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Novel Method of Nanoparticle Synthesis using Surface Grinding

N. Shivakumar, T. Ramesh, Srividhya P. K., A. Pugazhenthi, S. P. Manikandan

Abstract: ***Nanoparticles are of most important in all the areas because of their varied and unusual properties. nano particles could be produced using top down and bottom up approaches. We present a novel method of synthesizing nanoparticles such as C, ZnO, Al, Fe_2O_3. The surface grinding was taken as a fundamental process inside the proposed Nano Particle Synthesizer (NPS). Parameters such as speed of the grinding wheel, feed rate and coolant feed rate could be used for fixing the dimension and specification of our nano particles synthesizing unit. After Passing through the NPS, particles of micro and nanoparticles were collected in glass plate and characterized using Scanning Electron Microscope (SEM) to confirm the size and shape of nano particles. This method could be employed as an alternative method to High Energy Ball Milling for producing high pressure and high temperature that favors the synthesis of nano particles in specific shape and size.***

Keywords: ***nano particle, synthesis, surface grinding, mechanical route.***

I. INTRODUCTION

Nanoparticle production is of high demand, Ball milling is widely used in production of large quantities of nanoparticles [1-3]. Though ball milling technique is extensively studied several other mechanical machining techniques exist that favours the production of nanoparticle. Often mechanical route focus on synthesizing nanoparticles where the size is of prime importance and shape is secondary. Based on the surface grinding operation a Nano Particle Synthesizer (NPS) is fabricated and used for crushing micro sized powder materials to nano size. The resultant samples contain particles with size up to 100nm were observed using Scanning Electron Microscope(SEM).Different materials such as Carbon , Alumnium, Zinc Oxide were taken as coarse particles and converted to nano particles using NPS and their corresponding sizes were analyzed using SEM.

II. REVIEW OF LITERATURE

Nanoparticle synthesis using organic [4] and chemical route has been extensively studied. In case of Mechanical route "High energy Ball Milling" and "Mechanical Alloying" were widely employed for synthesis of nanoparticles. Techniques such as Mechanical Exfoliation of graphite into graphene reveal that other mechanical methods need to be given importance. Carbon nano particle structures such as C_{60} and Carbon Nano Tube (CNT) require very high temperature and pressure for producing spherical or cylindrical structure [5]. Such kind of high pressure and temperature could be produced using Surface grinding method within a short span of time. Iron alumina nanocomposite particles were synthesized using ball milling [6]. Similarly ZnO nano particles were synthesized using Reactive Ball Milling [7].

This work focus on other Mechanical machining methods such as surface grinding for synthesis of C, Fe_2O_3, Al, ZnO nanoparticle.

III. EXPERIMENTAL SETUP

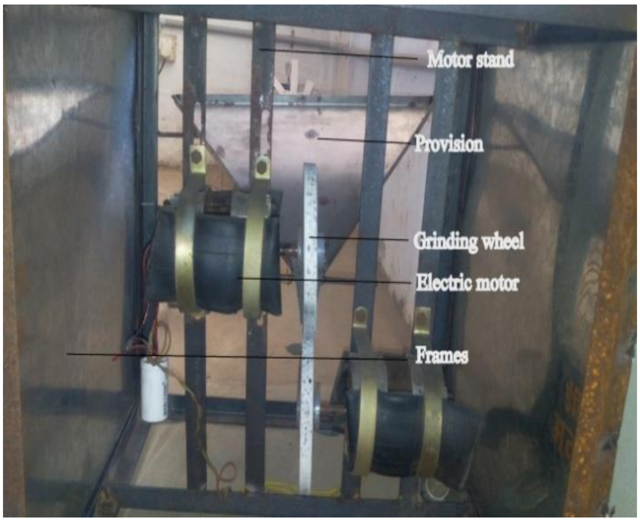

Fig. 1 Nano Particle Synthesizer (NPS) Assembly

The above Fig.1 shows the different parts involved in the Assembly of NPS. Electric motor with a speed of 3000 rpm is attached adjacently facing each other and a narrow thin gap of 0.5 to 1mm has been maintained between two grinding wheel as shown in below Fig. 2. Steel frame has been utilized to assemble the motors

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* Correspondence Author
N. Shivakumar*, Department of Mechanical Engineering, Periyar Maniammai Institute of Science & Technology, Vallam, Thanjavur, India. Email: nanoshivam@gmail.com
Dr. T. Ramesh, Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli, India. Email: tramesh@nitt.edu
Dr. Srividhya P. K., Department of Mechanical Engineering, Periyar Maniammai Institute of Science & Technology, Vallam, Thanjavur, India. Email: srividya.aravazhi@gmail.com
A. Pugazhenthi, Department of Mechanical Engineering, Periyar Maniammai Institute of Science & Technology, Vallam, Thanjavur, India. Email: aspugazh@gmail.com
S. P. Manikandan, Department of Mechanical Engineering, Periyar Maniammai Institute of Science & Technology, Vallam, Thanjavur, India. Email: spmanikannu@gmail.com

