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Fabrication of Aluminum Matrix Composites by Stir Casting Technique and Stirring Process Parameters Optimization

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Abstract

Aluminum matrix composites (AMCs) and hybrid aluminum matrix composites (HAMCs) becomes choice for automobile and aerospace industries due to its tunable mechanical properties such as very high strength to weight ratio, superior wear resistance, greater stiffness, better fatigue resistance, controlled co-efficient of thermal expansion and good stability at elevated temperature. Stir casting is an appropriate method for composite fabrication and widely used industrial fabrication of AMCs and HAMCs due to flexibility, cost-effectiveness and best suitable for mass production. Distribution of the reinforcement particles in the final prepared composite regulates the anticipated properties of AMCs and HAMCs. However, distribution of reinforcements is governed by stirring process parameters. The study of effect of stirring parameters in the particle distribution and optimal selection of these is still a challenge for the ever-growing industries and research. In this chapter accurate and precise attempts were taken to explore the effect of stirring parameters in stir casting process rigorously. Further, Optimal values of stirring parameters were suggested which may be helpful for the researchers for the development of AMCs and HAMCs. This chapter may also provide a better vision towards the selection of stirring parameters for industrial production of AMCs and HAMCs comprising superior mechanical properties.

Keywords: stir casting, stirring parameters, aluminum matrix composites, hybrid aluminum matrix, optimization

1. Introduction

Metal matrix composites (MMCs) are those composites in which metals are taken as base or matrix materials and ceramics or organic compounds are used as reinforcements to enhance the properties of the composite as compared to the base metal. Aluminum matrix composites (AMCs), magnesium matrix composites, copper matrix composites are some examples of MMCs which are in demand these days in various applications such as automobile industries, aerospace industries, and electronics industries etc. due to their suitable properties with low cost availability [1, 2]. Nowadays, aluminum matrix composites (AMCs) and hybrid aluminum matrix composites (HAMCs) are most commonly used MMCs [3]. Aluminum matrix composites are those type of composites which contains aluminum or aluminum alloy as base material (matrix) and nonmetals as reinforcements. Reinforcements can be added in weight % or volume % and in various form i.e. particulates, whiskers and fibers. In case of hybrid aluminum matrix (HAMC) more than one reinforcements are added in aluminum matrix. Particles reinforced aluminum matrix composites are used in aerospace, automobile and structural application due very high strength to weight ratio, superior wear resistance, high stiffness, higher fatigue resistance controlled co-efficient of thermal expansion and better stability at elevated temperature, high thermal and electrical conductivity compared to conventional metals and alloys, which makes it suitable for design of an extensive range of components in advanced applications [1, 2, 4–7]. Selection of processing of technique plays a vital role over the property of the composite.

Stir casting is a suitable processing technique to fabricate aluminum matrix composites and hybrid aluminum matrix composites as it is an economical process and preferred for mass production. The first step of stir casting involves melting of aluminum. During melting, aluminum melt reacts with the atmosphere and moisture and forms a layer of aluminum oxide (Al_2O_3) as given by Eq. (1). This layer shields the surface of the melt from further reaction with atmosphere [8].

$$2Al + 3H_2O \Leftrightarrow Al_2O_3 + 6H \tag{1}$$

Stir casting process involves stirring of melt, in which the melt is stirred continuously which exposes the melt surface to the atmosphere which tend to continuous oxidation of aluminum melt. As a result of continuous oxidation, the wettability of the aluminum reduces and the reinforcement particles remain unmixed. Al_2O_3 is a very stable chemical compound, which cannot be reduced under normal conditions and the wettability of melt remains unchanged. To stop the oxidation completely, an inert environment has to be created, which involves lots of complications. Therefore adding wetting agents such as TiK_2F_6, borax and magnesium in the melt is an alternate solution of this problem and widely used for the fabrication of AMCs and HAMCs [9, 10]. Apart from the oxidation problem, achieving homogeneous distribution of particles in the melt is another major problem frequently faced in stir casting process, which is controlled by stirring parameters. Therefore selection of stirring parameters plays major role in stir casting process. Stirring speed, stirring time, impeller blade angle, size of impeller and position of impeller are major parameters, affecting the distribution of the reinforcements in the matrix. Many authors attempted to find effect and the optimal values of stirring parameters.

Hashim et al. [11] used finite element analysis to simulate the fluid flow and investigated optimal values of stirring speed, and impeller position to achieve effective flow patterns to distribute the solid particles in the melt homogeneously. Naher et al. [3] performed Scaled-up stirring experiments with liquids having similar characteristics of aluminum melt and used SiC particles as reinforcements. The experiment was carried out in a transparent crucible and established photographing flow patterns. Ravi et al. [2] investigated effect of mixing parameters through a water model for the fabrication of Al-SiC composite through stir casting. Impeller blade angle, stirring speed, direction of impeller rotation were taken as stirring parameters. Lu and Lu [12] used finite element method to simulate the flow pattern and to find effects of stirring parameters like blade angle, stirring speed, impeller size, and the stirrer geometry over the flow characteristic. Sahu and Sahu [13] used computational fluid dynamics to simulate the fluid flow and optimized stirring parameters like blade angle, impeller size and stirring speed using Grey Taguchi method. This chapter attempt to review the studies conducted on the effect of stirring parameters and optimization of stirring parameters for the fabrication of AMCs and HAMCs through stir casting method.

