as infiltration process (squeeze casting infiltration/pressure die infiltration, Gas pressure infiltration, diffusion bonding, deposition techniques [5].

From listed all manufacturing techniques for MMCs, stir casting is most preferred method in terms of economic aspects than other processes. Powder metallurgy method are less preferred because of size of die and cost associated with equipment are higher than other processes. [10] It has been observed that stir casting is a technique to manufactured MMC using small size furnace and associated stirrer for mixing the molten metal matrix and reinforced material[11]. Mechanical stirrer is placed on the top of the muffle furnace to prepare metal matrix composite Figure 3 [12].

Figure 3. *Stirrer in muffle furnace*[12]

3. Literature Review

3.1. Types of MMCs

MMCs have been classified in to four major types such as Copper Matrix Composites Aluminum Matrix composites, Titanium Matrix Composite, Magnesium Matrix Composites, and . MMCs are also classified in terms of reinforcement constituent type such as particle reinforce, Whisker reinforced, Continuous fiber-reinforced, Mono filament reinforced.[8] MMCs are known as nascent material due to its excellent and improved properties over parent matrix material. These materials can be machined by various machines such as conventional machines with some constraints such as tool wear, tool worn out, machined with lower surface finish, less material removal rate, more time consumed and higher vibrations. MMCs are made by dissimilar engineering techniques recognized as powder metallurgy, compacting, sintering, reinforcement added stirring process, die compaction[14].

It has been observed from most of research article that as hardness increases it is difficult to machine any material through ordinary or conventional machining techniques. Now a days hard to cut material such as composites are extremely used in numerous applications. MMCs / composites machining is possible only by unconventional machining techniques resemble as electro-discharge, water jet, Laser beam, electron beam, Abrasive jet machining.

MMCs are machined efficiently without any constraints with help of non-conventional machining.[15] This article aims to explore machinability of MMCs using wire cut electro discharge machining in terms of type of MMCs, method of manufacturing, techniques used, responses, research findings. In advanced survey of MMCs influencing parameters have also been reviewed that is stirring parameter, wt. % of reinforcement, various types of reinforcement, size of reinforcement.

Literature reviews are made to emphasize research findings and types of metal matrix composites, however following literatures are based on MMCs developed via liquid state method in the following table 1.

Table 1. *Literature review of MMC developed by stir casting method.*

Sr. No.	Author	Type of MMCs	Techniques used	Responses	Research findings.
1.	Hwa Yan et al., [16]	Al6061/ Al_2O_{3p}	Optical microscope SEM Profilometry	Cutting speed (MRR) SR Width of the slit of cutting material	High wire speed, High flushing pressure and low wire tensions were influential parameters.
2.	Patil et al., [17]	Al / SiC	RSM Regression model SEM	MRR	Experiments explored that increased percentage of ceramic particles caused decreasing MRR.
3.	Jain et al., [18]	Al6061/SiC_p	Taguchi L_{29} Orthogonal array, ANOVA, Regression analysis	Surface roughness	Voltage was found substantial parameter on SR
4.	Satishkumar et al., [19]	Al7075/ B_4C_p/ Al_2O_{3p}	Taguchi $_{L9}$ OA ANOVA Regression analysis	MRR SR	T_{ON} was most significant parameter on MRR
5.	Shandilya et al., [20]	Al6061/ SiC_p	ANOVA Regression analysis Mathematical model, SEM	Kerf width	Pule on time has less significance on kerf width.
6.	Shandilya et al., [21]	Al6061/SiC_p	SEM EDS Analysis	Wire breakage frequency Surface morphology	To get lower wire breakage rate, lower voltage, low Ton and high Toff and high wire speed are desirable.

