An Extensive Literature Review on the Usage of Fly Ash as a Reinforcing Agent for Different Matrices

Ajit Kumar Senapati, Abhijit Bhatta, Satyajeet Mohanty, P. C.Mishra, B. C. Routra

Abstract— In recent years composites reinforced with fly ash particulates have attracted considerable interest due to their inherent good mechanical properties and low cost. In this investigation an attempt has been made to provide an extensive literature review on the overall performance of these fly ash reinforced composites. Literatures in each category are reviewed according to the key factors mentioned. The literature review framework in this paper provides a clear overview of the usage of fly ash as a reinforcing agent in different matrices along with its distinctive performances

Index Terms— Fly ash, MMC, reinforcement, matrix, Mechanical properties.

I. INTRODUCTION

In recent years different matrices (metal/non metal) reinforced with ceramic particulates have attracted considerable interest due to their inherent good mechanical as well as tribological properties [2] and low cost. In the present era due to the rapid environmental degradation and high production cost, it stands as a challenge for the industries to compete with others in the market. As implementation of composite forming procedure along with fly ash decreases the production cost [30] concurrently enhancing the property of the materials , hence in this article the usability of one of such industrial waste material i.e. fly ash [1] has been reviewed extensively for both the above said purposes i.e. the need of an alternative eco-friendly solution and the property enhancing ability of the fly ash

II. FUNDAMENTALS OF COMPOSITE

A. Composites

Fibers or particles embedded in matrix of another material are the best example of modern-day composite materials, which are mostly structural.

B. Classification of Composites

Composite materials are commonly classified at following two distinct levels: The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs).

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Metal–matrix composites are materials in which tailored properties are achieved by systematic combinations of various constituents [6]. The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites. The second level of classification refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibre Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibres. Fibre Reinforced Composites are composed of fibres embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fibre length. On the other hand, when the length of the fibre is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fiber reinforced. Fibres are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibres must be supported to keep individual fibres from bending and buckling. Laminar Composites are composed of layers of materials held together by matrix. Sandwich structures fall under this category. Particulate Composites are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category.Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications.Two main kinds of polymers are thermosets and thermoplastics. [20] Metal Matrix *Composites*, at*present* though generating a wide interest in research fraternity, are not as widely in use as their plastic counterparts. High strength, weight efficiency [19], fracture toughness and stiffness [1], are offered by metal matrices than those offered by their polymer counterparts.

III. FLY ASH

Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the *fine particles* that rise with the flue gases. A typical composition of fly ash being used is given in the table below:[21]

Composition of cenospheres of fly ash [wt. %]

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Carbon/LOI
29.9	56.92	8.44	2.75	1.99

Fly ash is used as reinforcement in molten metal and cast because it can reduce the overall weight and density, due to the low density of fly ash [1].

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More recently, fly ash has been used as a component in geopolymers, where the reactivity of the fly ash glasses is used to generate a binder comparable to a hydrated Portland cement in appearance and properties, but with possibly reduced CO_2 emissions [1].

IV. KEY FACTORS REFERRED FOR THE REVIEW OF PROPERTIES

For the feasibility study in applying of fly ash as a filler material , the following key factors such as Tensile strength, Yield strength, Compressive strength, Hardness, Wear rate, Slurry erosive wear resistance, Wear resistance , Corrosion resistance, Density etc. are taken into consideration for analysis .

V. LITERATURE REVIEW ACCORDING TO THE KEY FACTORS AS MENTIONED

The results of the several investigations regarding the key factors as mentioned above are as follows:

A. Tensile Strength:

The results of the several investigations regarding tensile strength as follows:

Tensile strength has been the prime factor of testing in recent years for many authors like Anilkumar H.C[2], Ankush Sachdeva[3], Arun.L.R[4], Arun L. R[5], Ganesan Pandi[9], G.N. Lokesh[10], K.S.Ravishankar[13], K.V.Mahendra[15], M.Sreenivasa Reddy[19], N. Suresh[21], , P.K. Rohatgi[22], G. K. Purohit[24], Sandeep Kumar[25], T.P.D. Rajan[28], Dr. Zuoyong Dou [31] on different metal matrices.