2. Stir casting

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost net shaping and easier control of composite structure [14].

Stir casting setup as shown in **Figure 1**, consist of a furnace, reinforcement feeder and mechanical stirrer. The furnace is used to heating and melting of the materials. The bottom poring furnace is more suitable for the stir casting as after stirring of the mixed slurry instant poring is required to avoid the settling of the solid particles in the bottom the crucible. The mechanical stirrer is used to form the vortex which leads the mixing of the reinforcement material which are introduced in the melt. Stirrer consist of the stirring rod and the impeller blade. The impeller blade may be of, various geometry and various number of blades. Flat blade with three number are the preferred as it leads to axial flow pattern in the crucible with less power consumption. This stirrer is connected to the variable speed motors, the rotation speed of the stirrer is controlled by the regulator attached with the motor. Further, the feeder is attached with the furnace and used to feed the reinforcement powder in the melt. A permanent mold, sand mold or a lost-wax mold can be used for pouring the mixed slurry.

Various steps involved in stir casting process is shown in **Figure 2**. In this process, the matrix material are kept in the bottom pouring furnace for melting. Simultaneously, reinforcements are preheated in a different furnace at certain temperature to remove moisture, impurities etc. After melting the matrix material at certain temperature the mechanical stirring is started to form vortex for certain time period then reinforcements particles are poured by the feeder provided in the setup at constant feed rate at the center of the vortex, the stirring process is continued for certain time period after complete feeding of reinforcements particles. The
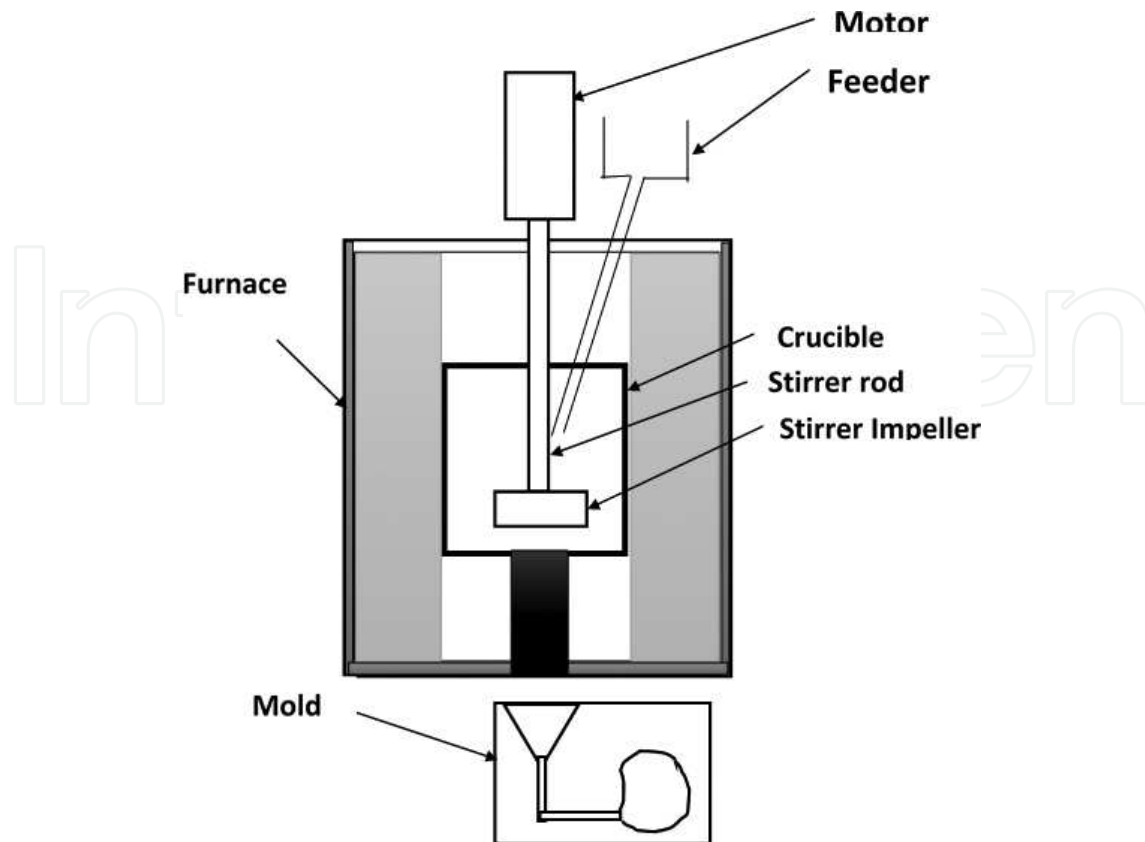
Figure 1. Schematic of stir casting setup.

molten mixture is then poured in preheated mold and kept for natural cooling and solidification. Further, post casting process such as heat treatment, machining, testing, inspection etc. has been done. There are various impeller blade geometry are available. Melting of the matrix material is very first step that has been done during this process.