7.	Sriram et al., [22]	Al-Si_c MMC	Taguchi L_9 array ANOVA	Cutting speed, spark gap, MRR and SR.	Mathematical correlations were developed to determine responses for different machining situations.
8.	Shandilya et al., [23]	Al6061/ SiC_p	RSM ANN Modeling	Cutting speed	Voltage was found most influential parameter.
9.	Marigoudar et al., [24]	ZA43/ SiC_p	SEM ANOVA	MRR SR	MRR was increased with increasing Ton time and Ip, MRR decreased with increasing Toff time
10.	Fard et al., [25]	Al/ SiC	Taguchi L_{27} Orthogonal array ANOVA	SR, cutting velocity.	Ton time and discharge current have utmost significant parameters.
11.	Saini et al., [26]	Al6061/SiC_p	Taguchi L_9 Orthogonal array, ANOVA DOE,	MRR SR	Pulse on time is most significant parameter on responses.
12.	Peter et al., [27]	A413/B_4C/Fly Ash	ANOVA Grey Relational Analysis (GRA)	Material removal rate, Surface roughness	Gap voltage and pulse on time are most influential factors on responses.
13.	Srivastava et al., [28]	Al2021/ SiC	Microstructure investigation through SEM	MRR SR	Using non conational machining better surface finish can be obtained. MRR and SR Increases with increases of Peak current
14.	Sharma et al., [29]	Al6063/$ZrSiO_4$	Box Behnken design of RSM ANOVA	Cutting Rate	Cutting rate was increased by growing Ip and Ton time.
15.	Rao et al., [30]	Al7075/ SiC_p	ANOVA, RSM SEM Genetic Algoritham-II	SR MRR Wire wear ratio	Genetic algorithm II Techniques is proved excellent to get better production rate and good surface quality
16.	Pramanik et al., [31]	Al6061/SiC	SEM analysis	MRR, SR Taper Kerf width	Low melting material melt easily bus reinforced material delays MRR and transferred to electrode.
17.	Shandilya et al., [32]	Al6061/SiC_p	RSM ANN prediction model, ANOVA	MRR Cutting width (Kerf)	Pulse off time and servo volage are most significant on response variable.
18.	Pramanik et al., [33]	Al6061/SiC_p	Taguchi $_{L9}$ Orthogonal array	MRR, SR Kerf width	Longer Pulse on time increases MRR.
19.	Garg et al., [34]	Al6063/$ZrSiO_{4P}$	Taguchi L_{29} Orthogonal array ANOVA	Dimensional deviation	Dimensional deviation was increased as Ton time and Ip increased.
20.	Pujara et al., [35]	LM6/SiC	Teaching learning-based optimization Taguchi L_{27} Orthogonal array ANOVA	MRR SR	Wire tension, Ton time, Toff time, Ip were significant parameter for MRR and SR
21.	Udaya Prakash et al., [10]	Al356/ B_4C/Fly Ash	Taguchi L_{27} Orthogonal array, ANOVA	Material removal rate	Gap voltage (66.27 %) is most significant parameter to get higher MRR

22.	James et al., [36]	Al6061/ Al_2O_3/ZrO_2	Micro graph study Tensile test	Hardness of Composite	Casted Composites have the higher tensile strength than base material.
23.	Prakash et al., [37]	Al7075/ Graphane	SEM analysis	Mechanical properties	Tensile strength is higher than other GNP composites.
24.	Dey et al., [38]	AA6061/ Cenoshpere	Taguchi ANOVA Regression	Cutting speed Kerf width SR	Ton time and weight % of reinforcement are most significant on CS, KW and SR.
25.	Ramanujam et al., [39]	AA 7075/ Al_2O_{3p}	SEM Taguchi L_9 Orthogonal array, ANOVA GRA	MRR SR	Wire feed rate has been observed most influential parameter on surface roughness.
26.	Venkatesh et al., [14]	Al6061 reinforced with hybrid nano particles.	RSM Technique ANOVA with design expert software	MRR Surface Quality	The quality Of MRR and SR are influenced by high pulse on time and high voltage.
27.	Srivastava et al., [40]	A359/B_4C_p/ Al_2O_{3p} MMC made by electromagnetic stir casting	scanning electron microscopy by field-effect	Surface integrity Recast layer	Recast layer deposited on the surface during turning through WEDM creates dull surface illustrations
28.	Phate et al., [41]	Al/ SiC_{p20}	Taguchi-based hybrid grey-fuzzy grade ANOVA	Surface roughness	T_{on} time is most influential parameter on responses.
29.	Ponnuvel et al., [42]	Al/Gr/B_4C	Central composite face centered design of RSM 2^{nd} order Regresson	Kerf width Surface roughness and MRR	For prediction of response variable Artificial nural network techniques shows excellent result as compared with experimental results.
30.	Manikandan et al., [43]	LM6/SiC/Dunite	Adaptive neuro fuzzy interference system (ANFIS) Taguchi,ANOVA	MRR SR OVER cut Circularity error	Pulse ON time is major significant parameter on responses.
31.	Suresh et al., [44]	Al 7075 / nano SiC	Taguchi L_9 Orthogonal array, ANOVA DOE, SEM Analysis	MRR SR	Gap voltage has found most significant on MRR while wt % of reinforcement has found most significant on SR
32.	Kanth Grover et al.,[45]	Al/SiC/Gr/Fe_2O_3 MMC	Taguchi L_{27} Orthogonal array, ANOVA	Surface roughness	Stir casting composites are machine by WEDM
33.	Ananth et al., [11]	LM6/Fly Ash	Taguchi L_{27} Orthogonal array, ANOVA	Material Removal Rate	Gap voltage was most significant parameter.
34.	Kumar et al., [46]	Al6061/SiC/Gr/ Fe_2O_3	Taguchi L_{27} Orthogonal array, ANOVA Regression analysis	MRR Spark gap width	Pulse on Time is most significant parameter on MRR accomplished by peak current and Ton time
35.	Raju et al., [47]	Al6061/ B_4C	SEM Analysis	MRR SR	Increases in Ip, Ton time, Toff time, MRR increased and SR decreased

