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Design and Construction of Metal Sheet Cost Effective Combustion Chamber with Furnace for Synthesis of Luminescent Materials

S.P.Hargunani^{1*}, R.M.Chavan¹, R.P.Sonekar¹, G.A. Aghalte²

¹Department of Physics, G. S. Science, Arts & Commerce College. Khamgaon, India

²Lokmanya Tilak Mahavidyalay, Wani. Dist: Yavatmal, India

ABSTRACT: Designing of the furnace and chamber as per the specific requirements is always a challenging work. For the synthesis of materials various techniques are adopted. Easier and chipper yet efficient technique is important and innovative work. In this view the paper exhibits the fabrication of combustion chamber with technical details at reduced cost. The specific requirement of such a chamber in combustion synthesis is justified.

KEYWORDS:-Solution combustion, Furnace, Combustion chamber, borate phosphor, luminescent materials

I. INTRODUCTION

Synthesis of luminescent materials has received utmost attention of front lineresearchers.[1] Luminescent materials are very important in view of their applications indiverse fields. Major applications are in display devices and lighting.[2,3,4] Phosphorsconsistofhostandactivators.Sometimesenergytransferagentsarenecessary.[5]Generally rare earths are known to be efficient activators. The synthesis of phosphors isnotonlycrucialbutalsocritical.The majority of phosphors' chemical formulas may lead one to believe that because the host materials are well-known, the synthesis of luminescent materials should be straightforward. However, the actual synthesis of phosphors with the desired properties can be quite challenging. The difficulties arise because it is necessary to take into account a number of factors, such as the cost of production, batch homogeneity and reproducibility, specific grain size and morphology appropriate for the application, and the incorporation of activators at the desired sites.[6,7]

Lower reaction temperatures are not possible with the majority of conventional methods. Obtaining the reactants in their smallest form can sometimes be used to reach these temperatures. The most obvious advantage of this method is that it does not require the use of refractory muffles, insulators, or crucible materials because the heat is supplied "within" (with the exception of that required to start the reaction)[8]. This is an inventive method of lowering the operating temperature. Volumetric SHGS, also known as combustion synthesis, have recently been described [9.10].In the combustion synthesis, exothermic reactions between fuels like urea and metal nitrates are utilized. The ratio of nitrate to fuel can be changed to change the temperature that is produced. When this ratio is such that the oxidizing and reducing valencies of the fuel and oxidizers are balanced, the highest temperatures are reached [11].

During the combustion synthesis, the exothermic reaction between the fuels and oxidizers produces a variety of gases, including water vapor. There are times when the gases are harmful and toxic. Utilizing a facility to remove such gases from the reaction environment within a predetermined amount of time becomes extremely important. A suitable design as the requirement is thus inevitable. This paperdeals with the fabrication of low cost combustion chamber along with the furnace ofrequired temperature profile.

II. EXPERIMENTAL

Fabrication of Chamber

Table 1 displays the requirements and specifications for the Chamber, and the labelled diagram in figure 1 is used for fabrication. The volume of the chamber is the only important factor here. The sample size for the synthesis of luminescent materials must always be less than 10 gm. It's possible that a lot of gases will be released. Because the entire combustion process is finished in two to three minutes, the gases had to be removed within this time frame.Figure 4. Shows the fabricated chamber used for combustion synthesis

Fabrication of Muffle Furnace

Table 2 displays the requirements and their specifications for the Muffle Furnace. The china basin, crucible, or beaker that is used to start the combustion should fit in the high temperature zone of the furnace. This is the specific zone height. The vertical temperature gradient should be constant and the radial temperature gradient should be negligible. A furnace's vertical cross section is depicted in the diagram. The worked-out specifics are arranged in a systematic list. Fabricated furnace is shown in figure 4. The synthesized powder sample in fabricated furnace is given in figure 5.

Temperature Profile of Furnace The relation between heat generated, time, resistance, current through wire is $H \mu I^2 r t$. "The total resistance of the kanthal wire is 128.8 ohm. The maximum temperature of Furnace that could be maintained is about 1000°C. The temperature profile of furnace in terms of its radial and vertical profiles" is shown in fig.3.