2.1. Melting of matrix material

Out of various furnaces, bottom pouring furnace is suitable for fabrication of metal matrix composites in stir casting route, this type of furnace consist of automatic bottom pouring technique which provides instant pouring of the melt mix (matrix and reinforcement). Automatic bottom pouring is mainly used in investment casting industry. In this technique, a hole is created in the base of melting crucible to provide bottom pouring and was shielded by a cylinder-shaped shell of metals [15]. In stir casting process, the matrix material is melted and maintained a certain temperature for 2–3 h in this furnace. Simultaneously, reinforcements are preheated in a different furnace. After melting of the matrix material, the stirring process has been started to form the vortex.

2.2. Mechanical stirring

In stir casting process, the mechanical stirrer is coupled with the varying speed motor to control the speed of the stirrer. There are various stages of impeller stirrer i.e. single stage, double stage and multistage impeller. Double stage and multi stage stirrer are mainly used in

chemical industries whereas single stage impeller stirrer is commonly used for fabrication of AMCs and HAMCs due flexibility and to avoid excessive vortex flow [12, 13]. **Figure 3** shows various stages of impeller stirrer.
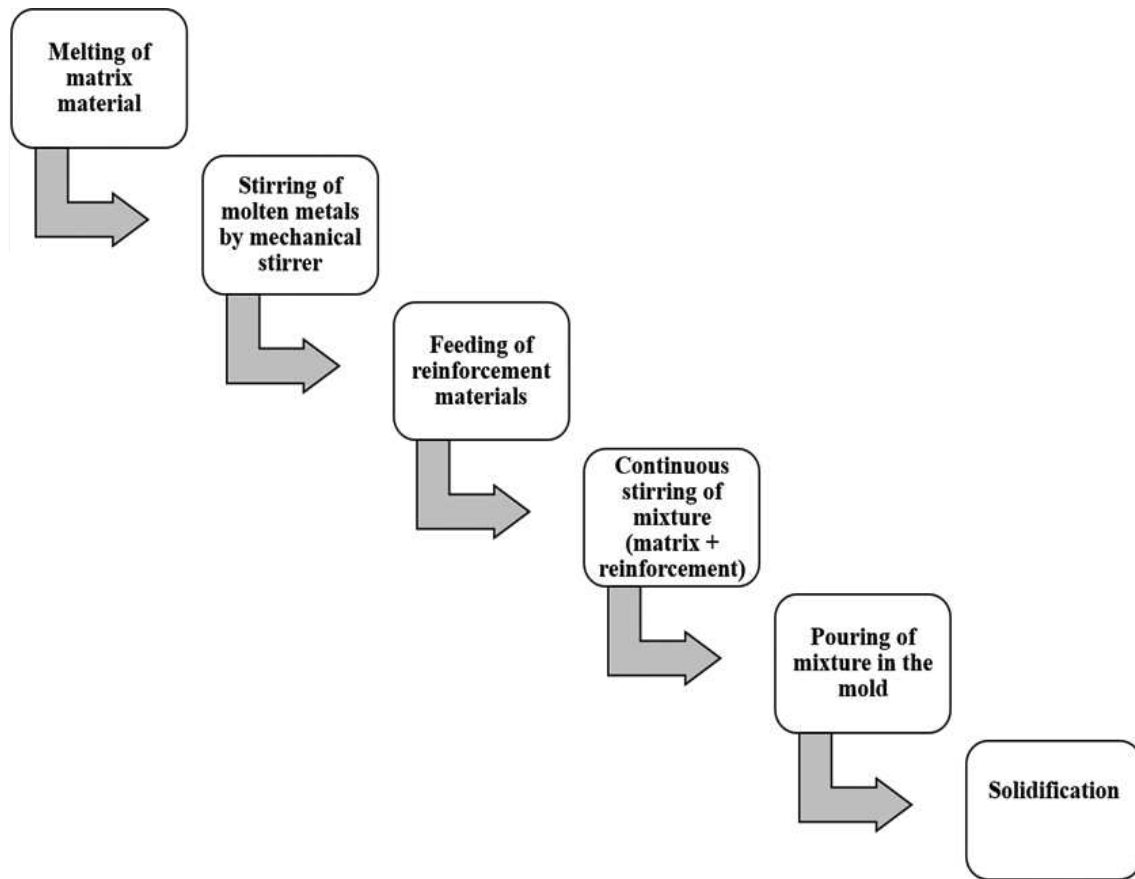

