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Use of Colliery Shale for Refractory Lining of Torpedo Ladles

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Abstract:*Torpedo ladle is mainly used for transporting hot metal from BF to steel melting shop. Sometimes pretreatment of hot metal is also carried out in torpedo ladle.*
Torpedo ladles have been conventionally lined with chamotte bricks. Since the 1980s, molten iron preliminary processing has become popular to remove impurities from the metal by means of dephospholization, desulfurization, or desiliconization.
However, under such conditions, the conventional chamotte brick linings, having shown severe deterioration in their life span, were replaced with Al2O3-SiC-C bricks, which are far superior in terms of corrosion resistance and thermal spalling resistance.
During coal excavation in collieries on the aftermath of first blasting, the first layer which comes out consists of unwanted materials. Upon the second blasting, the material that comes out is again a waste generated during the mining which is known as colliery shale (CS), which contains mainly Silica, Alumina, Carbon and other impurities such as Ferrous Oxides, Calcium Oxides, Sodium Oxides, volatiles etc in very negligible amounts. This material chiefly contains about 20~25% Carbon, 19~24%
Alumina, 40~45% Silica. Upon Carbothermal reduction of this material produces mainly Silicon-Carbide and Alumina in-situ at a low temperature. Preliminary investigation conducted by heating this material in inert atmosphere in a conventional heat treatment furnace has shown that, superior quality Silicon Carbide and Alumina-in situ are produced at 1100~1300^{0}C i.e. both the phases grow simultaneously. Thus, this provides a method for economic production of in-situ Alumina-Silicon carbide powder at a very low cost unlike the conventional process requiring high temperature (Temperature > 1600^{0}C) for production. Utilizing this material, it is aimed to produce refractory material to be used for lining of torpedo Ladle.
Key words: *Colliery Shale, Refractory Lining, Torpedo Ladle.*

The inner lining of the Torpedo car is either relined or repaired. The relining process consists of replacing the worn bricks with new bricks. The intermediate repair is done every 100 to 160 heats. The repair process consists of remolding of the unshaped refractories in the mouth, replacement of worn bricks with new one, padding of worn lining with unshaped refractory.
FeO and CaO content in the slag increased causing the slag to react with SiO2 and Al2O3 in the Chamotte brick to form low melting point products such as 2FeO SiO2 (Faylite melting Pt 1210Deg.) etc. As a counter measure a new type of Brick based on Al2O3-SiC-C system was developed by increasing the Al2O3 content to increase the corrosion resistance.

a) Brief description of the subject: including work done in India and elsewhere:

Converting the waste product of any process in to any useful product for the benefit of the society and the mankind at large is a commendable work. The present work is along similar line. Colliery shale is a waste from the coal mines. This has three major constituents such as SiO_2, Al_2O_3 and C. By suitable treatment at high temperature this material can be converted to useful in situ ceramic composite powder such as SiC- Al_2O_3-C and Al_2O_3-SiO_2-SiC [13]. These powders can be further used for preparation of refractory lining material for Torpedo Ladle.
The Aluminium-Colliery Shale composite developed in the laboratory showed superior mechanical properties in comparison to Al- Al_2O_3 composite. Aluminium-CS composite also showed superior abrasion resistance compared to Al- Al_2O_3 composite. Metal matrix composite has been successfully produced by addition of Silicon carbide or Large periodical repairs are done after 1- to 25 intermediate repairs. Before 1983 high grade chamotte bricks were used to line the torpedo cars. However because of FeO addition and hot metal treatment in the car, Alumina singly or in combination. Combined addition can produce metal matrix composite with superior combination of physico-mechanical properties

Advantage of Colliery Shale are the following
1. Low Cost

2. Valuable ingredients such as Alumina, Silica and Carbon.
3. The composite material Al2O3-SiC- C can be produced at a lower temperature of 1100 to 1300^{0}C unlike conventional ceramic composites requiring 1600^{0}C.
4. In the product in-situ-form all the phases grow simultaneously resulting in superior Quality.

From the literature survey it was evident, efforts in the past were made to produce Aluminium Metal Matrix Composite (AMMC) with the addition of Al2O3, SiC, C etc, and further development works are underway by researchers to produce reinforcing ceramics and ceramic matrix composite. Earlier R & D were focused on preparation of Aluminium Metal Matrix Composite (AMMC) using Aluminium as base metal and reinforcing ceramic using combination of Silicon carbide and carbon [1-4].

c) Objectives:

1. Manufacture of a number of samples of in-situ Alumina-Silicon Carbide composite powder from colliery Shale (Colliery Mine's waste) at low cost using conventional heat treatment furnace at sufficiently low temperature.
2. Use these powders to manufacture AL2O3-SiC-C Bricks.
3. Assessment of physico-Mechanical properties of the Bricks.
4. Test its application in Steel Industries and other related areas.