Anilkumar H.C[2] determined the effect of particle size of fly ash particles on mechanical and tribological properties of fly ash reinforced aluminium alloy (Al 6061) composites samples, processed by stir casting route and concluded that, the tensile strength, decreased with the increase in particle size of reinforced fly ash,.On the other hand, N.Suresh [21] studied the effect of increase in the content of fly ash on mechanical properties of eutectic Al–Si alloys and concluded that with increase in content of fly ash, ultimate tensile strength increase by 44.3% .Ganesan Pandi [9] reviewed the machining and tribological behavior of aluminium hybrid

Composites and he concluded that tensile strength property got enhanced in a distinctive manner as compared to the base matrix. *T.P.D. Rajan* [28] studied the effect of three different stir casting routes on the structure and properties of fine fly ash particles on Al-7Si-.35Mg alloy matrix and concluded that the tensile strength has been reduced due to particle fracture and particle-matrix debonding. *Arun.L.R.* [4] made an attempt to produce enhanced composites using (*Al 6061*)alloy with cheaper method of fabricating i.e. by stir casting method and by proper reinforcement selection(Silicon Carbide (SiC) and fly ash) and concluded that the ultimate tensile strength got enhanced with increase in fly ash weight percentage and compared to base metal it has increased by 23.26%. *G. N. Lokesh* [10] investigated the "characterization of Al-Cu alloy reinforced fly ash metal matrix composites by *squeeze casting method* "and found that the ultimate tensile strength of squeeze cast samples increases with increase in percentage of fly ash. The gravity cast base alloy has lower UTS when compare to squeeze cast base alloy and composites. According to his explanation this may be due to the good bonding of fly ash particles with matrix as indicated by SEM analysis. *Prashant Kumar Suragimath* [24] studied the mechanical properties of *Aluminium alloy (LM6)* reinforced with SiC and fly ash and found that the tensile strength starts to increase with increase in weight percentage of fly ash .*Arun L.R.* [5] also made a characteristic study on *Aluminium* based Silicon Carbide and fly ash particulate Metal Matrix Composite and tested mechanical properties and found the same i.e. the Ultimate tensile strength has improved with increase in fly ash content.

Ankush Sachdeva [3] explored the possibility of using different reinforcements (silicon carbide, fly ash and graphite) to enhance the properties of *Aluminium alloy (Al5052)* composites which indicated that *Aluminum alloy(5052)* had measured a tensile strength of 210 MPA which was increased to max. of 260 MPA having the increase range of 11-24% .

Zuoyong Dou [31] on the other hand studied the effectiveness of aluminum alloy–fly ash composites for *Electromagnetic shielding* and as a result he found that the addition of fly ash particulate decreased the tensile strength of the matrix *2024Al* due to the inferior mechanical properties of the fly ash particulate. *P.K. Rohatgi* [22] demonstrated the feasibility of incorporating fly ash cenospheres in *die cast magnesium alloy (AZ91D)* and concluded that the ultimate tensile strength of the composites increases with the addition of fly ash cenospheres. The tensile strength of the *AZ91D*-5 wt.% fly ash composite shows a peak and then decreases for the composites with 10 and 15 wt.%. *Sandeep Kumar Ravesh* [25] made an attempt to develop aluminium based silicon carbide particulate MMCs with an objective to develop a conventional low cast method of producing MMCs and to obtain homogeneous dispersion of ceramic material and characterize them for mechanical properties such as tensile strength and he found that tensile Strength starts increases with increase in weight percentage of SiC. The best result of tensile strength has been obtained at 10% weight percentage of SiC & 5% of fly ash. *Anilkumar H.C.* [13] also said that with increase in the weight fractions of the fly ash particles increases the ultimate tensile strength and also said that it decreased with increase in particle size of the fly ash. *K.V. Mahendra* [15] studied the fabrication of Al–4.5% Cu alloy with fly ash metal matrix composites and characterised its properties and he explored that tensile strength increases with an increasing percentage of fly ash particulates . *M.Sreenivasa Reddy* [19] studied the effect of reinforcements and heat treatment on tensile strength of Al-Si-Mg based hybrid composites and found that MMC of *Al(7075)* reinforced with E-glass and fly ash particulates are found to have the improved tensile strength Compared to *Al (7075) alloy* alone. Hence, the MMC formed is superior to *Al (7075)*, with almost same density as that of the individual. Further, the specimen C8 (with 3%fly ash &2% E-glass fiber composition) of solution heat treatment and 1 hour aging exhibit excellent tensile strength. i.e 254.09N/mm2 , 3 and 5 hours of aging has not increased the tensile strength of the composite.