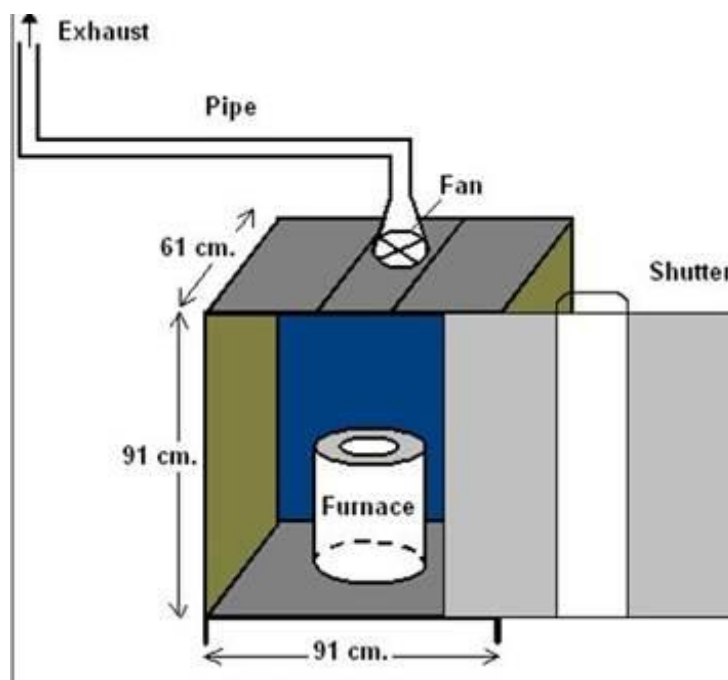


Fig. 1 Combustion Chamber

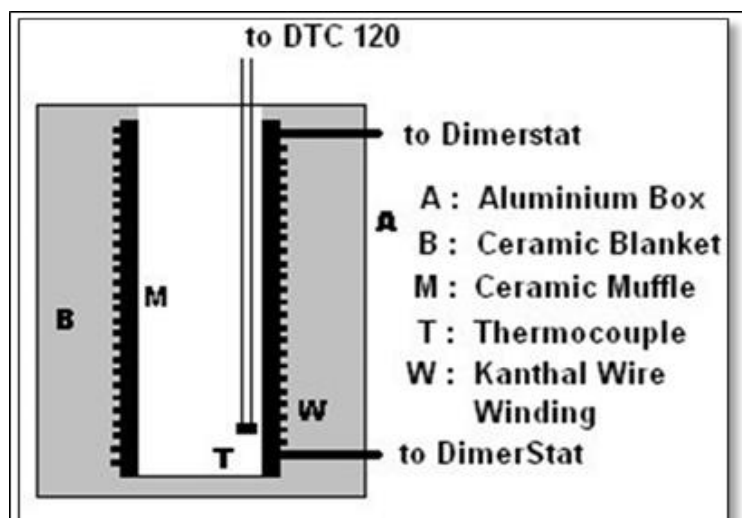


Fig. 2 Cross View Muffle Furnace

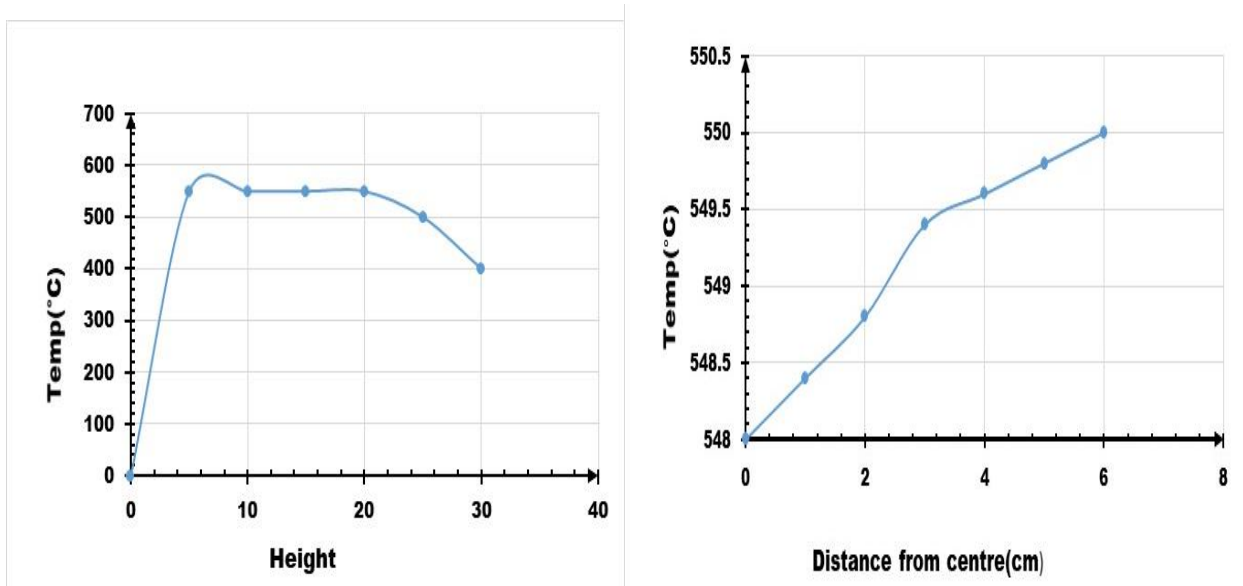


Figure 3 Temperature profile of Furnace



Figure 4. Fabricated chamber & furnace used for combustion synthesis.



Figure 5. Powder samples synthesized in furnace and chamber.

III. APPLICATIONS

The Combustion chamber is used for the synthesis of various luminescent materials. It can also be used for acid distillation. Some of the rare earth doped luminescent materials have been prepared in this chamber. The PL findings and the estimated volumes of various gases during the synthesis of few luminescent materials are shown are tabulated in Table3. The PL intensities agree well with literature.

Table1.Details of Chamber

S.N.	Item	Ratings/ Specifications	Justification	Cost
1.	SteelAngles	2mmX 2.5cmX 10m.	Fortherigidsupport.	Rs.500/-
2.	SteelPlates	2mmX 2.5cmX 5m.		Rs.400/-
3.	AsbestosSheets	4mm X 182 cm X 122cmX2pc.	Insulation from theoutsideenvironment	Rs.400/-