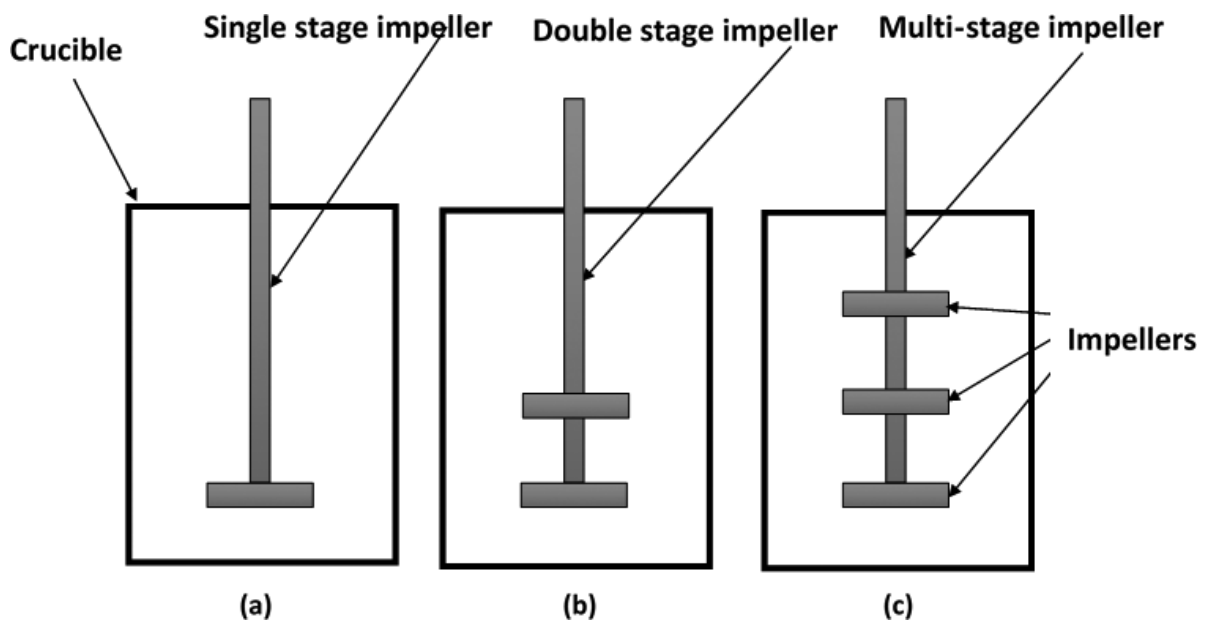**Figure 2.** Process of stir casting.

Figure 3. (a) Single stage impeller stirrer, (b) double stage impeller stirrer, (c) multistage impeller stirrer.

Stirring plays a vital role over the final microstructure and mechanical properties of the casted composites as it controls the distribution of reinforcements within the matrix. Optimum mechanical properties can be attained by the uniform distribution of reinforcement and this problem is a common to most of processing techniques, including stir casting [16]. This problem can be solved by optimal selection of stirring parameters.

Researcher has provided a range of stirring parameters based on the properties of the matrix, reinforcement, wettability and oxidation factors for various combination of material as listed in **Table 1**. This table shows the parameters selected by various authors for the fabrications of aluminum matrix composites and aluminum hybrid matrix composites. These parameters are type of matrix material, percentage of reinforcements, stirring speed, stirring time and feed rate. The range of certain stirring parameters has been used by the authors such as the stirring speed should be in the range of 450–700 rpm, stirring time in between 5 and 15 min federate in the range of 0.9–1.5 g/s for different percentage of reinforcements.

Mechanical properties of AMCs and HAMCs mainly depends on the dispersion of the reinforcements throughout the composite. The dispersion of reinforcements is governed by stirring parameters. Hence, performing experiment with selecting random stirring parameters may not provide homogeneous dispersion of reinforcement particle which leads to lower mechanical properties. Therefore, understanding of effect of stirring parameters and selection of optimal stirring process parameters is crucial. The effect of various stirring parameters with suggested optimal values of this parameters is discussed further.

2.3. Effect and optimization of stirring process parameters

There are some significant stirring process parameters which affect the distribution of reinforcement at most. These parameters are stirring speed, stirring time, blade angle, stirrer size, position of the stirrer and feed rate of reinforcements. The main purpose of introducing stirrer is to form vortex in melt which transfers the reinforcement particles in the matrix melt and maintain them in suspension. There are various types of stirrer are existing for this purpose but

S. N.	Matrix	Reinforcement	Reinforcement %	Stirring speed (rpm)	Stirring time (min)	Feed rate	Reference
1	A6061/1545K	B_4C	5 wt. %	450	–	–	[16]
2	A384	SiC	10 wt. %	500, 600, 700	5, 10, 15	–	[17]
3	LM25	B_4C/Al_2O_3	Wt. % (0, 2, 3)/ (0, 2, 3)	550	10	–	[14]
4	Al 6061/Al 7075	B_4C/graphite	Wt. % 10/5	500/700	5	0.9–1.5	[18]
5	Al 7075	B_4C	10 vol. %	500	–	–	[19]
6	Al 7075	Graphite	5, 10, 15, 20 wt. %	500	5	–	[20]
7	Al 6061	Nano Al_2O_3	0.5, 1, 1.5 wt. %	450	15	–	[21]

Table 1. Stirring parameters selected by the authors.

for minimizing the power requirement stirrer are designed such that it provide high degree of axial flow [11].

2.3.1. Stirring speed

Stirring speed is a significant parameters which affect the distribution of the reinforcement particles within the matrix material. Prabu et al. investigated the effect of stirring speed and stirring time on the hardness of casted silicon carbide reinforced aluminum matrix composite, in which the stirring speed were selected 500, 600 and 700 rpm and the stirring time was taken as 5, 10 and 15 min. The experimental study concluded 600 rpm and 10 min is the best combination of stirring speed and stirring time for uniform hardness value through the composite which confirms the uniform distribution of SiC particles over the aluminum matrix. Further, Design of impeller i.e. impeller blade angle plays a vital role over the flow characteristic and power consumption by the stirring motors.