B. Yield strength:

Ganesan Pandi [9] made a review on machining and tribological behavior of aluminium hybrid composites (aluminium+graphite+alumina) and found that the yield strength got enhanced. *P.K. Rohatgi* [23]

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compared the compressive properties (compressive yield strength) of the composites of A356 alloy with other foam materials during which , the obtained stress–strain curves of composites showed a stress plateau region, which is commonly observed in foam materials when pores are crushed during compression. The composites containing fly ash cenospheres with a density in the range of 1250–2180 kg/m3 exhibited compressive yield strengths of 9–83 Mpa. *A. Daoud* [22] demonstrated for analyzing the feasibility of incorporating fly ash cenospheres in die cast magnesium alloy (*AZ91D*) and found that the addition of 5 wt. % cenospheres into *AZ91D* alloy decreases the yield strength of the composite, but increasing the fly ash content to 10 and 15 wt. % does not significantly affect the yield strength.

C. Compressive strength:

Anilkumar H.C. [2] again concluded that compressive strength decreased with the increase in particle size of reinforced fly ash but an increase in the weight fractions of the fly ash particles increases the compressive strength in aluminium alloy matrix composites. *L. Lancaster*[16] described the synthesis methods of agro-industrial waste filled metal matrix composite materials and their properties and concluded that Al-MMCs produced by modified compocasting cum Squeeze (taking fly ash as composite forming material) exhibited better compressive strength than stir casting and alone compocasting for Aluminium based MMCs. *Ganesan Pandi* [9] also concluded that Aluminium hybrid(aluminium+graphite+alumina) composites have their compressive strength increased than that of the base matrix.

Arun.L.R. [4] also suggested that the compressive strength of (*Al 6061*) composites with silicon carbide increases with increase in reinforcement wt%. *J.K. Kim* [23] compared the variations in the compressive properties of the composites (*A356 based*) with other foam materials and found that the compressive strength increased with the composite density. *P.K. Rohatgi* [22] also said that the addition of 5 wt. % cenospheres into *AZ91D* alloy decreases the ultimate compressive strength but increasing the fly ash content to 10 and 15 wt.% does not significantly affect the compressive and justified that, failure of the composite under compression starts by crack formation within the *AZ91D* matrix by normal void nucleation and growth. The cracks avoid cenospheres, favoring propagation through the matrix, leading to composite fracture.

D. Hardness:

Anilkumar H.C. [2] determined the effect of particle size of fly ash particles on mechanical and tribological properties of fly ash reinforced aluminium alloy (Al 6061) composites samples, processed by stir casting route and found that the hardness of the aluminium alloy (Al 6061) composites decreased with the increase in particle size of reinforced fly ash and.*N. Suresh* [21] studied the effect of increase in the content of fly ash on mechanical properties of eutectic Al–Si alloys and concluded that with increase the content of fly ash, hardness increase by 34.7% *L. Lancaster* [16] described the synthesis methods of agro-industrial waste filled metal matrix composite materials and their properties and concluded that for aluminium matrix ,Increasing the percentage of fly ash, the hardness of Al composite increases distinctly with significant decrease of density . In other words, the hardness to weight ratio increases significantly with the addition of fly ash. *Dr. Selvi.S* [8] investigated the mechanical properties of AL-MMCs theoritically and experimentally and concluded that the hardness of the Al-MMC composites increases as the fly ash content increases. *Ganesan Pandi*[9] reviewed the machining and tribological behavior of aluminium hybrid composites and he concluded that hardness got enhanced in a distinctive manner as compared to the base matrix. *Arun.L.R* [4] made an attempt to produce enhanced composites out of (*Al 6061*)alloy with cheaper method of fabricating i.e. by stir casting method and by proper reinforcement selection(Silicon Carbide (SiC) and fly ash) and concluded that Hardness of aluminium (Al6061) is increased from 50BHN to 88BHN with addition of fly ash and magnesium. *G. N. Lokesh* [10] investigated the "characterization of Al-Cu alloy reinforced fly ash metal matrix composites by squeeze casting method "and found that the hardness of squeeze cast samples in the composites increases with increase in percentage of fly ash with the recorded value of 119BHN for 12wt% fly ash composite. *Ankush Sachdeva* [3] explored the possibility of using different reinforcements (silicon carbide, fly ash and graphite) to enhance the properties of aluminium alloy (Al5052) composites which indicated that hardness was improved, comparing with the unreinforced alloy composite containing reinforcement percentage (8% Sic+8%Fly Ash+4% Graphite) fabricated at 1000° C showed the maximum value of the hardness. Hardness value of 70 was increased to max of 81 and with the range of 5-16% increase with the addition of different weight % of reinforcements.