Fig. 2 Surface Grinding of particles

A slant triangular steel plate has been assembled on one side of the NPS to supply micro sized powder materials. The micro sized powders will get stuck between two grinding wheels which are running at 3000rpm. Particles were crushed when two grinding wheels were rotated opposite to each other. As a result of friction between grinding wheels and micro sized material the temperature as well as pressure were increased multifold as shown in the Fig. 2. It is proposed that NPS could be used to achieve rapid increase of pressure and temperature within short span of time (say Few microseconds) in synthesizing nano particles. Wheel alignment in conventional surface grinding machine and Nano Particle synthesizer is show in the below Fig. 3a and 3b.

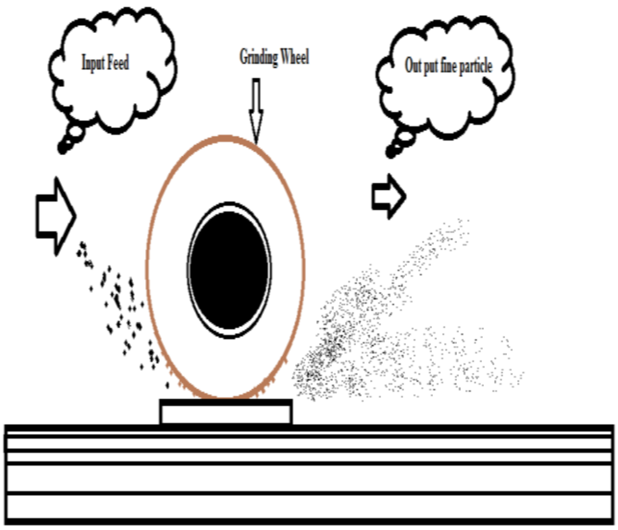

Fig. 3a Arrangement of grinding wheel in surface grinding machine

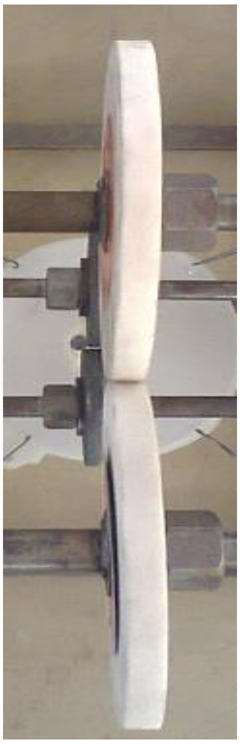

Fig. 3b Arrangement of grinding wheel in NPS

IV. SURFACE GRINDING

A. Sample Before Surface Grinding

C, ZnO, Al, Fe samples were separately fed through NPS. Samples before surface grinding process are shown in the below Fig. 4 and Fig. 5.

Fig. 4 Carbon, Iron oxide samples before surface grinding

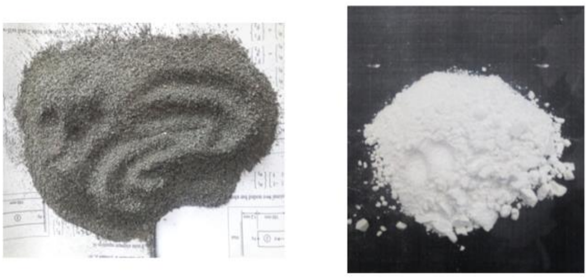

Fig. 5 Al, ZnO samples before surface grinding.

B. Sample After Surface Grinding

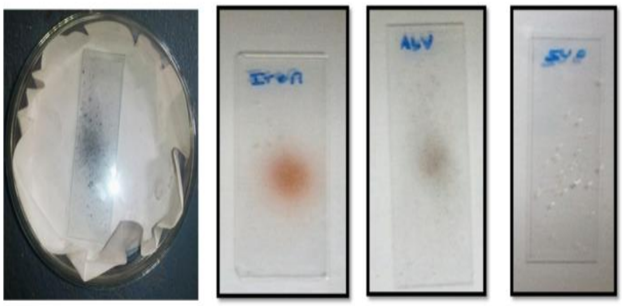

Fig. 6 Carbon, Iron oxide, Al, ZnO sample after surface grinding

Samples after surface grinding process are shown in the above Fig. 5

V. CHARACTERIZATION RESULTS

The samples after surface grinding were imaged under Scanning electron Microscope (SEM).