2.3.2. Impeller blade angle

The vortex formed by the stirring on solid-liquid mixing transfers reinforcements particles into the melt from the liquid surface whereas shearing action assist to break the accumulation formed by the reinforcement particles and lead to uniform distribution. Therefore, selection of a suitable blade angle is crucial to acquire good level of axial flow and shearing action.

To investigate the effect of impeller blade angle, researchers used water model and CFD model. They selected blade angle as 15, 30, 45, 60 and 90°. In a water model Ravi et al. investigated the effect of impeller blade angle over the distribution of solid particles in the liquid. They found at low angle ($\alpha = 15°$) particles are dispersed below the stirrer. Impeller with blade angle ($\alpha = 30°$) performed well and shows uniform dispersion without concentration of particles. Whereas, impeller with high blade angle ($\alpha > 30°$), most of the solid particles concentrate at just below the tip of the impeller blade which results more radial variation. Thus, 30° was concluded as optimal value of blade angle with respect to stirrer axis which is in good agreement with FEM Model by Sahu and Sahu and Lu and Lu. They attempted to reduce stagnant and dead zones in the flow pattern with blade angle 30, 45, 60 and 90° with respect to the impeller axis. Inactive zone in the cylindrical portion and bottom portion of the crucible are said stagnant zone and dead zone respectively. High blade angle ($\alpha > 90°$) lead to high level of shearing flow and consume high power as well. Shearing action ensure the solid particle suspension in the melt but without axial suction pressure it is difficult to suck solid particles into the melt. The axial flow can be increased by decreasing the blade angle and significant axial flow was seen close to the liquid surface when the blade angle decreased to 30° [2, 12, 13] (**Figure 4**). Moreover, stirring time plays an important role over the distribution of solid particles and power consumption by the stirring motor.

2.3.3. Stirring time

Stirring time is a significant process parameter in stir casting process. Lower stirring time may lead to clustering of particle reinforcements and results non-homogeneous distribution of reinforcement particles. Whereas, higher stirring time may lead to the deformation of the
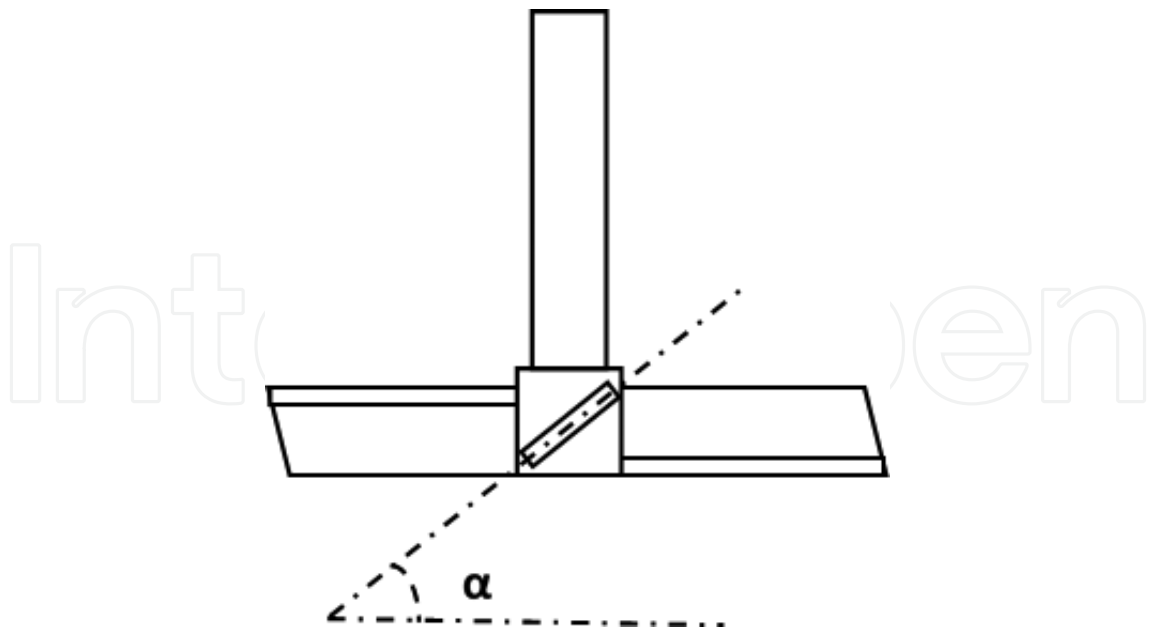
Figure 4. Impeller blade angle.

stainless steel stirrer impeller blade at very high working temperature. The working temperature of some reinforcement such as boron carbide with aluminum matrix are very high. This temperature range is 850–950°C, which may deform the stirrer impeller. Moreover, unwanted high stirring time also consumes more power which leads to rise in fabrication cost of composite. Therefore, optimal value of stirring time is essential. Prabu et al. studied effect of stirring time on microstructure and hardness of Al/SiC composite has been investigated and suggested 10 min as optimal value of stirring to achieve better distribution of reinforcements and uniform value of hardness throughout the composite [17]. Apart from stirring time, the position of stirrer is important and discussed further.

2.3.4. Impeller position

The position of the impeller should not be more than 30% of the height of the fluid from base of the crucible to avoid agglomeration of reinforcements particles at the bottom of the crucible. **Figure 5** shows the position of stirrer impeller. In which height of impeller (h) from the bottom of the crucible is given in Eq. (2) [11].

$$h \geq 0.3H_0 \tag{2}$$

Where h is the position of the impeller from the bottom of crucible and H_0 is the height of the fluid.