4.	ExhaustPipe	PVC,8cmD,2m	Forguided outlet	Rs.300/-
5.	ExhaustFan	Time Fresh Air Fan;Sweep 150mm,rpm1400,Output1W,Max. Current0.8A.	SpecificRPMforefficien texhaust	Rs.1500/-
6.	SteelHopper	18cmDX 20cmh		Rs.100/-
7.	Miscellaneous	Rivets,Bolts,GlassPlate,etc.		Rs.200/-
Total				Rs3400/-

Table2.Details of Muffle Furnace

S.N.	Item	Ratings/Specifications	Cost
1.	Ceramic (KumarManufacturersKolkata) Muffle	Max.Temp. 1200 °CHeight30cm.InnerDia.13cm.OuterDi a.15cm.	Rs. 1500/-
2.	KanthalWire(67%Fe,25% Cr,5%Al,3%Co)	22SWG, 5 Amps. 20m.	Rs. 1300/-
3.	AluminumCylindricalBox	28cmDX 33cm	Rs.1000/-
4.	CeramicBlanket	4cmX1mX1m	Rs.500/-
5.	Miscellaneous	Connector,InsulatingBeads,Connecting Wires,etc	Rs.100/-
6.	DimmerStat(REAgronics,Mumbai)	8Amps.,270Volt,ClosedType,Aircool ed	Rs.1650/-
7.	TempController/IndicatorDTC- 120(Indotherm)	3½Digit	Rs.1550/-
8.	Thermocouple AlumelChromel(Fabricated)	22 SWG, 18cm.	Rs.50/-
Total			Rs.7750/-

Table 3. PL Results of Luminescent Materials.