P.K. Rohatgi [22] demonstrated the feasibility of incorporating fly ash cenospheres in die cast magnesium alloy (*AZ91D*) and concluded that the hardness of the *AZ91D*-based composites is increased by adding fly ash. The hardness of the composites is a maximum where 5 wt. % fly ash is added and becomes slightly lower with the addition of 10 and 15 wt. % fly ash. This decrease is attributed to an increase in the porosity content with increasing wt. % fly ash.

Sulardjaka [27] tested the hardness of MMC ALFA formed by *aluminium matrix* and opined that Carbothermally reduced fly ash produces SiC phase that enhances reinforcement of fly ash on aluminum matrix and hence increases the hardness of the MMC . Sintering at temperature 550^{o}C for 2 hours give higher hardness than sintering at temperature 600^{o}C for 2 hours. Composite sintered at temperature 550^{o}C for 2 hours has better hardness and wear resistance than sintered at 600^{o}C for 2 hours. *Sandeep Kumar Ravesh* [25] made an attempt to develop aluminium based silicon carbide particulate MMCs with an objective to develop a conventional low cast method of producing MMCs and to obtain homogeneous dispersion of ceramic material and characterize them for mechanical properties and he found that the hardness of Metal Matrix Composite increased with increase in SiC content. *Anilkumar H.C.*[13] also determined that with increase in the weight fractions of the fly ash particles increases the hardness. *K.V. Mahendra*[15] studied the fabrication of Al–4.5% Cu alloy with fly ash metal matrix composites and characterised its properties and he explored that the hardness increases with an increasing percentage of the fly ash particulates.

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A. Wear rate, Slurry erosive wear resistance, wear resistance:

Anilkumar H.C. [2] determined the effect of particle size of fly ash particles on mechanical and tribological properties of fly ash reinforced *aluminium alloy (Al 6061)* composites samples, processed by stir casting route and found that the wear rate decreased with the increase in particle size of fly ash particles. *N. Suresh* [21] studied the effect of increase in the content of fly ash on mechanical properties of eutectic *Al–Si alloys* and concluded that the wear loss decreases by 33% at the highest sliding distance. *Dr. Selvi.S* [8] investigated the mechanical properties of AL-MMCs theoritically and experimentally and also concluded that the fly ash particles improve the wear resistance of the *Al MMC* and the presence of SiO2 in fly ash increase wear resistance of *Al MMC* and that changes of wear rates are observed in the sliding wear test. *M. Ramachandra* [17] studied the wear and friction characteristics of the Al (12 wt% Si) up to 15 wt% of flyash composite in the as-cast conditions by conducting sliding wear test, slurry erosive wear test and concluded that the effect of increased reinforcement on the wear behavior of the MMCs is to increase the wear resistance and reduce the coefficient of friction. The MMCs exhibited better wear resistance (20–30% improvement) due to its superior loadbearing capacity.Increased normal load and sliding velocity increases magnitude of wear and frictional force. Four different wear mechanisms were found to operate under the test conditions of variation in normal load, % flyash content and sliding velocity. They are abrasion, oxidation, delamination, thermal softening and adhesion. The dominant wear mechanism under the lower load of 4.9N and a sliding velocity of 47.1 m/min is abrasion. At medium and higher loads 9.8 and 14.7N and at a moderate sliding velocity of 56.54 and 65.97 m/min the wear mechanism was found to be delamination and oxidation. Slurry erosive wear resistance increased with increase in flyash content. The formation of passive layer on the surface of the slurry erosive specimens decreased wear loss forming a protective layer against impact of slurry.