2.3.5. Impeller blade size

The impeller blade size is the diameter of the impeller blade which is given in term of the diameter of the crucible. The size of impeller plays a substantial role over the distribution of particles. If the size impeller is too small then the reinforcement particles persist suspended at
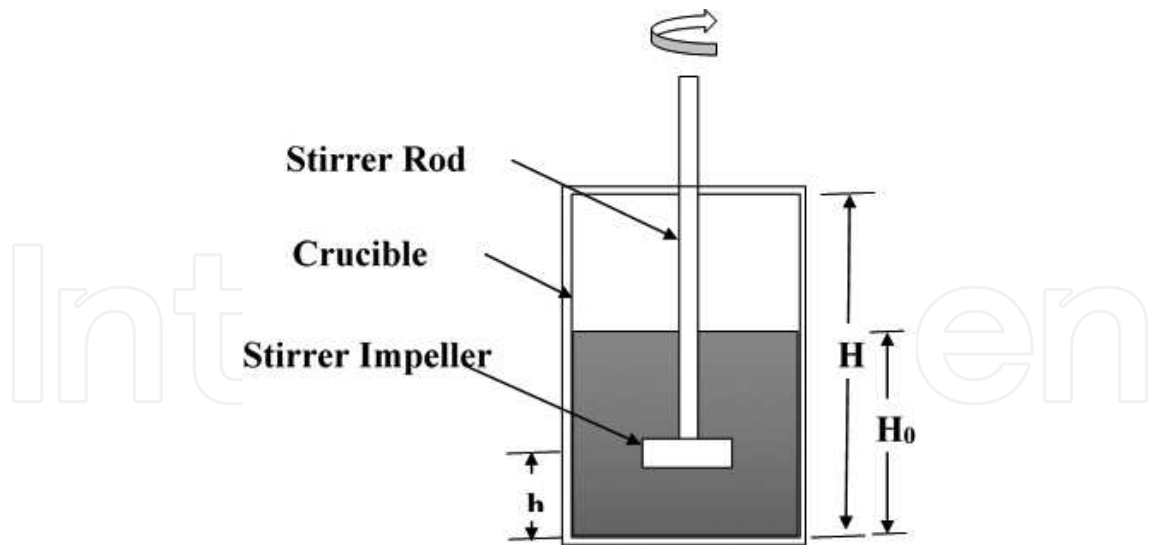
Figure 5. Position of stirrer in the crucible.

the periphery of the crucible which cause lack of suspension of particles at the center. Whereas if the impeller size is too large then the reinforcements particles concentrated at the center of the crucible bottom. Hence, optimal size of impeller is that size which provides distributed particle in both center as well as the periphery of the crucible at the similar speed. So the optimal diameter of the impeller d, is 0.5 times of D, the diameter of crucible for flat base crucible single stage stirring at 550 rpm [13], and 0.55 times of D, the diameter of crucible for semispherical base crucible and multistage stirring at 1000 rpm [12] (**Figure 6**). Whereas the blade width b is equal to 0.1–0.2 times of D, the crucible diameter [11].

At the initial stage of stirring process, Ekman boundary layer theory is well recognized. This theory is associated with particle lifting in rotating fluid phenomenon. Particle dispersion number (PDN) is a correlation between observed particle lifting in the Ekman layer and flow
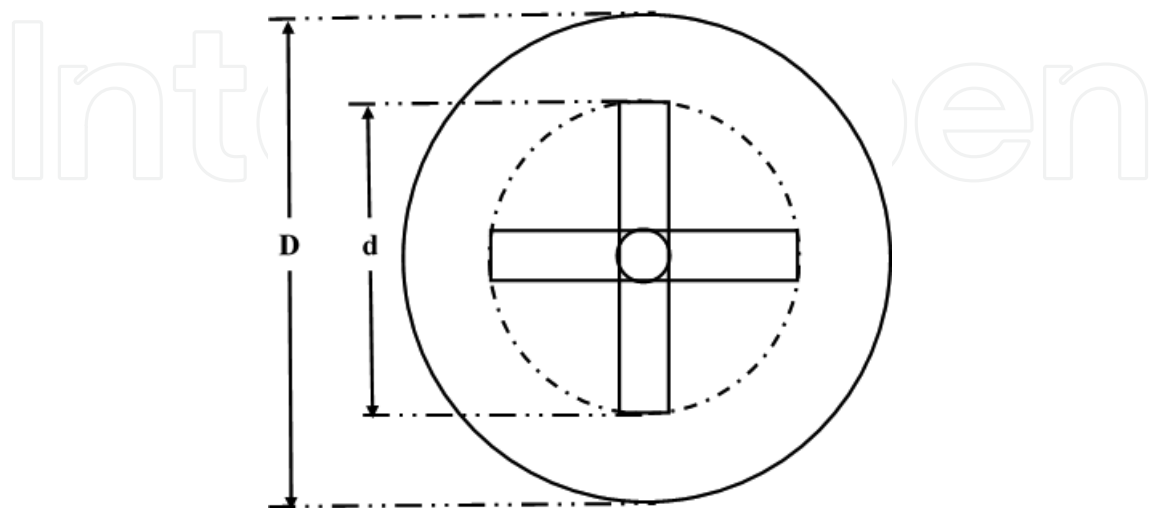

Figure 6. Impeller and crucible diameter.

parameters. A secondary flow in the axial direction is formed due to the momentum transfer from high momentum region to low momentum region through Ekman layer. For single-phase fluid, the spin-up time scale t and character velocity V_E in Ekman layer is given in Eqs. (3) and (4) respectively.

$$t = \left(E\Omega^2\right)^{-1/2} \tag{3}$$

$$V_E = \frac{H_0}{t} \tag{4}$$

Where E is the Ekman number, Ω is angular velocity of the container and H_0 is the height of the melt.