- Use of in situ Alumina-Silicon Carbide for making the Brics.

(f) Institution if any already engaged in similar work and linkage proposed / established with them: No
(g) Minimum required tenure of the project: 3 Years
(h) Practical relevance / utility of the project:

d) Detailed methodology

- Production of Aluminium-Silicon Carbide from colliery Shale in a conventional heat treatment furnace at a lower temperature
- Samples from following coalfields will be used:

1. Western Coalfields Limited, Nagpur, Maharashtra.
2. TataSteel Coalfields, Jharia, Girdih etc Jharkhand,
3. Mahanadi Coalfields Limited, Bharatpur, Odisha

- Analysis of the product, its chemistry and X-Ray analysis.
- Kinetic studies for the formation of in situ Alumina-Silicon Carbide from colliery shale

1. Develop useful materials out of waste
2. Develop materials for important applications such as Aerospace etc.

(i) Expected outcome of the project:

1. Economic production of in situ Alumina- Silicon Carbide composites powder,
2. Production of Refractory Bricks using the Composites.
3. Patents
4. Research publications in International journals.

(j) Agencies which can utilize the results of the project:

1. Steel industries
2. Ceramic Industries

(k) Component wise justification of the costing of the project.
(l) Cost benefits analysis in terms of physical outputs and mining benefits: Further this Alumina-Silicon carbide composite is utilized inmanufacturing refractory bricks for use in steel industries.

(m) Statement of originality and certification on no duplication with existing work / ongoing projects.

(n) PERT chart for action plan with milestones for project period.

An economic process to extract Alumina- Silicon carbide composite from the colliery wastes to be established and standardized.

The project submitted herewith is based on the original work of the investigators. We certify that the innovation in this project is our wealth and all the inventions are solely based on the investigations by the investigators.

Mechanism for monitoring progress of the project.

Achievable Targets	1-2 months	3-4 months	5-6 months	7-8 months	9-10 months	11-12 months	13-19 months	20-24 months	25-32 months	33-36 months
1.Collection of raw material(colliery shale from different mines	→									
2.Characterization of raw material		→								
3.Studies on reaction kinetics			→							
4.Preparation of in-situ Al_2O_3-SiC composite from colliery shale using conventional heat treatment furnace.				→						
5.Property evaluation of in-situ Al_2O_3-SiC composite					→					
6.Preparation of summary 0f results						→				
7. Preparation of Refractory Bricks.							→			
8. Characterization of the refractory bricks.								→		
9. Functional test of the Refractory bricks and testing it in Torpedo ladle.									→	
10. Report preparation										→

Facilities (Equipments / Instruments) required at institution(s) / Organisation(s) for carrying out the project:

Sl No.	Name of Equipment
1	Specimen Leveller (For metallographic specimen)
2	Endless belt Grinder
3	Double disc polishing machine
4	Sand Rammer + Attachment
5	Universal Strength Machine + Attachments
6	Electric Resistance-Bottom Pouring Melting Muffle Furnace Max. Temp- 1100 ^{0}C -working up to 1000 ^{0}C, 3 kg capacity & spares
7	Horizontal shape chamber type muffle furnace, max temp. 1050 ^{0}C – working up to 1000 ^{0}C
8	Elect. Resistance pit furnace max temp. 1050 ^{0}C – working up to 1000 ^{0}C
9	Muffle furnace (230V, single phase or 440V 3 phase AC supply) max temp. 1100 ^{0}C – working up to 1050 ^{0}C
10	Metallurgical Microscope having magnification 100 X to 1000 X
11	Horizontal shape chamber type muffle furnace, 150 x 150 x 250-300 mm, max temp. 1600 ^{0}C – working

	up to 1550 ^{0}C, thyristorised fully automatic control etc.
12	ESSAE Electronic precision weighing balance, model FB200, capacity 200 gm
13	MS Moulds
14	Tube furnace dia. 9 cm x 100 cm (R & D project work)
15	Rockwell cum Brinell Hardness tester with accessories for measuring hardness in Rockwell scale
16	Universal Testing Machine (Remodel Mechatronics)
17	Double disc polishing m/c
18	Hot Mounting Press
19	Torsion Testing m/c
20	Impact Testing m/c
21	Impact Testing m/c(Digital)
22	Erichsen cupping m/c
23	Vertical shape pit type furnace
24	Electronic tensile testing m/c (Tensometer)
25	Hot air oven
26	Ultrasonic cleaner
27	Image analyzer
28	Wear testing m/c

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