S.N.	Luminescent Material	Emission Wavelength	Relative Intensity	Total moles of the gases per mole of product	Application
1.	CeGdTbMgB ₅ O ₁₀	540.6nm	527	75	CFL Green component
2.	CeGdTbMgB ₅ O ₁₀ :Mn	618nm	45	75	Tricolour Red component
3.	Y ₂ O ₃ :Eu	610.8nm	165	8	Red component in CTV, PDP, CFL

IV. DISCUSSION

The low cost fabricated combustion chamber works very well for the synthesis of almost all luminescent materials. The chamber exhausts all the gases like CO₂, NO₂, CO, Cl₂, etc, toxic gases ejected during the combustion process. Thus the chamber is eco- friendly. The same chamber can be used for acid distillation. This combustion chamber has been used by the researchers not only from our group but also from other departments and those from nearby university as well. The price of commercially available Labconco Vertical clean bench combustion chamber marketed in India by M/S Cole-Parmer, Ultra pure Scientific, Mumbai is \$ 4380. The price of local make commercially available combustion chamber is not less than Rs. 35000/-. The cost of our combustion chamber is Rs. 11250/-.

V. CONCLUSIONS

The furnace and chamber were found to be adequate for the combustion-based synthesis of luminescent materials. The benefit of this technique is that the course of amalgamation is completely finished in no less than few moments the boundaries viz. incorporation of the activators at the desired locations, removal of undesirable impurities, application-appropriate grain size and morphology, production cost, batch homogeneity and reproducibility, etc. are realized. On the other hand, the design is straightforward, easy to follow, and chipper, and it could be made locally.

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BIOGRAPHY

Author-1 earned his B.Sc., M.Sc., and Ph.D. in physical science from SGBAU in 1997, 2000, and 2022, respectively. He is currently working as Associate Professor in Department of Physics at G S C Khamgaon, since 2003. He is Life member of AUPTA and a life member of the IAPTA. Research Spectrum since 2015. He has published more than 15 research papers in reputed international journals including Thomson Reuters (SCI & Web of Science) and conferences including IEEE and it's also available online. His main research work focuses on Photoluminescence materials & physics education research. He has 19 years of teaching experience and 10 years of research experience.



Author-2 earned his B.Sc. and M.Sc. in physical science from Post Graduate Teaching Department of Physics, RashtrasantTukdojiMaharaj Nagpur University, Nagpur in 2006 and 2008 respectively. He is currently working as an Assistant Professor in Department of Physics from G. S. Science, Arts and Commerce College, Khamgaon Dist. Buldhana (M.S.) since 2017. His main research work focuses on Photoluminescence Materials. He has 05 years of teaching experience.



Author-3 earned his B.Sc. and M.Sc. in physical science from Post Graduate Teaching Department of Physics, RashtrasantTukdojiMaharaj Nagpur University, Nagpur in 1987 and 1989 respectively and Ph.D. in physical science from SGBAU in 2008. He is recognized Ph. D. Supervisor of S G B Amravati University Amravati in Physics in the Faculty of Science (Wide Order No. SGBAU/PhD/70/2010 dated 08 – 02 – 2010. He is currently working as Professor in Department of Physical Science from Department of Physics, G. S. Science, Arts and Commerce College, Khamgaon Dist. Buldhana (M.S.) since 2010. He is Life member of AUPTA and a life member of the IAPTA. He has published more than 50 research papers in reputed international journals and conferences including IEEE and it's also available online. His main research work focuses on Data Mini Photoluminescence materials. He has 29 years of teaching experience and 12 years of research experience.



Author-4 earned his B. Sc., M.Sc. and Ph.D. in physical science from SGBAU in 1990, 1994 and 2008 respectively. He is currently working as Professor in Department of Physics from LokmanyaTilak Science College, Wani Dist. Yavatmal since 1996. He has published more than 10 research papers in reputed international journals and conferences and it's also available online. His main research work focuses on Photoluminescence materials. He has 27 years of teaching experience and 12 years of research experience.





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