To correlate the observed particle lifting in the Ekman layer with the flow parameters, a particulate dispersion number PDN, defined as the ratio of the characteristic velocity in the Ekman boundary layer to the terminal falling velocity. When this number is much greater than unity, the settling velocity is smaller than the axial velocity of the secondary flow, and thus the particles will be convected to the top of the melt. On the contrary, the particles will remain at the bottom when PD is smaller than unity. For flow in a coaxial rotating cylinder, PD is given by Eq. (5) [11].

$$PDN = \left[\frac{H_0\left(\mu\omega\right)^{\frac{1}{2}}}{r_i^{\frac{1}{4}}d^{\frac{3}{4}}V_t}\right] \tag{5}$$

Where, H_0 is the height of the melt, μ the viscosity of the slurry, ω is the angular velocity of the container, r_i is the radius of the inner cylinder, d is the gap between the inner and outer cylinder, V_t is the particles settling velocity. Feeding of reinforcement particles is key parameters to avoid clustering of particles which is discussed further.

2.3.6. Feed rate

Mechanical stirrer forms vortex and reinforcements particles are feed in the center of the vortex. Feeder should be designed in such a manner that it allows continuous flow of particles. High feed rate results particles accumulation in the composite and low federate is difficult to achieve due to the formation of lumps of small solid particles. Thus, selection of optimal rate of feeding is crucial. Less than 0.8 g/s is very difficult to achieve and greater than 1.5 g/s results particle accumulation, hence the optimal rate of feeding is in the range of 0.8–1.5 g/s to avoid the accumulation of reinforcements in the composite and achieve homogeneous dispersion of reinforcement particles throughout the composite [11, 18, 22].

Fabrication of AMCs and HAMCs by stir casting method with optimal combination of above stated stirring process parameters govern the mechanical properties of the composites and discussed further.

2.3.7. Optimal values

Author were used different models for the optimization of stirring parameters. The models used by authors are water model, FEM model and experimental model. Authors were

attempted to find the optimal values of stirring parameters for single stage and multistage impeller stirrer, which is listed in **Table 2**.

Based on extensive review on stirring parameters the position of the stirrer is advised as 25–30% of the height of the melt height from the bottom of the crucible to avoid the dead zone, which is the reason of the agglomeration of reinforcements at the bottom of the crucible [12]. In case of water model, if the impeller blade angle was taken less than 30° then the solid particle dispersed below the stirrer. Impeller with 30° blade angle displays homogeneous distribution without concentration of particles. While, for impeller blade angle more than 30°, most of the solid particles concentrated at just below the tip of the impeller blade. In case of FEM Model, angle ($\alpha < 30°$) showed good axial flow but less shearing action, whereas ($\alpha > 30°$) showed good shearing action but less axial flow. Blade angle as 30° provides good level of axial flow and shearing action to such the solid particles into the melt from the melt surface and break the accumulation of mixing particles. Thus impeller blade angle 30° is suggested as optimal value to achieve homogeneous dispersion of reinforcements particles in the melt [2, 12, 13]. Stirrer size (d < 0.5 D) cause lack of suspension of particles at the center while stirrer size (d > 0.55 D) results particles concentrated at the center of the crucible base. Thus optimal diameter is 0.5 D at 550 rpm for single stage stirring and 0.55 at 1000 rpm for multistage stirring [12, 13]. The blade width b is in the range 0.1 D–0.2 D, where D is crucible diameter [11]. Hence, optimal size of impeller is proposed as in the range of 0.5D–0.55D to achieve particle distributed in both center as well as the periphery of the crucible at the similar speed. The stirring speed varies in the range of 200–1000 rpm, based on the reinforcement because of the wettability and oxidation factor. For multistage impeller stirring and CFD model, the optimal value of rpm is selected based on least value of stagnant zone and dead zone as better flow characteristic results good distribution of solid particles in the fluid. For multistage stirrer 1000 rpm has recommended as optimal value [12]. But in case of single stage impeller stirring 550 rpm as optimal value [13]. Stirring time less than 10 min (t < 10 min) lead to non-uniform distribution of reinforcements due to accumulation of reinforcement particles. Whereas stirring time more than 10 min (t > 10 min) cause deformation of stainless stirrer at high temperature which lead to non-homogeneous distribution of particles. Stirrer time of 10 min (t = 10 min) shows