V.K. Srivastava [29] studied the effects of flyash filler, impingement angle and particle velocity on the solid particle erosion behaviour of *E-glass fibre reinforced epoxy* (*GFRP*) composites and explored that erosive wears of *GFRP* composite with 4 g flyash as filler is the lowest. This filler restricts fibre–matrix debonding. *Prashant Kumar Suragimath*[24] studied the mechanical properties of *Aluminium alloy (LM6)* reinforced with SiC and fly ash and found that the wear resistance tends to increase with increase in addition of Fly Ash in LM6/SiC Hybrid composite. *Sulardjaka* [27] tested the wear resistance of *MMC ALFA* formed by *aluminium matrix* and opined that carbothermally reduced of fly ash produces SiC phase that enhance reinforcement of fly ash on aluminum matrix which increases wear resistance of MMC product. *M. Uthayakumar* [18] studied the effects of parameters such as load, sliding speed, and percentage of fly ash on the sliding wear, specifc wear rate, and friction coefficient were analyzed using Grey relational analysis on a pin-on-disc machine. Analysis of variance (ANOVA) was also employed to investigate which design parameters significantly affect the wear behavior of the composite and found that the composites retain the wear resistance properties at lower loads with increase in fly ash percentage. Mild wear was also observed in the composites as the sliding speed increases. For all the trials it is observed that mild-to-severe wear exists, and it is witnessed by the microscopic results. The applied load and sliding speed are the most influencing factors, and it is observed that their contributions to wear behavior are 49.71% and 30.43%,respectively.The optimum design parameters were predicted through Grey relational analysis (applied load =19.62 N, sliding speed = 3 m/s, and percentage of fly ash = 5 wt.%).The confirmation experiment is conducted with the level A2B3C1 to verify the optimal design parameter, and it exhibits better wear performance. *Grigorios Itskos* [11] evaluated the tribological performance of high-Ca fly ash-Al and Al-alloy-composites and concluded that addition of both high-Ca & high-Si flyash significantly enhanced the tribo performance of Al . Optimum Al substitution percentage is 15%wt in case of MFA & 10%wt in case of KFA, however addition of FA in Al upto 20% wt is generally feasible and results in advanced wear properties of composites. *Alloy Al-Si matrix* showed better tribological performance than flyash composites .However addition of ashes up to 15% wt. results in a rather restricted deterioration of wear strengths of products K.V. *Mahendra* [15] studied the fabrication of *Al–4.5% Cu alloy* with fly ash metal matrix composites and characterised its properties and he found that dry sliding wear resistance increases with an increasing percentage of fly ash. In the slurry erosive wear test, the resistance to wear increases with increasing fly ash content. The wear is enhanced in the case of basic media compared to acidic and neutral media.. The MMC produced can be used for bearing applications, because of its good wear resistance.

B. Corrosion Resistance:

L. Lancaster [16] described the synthesis methods of agro-industrial waste filled metal matrix composite materials and their properties and concluded that the Corrosion resistance properties decreased with an increased in the weight % of fly ash content in *Al Metal matrix*. The type of corrosion to be seen was pitting corrosion. Within 24 hours of corrosion, the formation of pit can be seen clearly in the reinforced material. This was due to fly ash presence that initiated the pit. These pits initiated at flaws within the surface film and at sites of the composites where they are mechanically damaged under the conditions where self-repair could not be established .*M. Ramachandra*[17] studied the wear and friction characteristics of the Al (12 wt% Si) up to 15 wt% of fly ash composite in the as-cast conditions by conducting sliding wear test, slurry erosive wear test and fog corrosion test concluded that corrosion resistance of reinforced samples has decreased with increase in flyash content. M. Walczak[14] studied the corrosion behaviour of aluminium fly ash composite taking AK12 as matrix and he found that fly ash particles lead to an enhanced pitting corrosion of the AK12/9.0% fly ash (75-100-mass fraction) composite in comparison with unreinforced matrix (AK12 alloy). The enhanced pitting corrosion of ALFA composite is associated with the introduction of nobler second phase of fly ash particles, cast defects like pores, and higher silicon content formed as a result of reaction between aluminium and silica.

The same factors (i.e. fly ash particles, cast defects and higher silicon content) also determine the properties of oxide film forming on the corroding surface.