1. Carbon

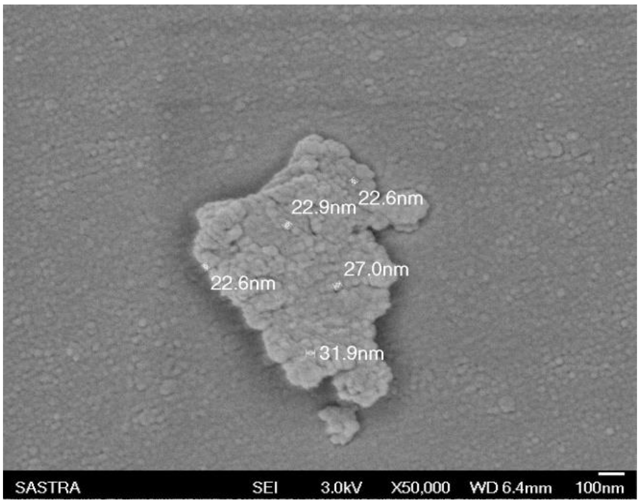

Fig. 7 SEM image of Carbon sample

Carbon nano particles in the size range of 20 to 30nm were observed in SEM analysis as shown in the above Fig.7.

2. Iron oxide

Fig. 8 Iron oxide SEM image sample 1

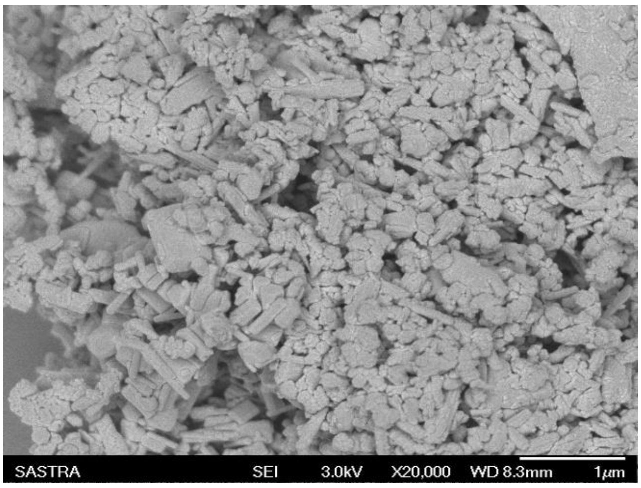

Fig. 9 Iron oxide SEM image sample 2

Fig 8 shows iron oxide sample regions with few surface ground regions. Fig. 9 shows several regions of highly surface ground iron oxide with particles in the size range of 10 to 100nm.This proves that method of surface grinding could yield nano particles from macro particles.

3. Aluminium

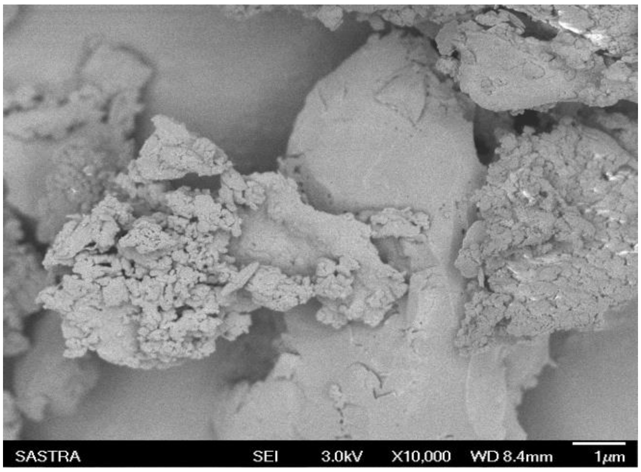

Fig. 10 Aluminium SEM image sample 1

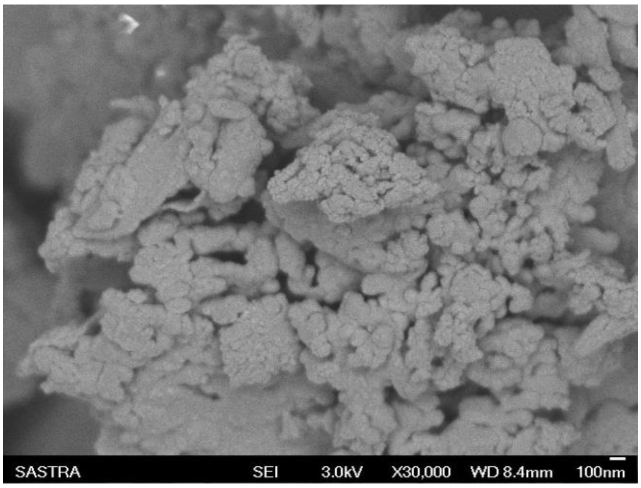

Fig. 11 Aluminium SEM image sample 2

Both Fig. 10 and 11 show powdery regions with Al particles in the size range less than 100nm.