36.	Singh et al., [48]	Al/SiC	Taguchi L_9 Orthogonal array, ANOVA, Regression Minitab	Surface roughness MRR	Discharge current is the most significant parameter on responses.

3.2. AMC Developed by other than stir casting method.

MMCs are made from various techniques among that stir casting process has been found cost effective method and due to this ample author have worked on stir casting methods. However other techniques such as powder metallurgy, hot pressing, squeeze casting have been also found accurate and precise way of manufacturing metal matrix composites. In

Table **2**, literature review is made based on MMCs developed by stir casting method.

Table 2. *Literature review of MMC developed by different methods other than stir casting.*

Sr. No.	Author	Type of MMCs / Manufacturing methods of MMCs	Techniques used	Responses	Research findings.
1.	Alma et al., [49]	Al/Xgnp MMC made by Powder metallurgy	SEM, X-Ray diffraction,	Hardness, Wear resistance	Hardnes of Al/Xgnp increased up to 1 wt % and beyond that hardness of MMC was decreased.
2.	Ekici et al., [50]	Al /B_4C MMC made by Hot pressing method	Taguchi L_{18} Orthogonal array, Linear regression analysis, SEM	SR MRR	Pulse on time (30.24 %) and wire speed (83.20 %) significant on performance parameters.
3.	Geeta Rani et al., [51]	Al6061/MoS_2 MMC made by Powder metallurgy	Taguchi L_9 Orthogonal array, ANOVA, Response graphs	MRR SR	Ton time and Ip were significant on MRR while Toff time and wire feed were substantial on SR.
4.	Karthik et al., [52]	$AlCoCrFeNiMo_{0.5}$ Powder metallurgy Techniques for MMCs.	Taguchi L_{18} Orthogonal array, ANOVA /	MRR SR Kerf Width (KW)	Pulse on Time parameters is most influential parameter to get optimized responses.
5.	Goutham murari et al., [53]	Al-SiC-TiC MMC made by Powder metallurgy	Taguchi L_{27} Orthogonal array	MRR SR	MRR is very high in presence of wax+paraffin+oil dielectric compared with deionized water as dielectric.
6.	Ishfaq et al., [54]	Al6061/SiC MMC made by Squeeze Casting	SEM Analysis	Cutting rate (MRR), SR Kerf width	Voltage has been observed most significant parameters on Surface roughness.
7.	Soundararanjan et al., [55]	A413/ B_4C MMC made by Stir cum squeeze casting	DOE, RSM SEM analysis	MRR SR	Result shows that Ton time and Ip are most influential parameter on MRR and Toff time is most significant on SR.