G. Density:

N. Suresh [21] studied the effect of increase in the content of fly ash on mechanical properties of eutectic Al–Si alloys and concluded that the density decreases by13.2% as compared to the base matrix .L. Lancaster [16] described the synthesis methods of agro-industrial waste filled metal matrix composite materials and their properties and concluded that increasing the percentage of fly ash decreases the density significantly. G.N. Lokesh [10] investigated the "characterization of Al-4.5wt%Cu alloy composites by squeeze casting method" and found that density decreases from 2.7714 to .7112g/cm3 with increase percentage of fly ash. J.K. Kim [23] compared the variations in the compressive properties of the composites (A356 based) with other foam materials and found that the density of composites increased for the same cenosphere volume fraction with increasing melt temperature, applied pressure, and the size of particles. This appears to be related to a decrease in voids present near particles by an enhancement of the melt flow in a bed of cenospheres.P.K. Rohatgi [22] demonstrated the feasibility of incorporating fly ash cenospheres in die cast magnesium alloy(AZ91D) and concluded that The density of the composites decreases with increasing percentage of fly ash content, but calculated values differ from theoretical values due to the presence of filled microballoons and porosity in the composite. K.V. Mahendra [15] studied the fabrication of Al–4.5% Cu alloy with fly ash metal matrix composites and characterised its properties and he explored *that density of the composites decreases as compared to the base matrix.*

Miscellaneous studies:

Baljeev Kumar [7] reviewed the effect of Fly ash as filler on various properties of *HDPE*/ fly ash polymer composites and found that there is an excellent compatibility between fly ash and polymers. *T.P.D. Rajan* [28] studied the effect of different types of stir casting on the structure and properties of fine fly ash particle reinforced mmc(Al-Si-0.35mg)alloy composite and concluded that modified compocasting cum squeeze casting route results in the best distribution of fly ash particles followed by compocasting alone and liquid metal stir casting in metal moulds. *X. Wu* [30] attempted to produce aluminium matrix composites with fly ash particles through BP-ECAC in a comparative view to the conventional powder metallurgy (PM) and ingot metallurgy and he found that capability of incorporating very fine particles as well as very high volume fractions renders BP-ECAC significant advantages over the conventional solidification processing and powder metallurgy routes. It is possible to produce ultrafine metal matrix composites and to greatly increase efficiency and thus reduce cost of production. *Harish K.Garg* [12] reviewed the machining of hybrid Aluminium Metal Matrix composite (Al/SiC/Gr and Al/Si10Mg/Fly ash/Gr) and concluded that there is essential need to select proper machining process for effective machining of hybrid Al/SiC/Grp-MMC. As such no sufficient number of literature on machining of hybrid Al/(SiCp + Grp)-MMC is available, but from the published research work it is clear that the *Al/SiC*-MMC machining is one of the major problem, which resist its wide spread application in industry. The technique of EDM can help us to obtain the desired results. *Baljeev Kumar* [7] reviewed the effect of Fly ash as filler on various properties of *HDPE*/ fly ash polymer composites and found that fly ash is used as reinforcing filler in *High density polyethylene* (*HDPE*). Some studies have pointed to the excellent compatibility between fly ash and polymers. Although incidental success stories are published, a systematic approach on investigating the influence of fly ash on polymer properties for the various different polymer types and the enormous amount of possible formulations has not yet been properly undertaken. Modification of Fly ash accompanied by compatibilization leads to the substantial improvement properties of the composites. However, it is obvious that the potential as reinforcing fillers in polymers especially for Fly ash/HDPE composites have not been fully brought into play. The stateof- art indicates that efforts should be continuously made before widely employing these advanced composites into practical usage. *S.K. Deya* [26] attempted to extend the wear study of A390 to an order of magnitude higher load, 5.0 N, to assess the upper limit of the UMW regime and found that the key factor in maintaining the UMW further would be to retain the large particles without fracturing them.

VI. CONCLUSION

The current literature review reveals that, extensive work has been reported to improve properties of different matrices by forming their composites being reinforced with fly ash particle , and from the above review it may be concluded that almost all properties except very few exceptions proved to have distinctive improvement in their properties , and hence fly ash should be implemented extensively in the commercial production of composites in industries as its use for the production of composites can turn industrial waste into industrial wealth. This also solves the problem of storage of fly ash [24] as well as brings down the production cost [30] giving an economical and eco-friendly solution.

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