4. Zinc Oxide

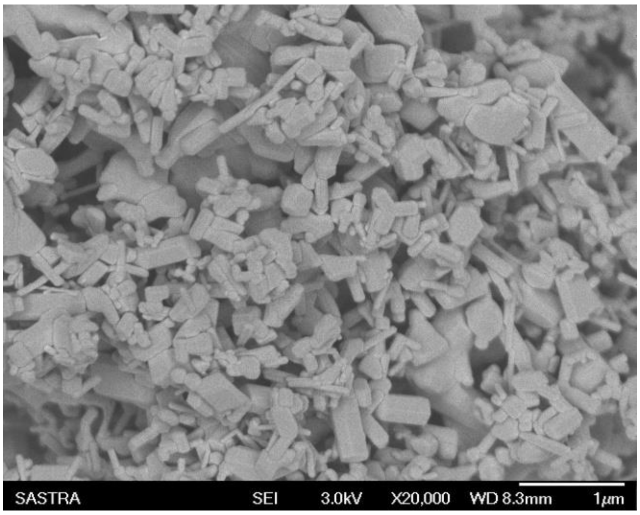

Fig. 12 ZnO SEM image sample 1

SEM images of Zn O reveals that surface ground particles with size range of 50 to 100nm as shown in Fig. 12 and Fig. 13.

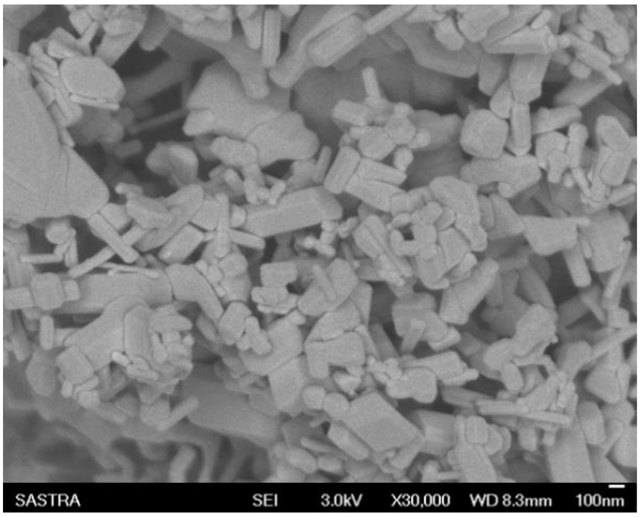

Fig. 13 ZnO SEM image sample 2

VI. CONCLUSION

Nano particle synthesis using mechanical route such as Ball Milling was extensively explored. This work suggests a novel method of nanoparticle synthesis using "surface grinding" phenomenon. SEM images of analyzed samples were proved that this method could yield nano particles in the size range of 20nm to 100nm.

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AUTHORS PROFILE

Mr. N. Shivakumar is an Assistant Professor in Mechanical Engineering with 8+ years of experience in teaching. He holds a Masters Degreein Nanotechnology and Bachelors in Mechanical Engineering. He is interested in nanomachine design and optimization using Quantum Algorithms. He strongly believes that nanomachine could revolutionize the world upside down. He worked for the creation of nanolinux which integrates opensource resources related to nanotechnology.

Dr. T. Ramesh is an Associate Professor in Mechanical Engineering Department from National Institute of science and Technology (NIT,Trichy). He has experience of more than 17+ years, His areas of research interest include: Metallurgy, MEMS, FEM, CFD. He has published more than 15 articles in peer reviewed journals also co authored a book titled "Introduction to finite elements in engineering" .

Dr. P. K. Srividhya is an outstanding Academician, Administrator and a Researcher with 25+ years of Experience. A Professor in Mechanical Engineering, She has guided Scholars across the world and was Crowned with many awards, publications and funded Projects to her credit. Her areas of research interest include: Biomass gasification and Pyrolysis, Solar Thermal and Photovoltaic applications, Manufacturing and Nanomaterials.

Mr. A. Pugazhenthi, is an Assistant Professor in Mechanical Engineering with 20+ years of experience, in teaching. He holds a MastersDegree in Nanotechnology and Bachelors in Mechanical Engineering. His areas of research interest include: Solar Thermal Systems, Nanomaterials and Finite Element Analysis.

Mr. S. P. Manikandan is an Assistant Professor in Mechanical Engineering Department at Periyar Maniammai Institute of Science and technology with 8+ years of experience in teaching. His Areas of research interest include: MEMS, nanotechnology.