Most of researcher worked on AMCs owing to their excellent properties and numerous applications identified in automobile parts, aviation parts, agricultural industries, defense sector. It has been observed from following literature review that some of the author worked on other than aluminum matrix composites such as magnesium matrix composite, titanium metal matrix composite, zinc matrix composite, copper matrix composite (CMC), and. Review of various metal matrix composite

other than AMC, which were made by powder metallurgy techniques and machined on WEDM to optimize MRR and SR are recorded in

Table **3**

Table 3. *Literature review of composites other than AMC*

Sr. No.	Author	Type of MMCs (Other than aluminum mmc)	Techniques used	Responses	Research findings.
1.	Babu rao et al., [56]	ZC63/ SiC_p	Principle component analysis ANOVA Taguchi , SEM	MRR, SR Wire wear ratio, Kerf width, white layer thickness	Ton time and wire tension were utmost significant parameters on MRR, SR kerf width.
2.	Meenakshi et al., [57]	Cu/Wc/SiCs MMC made by powder metallurgy.	Taguchi L_9 Orthogonal array, ANOVA, Multilinear regression analysis	Surface roughness	WC particles have most significant effect on surface roughness.
3.	Bose et al., [58]	Ti-TiB_2 Hybrid composite made by powder metallurgy	DOE RSM ANOVA fuzzy analytical hierarchy process, SEM	Kerf width Overcut SR, MRR	MRR and SR increased as Ton time and Ip increased.
4.	Bose et .al., [59]	Ti/B_4c	DOE, RSM ANOVA	Kerf width MRR Overcut SR	Power, Ip were significant parameter on MRR, SR. Ton time negatively influential on MRR

3.3. Application of Aluminum MMCs

Al7075 /Sic /TiB_2 has observed in various application such as aircraft structure, structural application and tool manufacturing [60] AA6082 with TiC added reinforced material is used in automotive component manufacturing and structural applications[61] AA6061 made with ZrO_2 is extensively used in defence sector, automotive industries and aerospace sector. [62] LM5 alloy with zirconia (ZrO_2) material has wide-ranging application in processing industries, decorative casting, marine

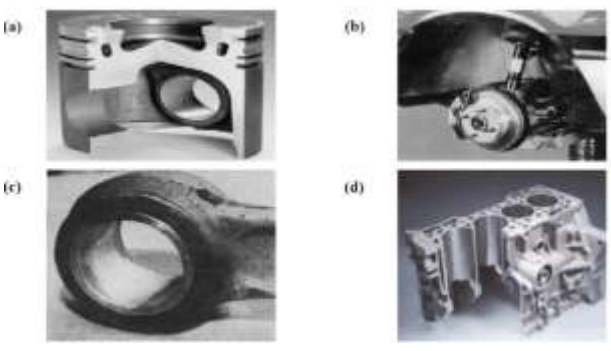

Figure 4. *Application of Stir Casting (a) Piston, (b) Automobile disc brake, (c) Connecting rod, (d) Engine frame*[63].

engineering[64] Al7075/Sic/Gr were manufactured using nano reinforcement of silicon carbide and graphite and the AMC is developed to manufactured automotive and aviation component/parts[65] Al7075 matrix with hybrid reinforcement such as TaC, Si_3N_4 and Ti has been observed fabulous application in defence and automotive sectors[66]. LM5/ZrO_2/Gr composite has been extensively used in defence, marine, automotive, aerospace industries, space craft, racing car and fighter plane[67]. AA6061-SiC MMC is pioneered AMC materials for industrial engineering, academicians, researchers and also frequently employed in aviation, manufacturing industries, automotive component manufacturing and structural applications[68] AA6061/Rice husk ash/TiC/Al_2O_3 material is well known matrix composite in automobile and aviation industries as hybrid reinforcement were added for greater strength and improved mechanical properties[69]. AA2025 T6 matrix material with red mud reinforcement is used in medical equipment manufacturing and aviation

industries[70]. Figure 4 witnessed of pioneered application of AMCs in numerous fields noticed as piston, automobile disc brake, bearing ended connecting rod and engine frame.

3.4. List of Reinforcement used in AMCs.

Table 4. Reinforcement used in Aluminum matrix composite, researchers can find the detailed analysis of reinforcement used and their effects on composites. As per the result of analysis almost all From the cases of composites mechanical properties were improved than matrix material and same can be observed in following table.