Author	Stirring speed (N)	Blade angle (α)	Diameter of impeller (d)	Position of impeller (h)	Stirring time (t)
	rpm	°	mm	mm	min
Single stage impeller stirrer					
Sahu and Sahu [13]	550	30	0.5D	$0.25H_0$	10
Prabu et al. [17]	600	–	–	–	10
Ravi et al. [2]	250–270	30	–	$0.3H_0$	–
Hashim et al. [11]	–	–	–	$0.3H_0$	–
Multi-stage impeller stirrer					
Lu and Lu [12]	1000	30	0.55D	$0.25H_0$	–

Table 2. Optimal values of stirring parameters.

uniform distribution of reinforcement particles without deformation of stirrer, thus 10 min is suggested as optimal value of stirring time [13, 17]. Feed rate less than 0.8 g/s is very difficult to achieve and greater than 1.5 g/s results particle accumulation, hence the optimal rate suggested as 0.8–1.5 g/s to avoid the accumulation of reinforcements in the composite and achieve homogeneous dispersion of reinforcement particles throughout the composite [11, 18, 22].

3. Applications

AMCs and HAMCs are used in wide range applications such as automobile applications aerospace applications, electronics applications and sports applications due to its attractive properties. In automobiles applications, these are mainly used in engines, suspension system, driveline, housing and bakes. Whereas in aerospace applications jet engine blade, satellite solar reflector and missile fins are their main application. **Table 3** shows of applications of AMCs and HAMCs in various industries i.e. automobile, aerospace, military, electronics and sports applications. The applications of the Aluminum matrix composites and the hybrid aluminum matrix composites are in various types of industries such as automobile industries, aerospace industries, electronic industries, sports and aerospace and military industries. It is mainly used in the engines of the automobiles and aerospace. It is also used in the brakes, and driveline as in disk brake rotors and propeller shaft etc. The complete details of applications is in the below table.

Automobile applications	Engine	Valve train, piston rod, piston pin, covers, cylinder heads, crank shaft main bearing, cylinder blocks, engine cradle, connecting rod, Piston Crown, Piston Ring Groove, Rocker Arm, Valve, Wrist Pin, Cylinder Block (liner), Connecting Rod
	Suspension	Struts
	Driveline	Propeller shaft, drive shaft, Shift Forks, Drive Shaft, Gears, Wheels, sprocket, pulley
	Housing	Differential bearing, Gear box, pumps
	Brakes	Disk brake rotors, calipers brake disk, car brake disk, brake rotor, rear drum
Aerospace/military applications		Missile fins, aircraft electrical ac doors, metal mirror optics, satellite solar reflector, wing panel, precision components, space shuttle mid-fuselage tubular, struts, jet engine blade
Electronics applications		Current collectors, multichip electronic module, electronic packaging
Sports		Tennis racket skis, bicycle frame, wheel rims, golf club heads

Table 3. Applications of AMCs and HAMCs [23–25].

4. Conclusion

The present discussion discovers the importance of the selection of the stirring parameters over the properties of the stir casted composite desired for current demand of the industries. This review has investigated the effect and optimization of stirring parameters. The range of stirring speed may vary depending upon the properties of the reinforcements and matrix

material, wettability and chemical properties from 200 to 1000 rpm. For multistage impeller stirring 1000 rpm has suggested as optimal value. But in case of single stage impeller stirring 550 rpm gives an optimal speed of stirring, as higher speed causes excessive tabulation. Also it is concluded that Impeller Blade angle at 30° angle gives optimal value, which will provides suitable combination axial flow and shearing action with lower power consumption. Position of the impeller should be kept at more the 25–30% of the height of the liquid from bottom the crucible. Optimal stirring time of 10 min is suggested. Diameter of the impeller should in the range of 50–55% of the diameter of the crucible and reinforcement federate, as in the range of 0.8–1.5 g/s to avoid the accumulation of reinforcement particles. This study also reveals that the fabrication of HAMCs and AMCs by stir casting route by optimal selection of parameters provides high strength, low cost and light weight composites.

The present discussion discovers the importance of the selection of the stirring parameters over the properties of the stir casted composite desired for current demand of the industries. This review has investigated the effect and optimization of stirring parameters. Position of the impeller is suggested to kept at more than 25–30% of the height of the liquid from base the crucible to avoid particle clustering. Further, the optimal value of impeller Blade angle must be at 30° to achieve suitable combination axial flow and shearing action with lower power consumption. Diameter of the impeller should in the range of 50–55% of the diameter of the crucible to avoid particle concentration at the center of the base of crucible. Moreover, the range of stirring speed may vary depending upon the properties of the reinforcements and matrix material, wettability and chemical properties from 200 to 1000 rpm. For multistage impeller stirring 1000 rpm gives as optimal value whereas single stage impeller stirring 550 rpm gives as optimal speed of stirring respectively, as higher speed causes excessive tabulation. Furthermore, optimal value of stirring time is suggested as 10 min to achieve homogeneous distribution of particles without deforming the stirrer and low power consumption. Feed rate should be in the range of 0.8–1.5 g/s to avoid the accumulation of reinforcement particles. This study also reveals that the fabrication of HAMCs and AMCs by stir casting route by optimal selection of parameters provides high strength, low cost and light weight composites.

Abbreviations

D   Crucible diameter

d   Impeller blade diameter

H   Height of crucible

h   Height of impeller from the bottom of the crucible

H_0 Height of fluid in the crucible

N   Stirring speed

t   Stirring time

α Impeller blade angle

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