Table 4. *Reinforcement used in Aluminum matrix composite*

Sr. No.	Authors	Reinforcement							
		SiC	**Al_2O_3**	**Graphite**	**Wc**	**B_4C**	**ZrO_2**	**TiC**	**Research findings.**
1.	Samal P. et al., [71]	✓							Mechanical property was enhanced greatly.
2.	Dey D. et al., [72]	✓							Strength and Hardness were improved significantly.
3.	Vijaykumar K. et al., [73]	✓							Hardness and tensile values were significantly affected by Sic reinforcement.
4.	Fenghong C. et al., [74]	✓			✓				Hardness was improved by hybrid reinforcement.
5.	Srivastava A. et al., [75]	✓							Hardness and Strength were increased greatly.
6.	Dar S, Kumar et al., [76]	✓							Were resistance, hardness and tensile strength were improved tremendously.
7.	Jamval A. et al., [77]		✓					✓	Mechanical properties of AMC was improved significantly.
8.	Kandpal B. et al., [78]		✓						Improves microhardness and ultimate tensile strength using Al_2O_3 reinforcement.
9.	Al salihi et al., [79]		✓						Mechanical properties were significantly improved.
10.	Mohanavel V. et al., [80]		✓						Mechanical properties were increased greatly.
11.	James J. et al., [36]		✓				✓		Tensile property was improved significantly and hardness value was also increased.
12.	Mohanavel V. et al., [81]		✓						Mechanical properties was decreased with increased mass fractional of graphite reinforcement.
13.	Hariprasad T. et al., [82]		✓			✓			Wear resistance of AMC was improved.
14.	R Sarvanan et al., [65]			✓					Graphite was added due to improve machinability
15.	Kumar S. et al., [83]			✓					Mechanical, tribological and electrical properties were enhanced significantly.
16.	Vijay S. Prasad et al., [84]			✓		✓			Improved hardness and tensile strength were observed
17.	Sutharsan S. et al., [85]			✓		✓			Hardness value was increased significantly.
18.	Rajesh D. et al., [86]				✓				Mechanical properties were increased as reinforcement increased.
19.	Krishna U et al., [87]				✓				Wear resistance of AMC was improved.

20.	Anand P et al., [88]				✓				young's modulus, hardness and Ultimate tensile strength, were significantly improved
21.	Rajesh D et al., [89]				✓				Mechanical properties were improving tremendously.
22.	Dhilipa A. et al., [90]				✓				Hardness and toughness values were increased.
23.	Babu N. Ravi et al., [91]				✓				Tensile and Hardness strength were increased and impact strength was decreased.
24.	Krishna A. et al., [92]				✓				Mechanical and tribological properties were increased significantly.
25.	Singh V. et al., [93]				✓				Hardness was improved.
26.	Reddy P. et al., [94]	✓				✓			Tensile, hardness and impact strength were significantly improved.
27.	Hynes N. et al., [95]					✓			Tensile, hardness and shear properties were enhanced.
28.	Al Ethari H, Fadhi et al., [96]					✓			Fracture toughness was improved greatly.
29.	Hynes N. et al., [97]					✓			Mechanical and Tribological properties were increases as reinforcement increased.
30.	Garg S. et al., [98]						✓		Yield strength was found significant.
31.	Chockalingam K. et al.,[62]						✓		Microstructures and mechanical properties were improved.
32.	Ravichandran M. et al., [99]							✓	Stirring speed and stirring time were influential parameter for better mechanical properties.
33.	Rathore H. et al., [61]							✓	Mechanical Characteristics were increased significantly

3.5. Stirring mechanism

Many researchers have worked on various stirring mechanism in order to mixing molten metal properly. Stirring mechanism with one blade, two blade and three blade connected on the rotating shaft for proper stirring action have been researched[63]. Various stirring mechanism shown in Figure 5.

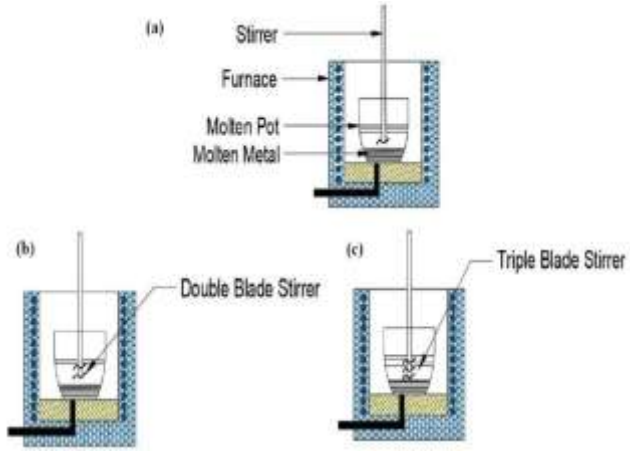

Figure 5. *Stirring Mechanism[63]. (a) Single blade stirrer, (b) Two blade stirrer, (c) three blade stirrer.*

Researcher also can be used drilling machine as stirrer, muffle or induction furnace could be placed below drilling machine and stirrer can be attached on the arbor of drilling machine[90]. As shown in

Figure 6 stirrer has attached on bench drilling machine to perform automatic stirring mechanism

Figure 6. *Stirrer in drill machine*[90]

4. Summary of literature review.

Form above literature review of scrutinize articles on distinguished MMCs, most common and widespread composite is AMC. It has the exceptional mechanical and chemical properties than other MMCs [16], in addition to this property AMC have good strength, wear resistance, high conductive, high specific stiffness, higher corrosion resistance. Extensive summary of the literature review is visualized in following 3D clustered column chart.

In extensive literature review, this article focused on the metal matrix composites manufacturing, machining of mmc, process parameters and research finding. However researcher worked on AMCs and the same were manufactured using different reinforcement acknowledged as Boron carbide (B_4C), silicon carbide (SiC), Alumina (Al_2O_3), fly Ash, Zirconium silicate ($ZrSiO_2$), Graphane, Cenoshpere (It is sphere made of silica and alumina with air or gas inside the sphere)[25], [100],[101],[51],[16],[102].

It has been observed from literature review that Silicon carbide, Boron carbide are most useful abrasive particle to manufactured the metal matrix composites. Silicon carbide particle improves mechanical properties of MMC [54], Al/SiCp MMC having excellent mechanical properties, higher thermal conductivity, high specific stiffness and excellent abrasive resistance than other AMC material[103]

Boron carbide has been mixed in the aluminum matrix metal to formed AMC. This AMC preforms excellent properties with higher hardness, good wear resistance, high elastic modulus, low specific weight, and great scope of neutron absorption [10]. It has been found that boron carbide is the hardest material after cubic boron nitride and diamond. It is mostly used in the application where high temperature during working because of their high refractoriness properties[8].

5. Conclusion

From the extensive literature review it has been reviewed that advanced hard to cut like material such as metal matrix composites are made from various manufacturing techniques, However the stir casting manufacturing method is found to be easy, economic and efficient method in comparison to other methods. Some observations have been drawn from the literature review are as listed below.

- ✓ MMC materials are machined using non-conventional machining methods.
- ✓ AMC Materials improves mechanical properties and tribological properties.
- ✓ Stir casting was found best, economical process to produce AMCs.
- ✓ AMC material have been utilized in automotive parts manufacturing, defense sector, aviation industries.
- ✓ Powder metallurgy, squeeze casting, and other manufacturing methods of MMCs have been found inefficient, costly and time-consuming process.
- ✓ Machining parameters during Wire cut EDM were taken as flushing pressure, Ton, Toff, wire tension, Ip, voltage.
- ✓ Most of researcher optimized performance parameter identified as MRR, SR.
- ✓ No of researcher used Al_2O_3, SiC, B_4C, Fly ash, Graphane, Zirconium silicate, as a reinforcement particle among all such particles SiC and B_4C were selected frequently in preparation of MMCs.

6. Future Scope

AMC using stir casting need to explore more for manufacturing of advanced hard to cut material for future related work. Hybridization in AMC also need to focused as the prime objective in future related research. It has been observed that hybrid reinforcement improves greater mechanical properties than single reinforcement composite. Major challenges in the development of AMC through stir casting is wettability between matrix material and reinforcement this also needs to be explore for future study.

It needs to explore for future prospective that aluminum metal matrix (AMC) machining should be done on wire cut EDM with some hybrid mechanism. One can also explored in the direction of stirring mechanism improvement.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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