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An Overview on Designing an Environmental Friendly Electrode Manufacturing Process (EFEMP)

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ABSTRACT

In The manufacturing of Carbon Graphite Electrodes and anodes its efficiency and consumption could be too much important factor so all the steps of production process of high volatile electrode considering design technology must be. Because of the limitation in designing in (EFEMP) Eco friendly Electrode manufacturing process of electrodes some the major quality and environment effects has impacted the technology. The baking technology is a conventional type and it was initiated by Germany in electrode manufacturing technology (EMT) but now a day's it's a traditional method of baking process. the new and advanced technology in the electrode manufacture are car bottom furnaces, ring pit furnace and tunnel kiln transportation furnace are playing most important role in the manufacturing of electrodes and anodes and these process are Re-baking process. Its necessary requirement to adopt the technology implementation and adaptation of new designs techniques advancement in graphite electrodes and anodes manufacturing even to maintain the quality and effectiveness of the product. so the design optimization in eco friendly re-baking process ERP is too much important in advancement for quality, cost, in effectiveness with less zero pollution.

Keywords : EFEPP, Ring Pit, Car Bottom, EMT, Tunnel Kiln Furnace, ERP.

I. INTRODUCTION

Aluminium, the third most prevalent element in the Earth's crust, may be found in anything from foil to the fuselage of a plane flying across the world. Aluminum must first be smelted and extracted using the Hall–Héroult process before it can be utilized to make a wide range of products. Green anodes are used to extract aluminum from bauxite, which is an aluminum-rich rock.Green anodes must have a low reactivity as well as good strength and conductivity to be useful in the Hall–Héroult process. The anodes must be baked to get these properties.[1] In the aluminum industry, the reduction cell consumes about 0.4 ton of carbon anodes for every ton of aluminum produced.[2] The electrodes (particularly the anode) are the primary consumables in the aluminum electrolytic process, accounting for nearly 15% to 25% of the entire cost of aluminum production.[3] Green (unbaked) anodes should be baked (heat-treated) to obtain the mechanical, thermal, and electrical properties that make them suitable for use as anodes in the aluminum production.[4] This process takes a long time (240 to 360 h) and consumes a large quantity of energy via the fuel injected. The energy consumption depends on the heating rate, the maximum anode baking temperature, the furnace design, and the operating conditions. For efficient aluminum production, the anode baking process must be optimized with respect to the

production cost, final anode quality and environmental emissions.[5]

Anodes are manufactured from calcined coke, butt, and recycled anode particles, with pitch serving as a binder. Green anodes are baked in massive furnaces to achieve particular density, mechanical strength, and electrical conductivity qualities. Baking is a critical and costly stage in the manufacturing of carbon anodes. The anode quality necessary is provided by the furnace's correct operation..[6] Furthermore, the anode baking process is known to have a significant impact on anode behaviour during aluminium electrolysis. To bake anode, graphite electrode, and cathode block, there are three types of furnaces: car bottom, rotary hearth, and pit type or ring type. The open-top or closed-type ring furnace is the most common form of anode baking furnace used in the anode business. The anodes are placed in trenches and protected with packing and insulation. The combustion process inside the flues, which is insignificantly different non open-top and closed-type flues, indirectly controls the anode baking process. [7]

Graphite Electrode (GE) is a high-value needle coke-based raw material that is largely utilized to improve the production of fine surface finishes in electric arc furnaces (EAF) for steelmaking, mining electric furnaces for smelting ferrous alloys, and electric discharge machining sectors. In a nutshell, GE is a critical component in the production of steel in electric arc furnaces (EAF).The key raw material utilized in GE production is needle coke, which is critical to the industry's expansion. With increased industrial activity across numerous sectors such as agriculture, manufacturing, mining, trading, and construction, demand for graphite electrode (GE) continues to rise. In the steel industry, graphite electrodes are predominantly utilized in Electric Arc Furnaces (EAF) and Ladle furnaces. So far, electrode consumption has accounted for only 2-3 percent of the total cost of steel production.[8]

1.1 Raw Material for Graphite electrode

Graphite electrodes and anode rods are made from petroleum coke after it is mixed with coal tar pitch. They are then extruded and shaped, baked to carbonize the binder (pitch), and finally graphitized by heating it to temperatures approaching 3000 °C, at which the carbon atoms arrange into graphite

1.1.1 (Calcinated Petroleum coke) CPC:-

The too important and the most significant material is calcinated petroleum coke, which can have a variety of structures quality, from distillation fluid coke that is almost isotropic to great anisotropic needle pitcher. Because of its structured qualities , Great an isotropicity needle Pitcher is very useful to produced high-strength electrodes for use in electric arc furnaces for steel manufactures where a very high level of, thermoelectric and thermo mechanical load-bearing capability is required. The delayed Re-Baking process, which is a mild, slow carbonization process of le t over from cruding distillation, A practical product all of the cpc.

Binder coke is a special type of coke used as a binder because of high degree of graphitization. Due to the strong strength for parallel practical of its turbo static layer structure and a distinctive grainuals with specifically physical structures.

Fig.1 Calcinated Petrolium Coke.

1.1.2 Binding agent needle cock (almost one fourth in total):-

The solid particles are acclimatized with each other with the help of Binder Needle coke pitch.As a result converts into plasticity for required deformation and reshaping due to its higher damping quality.

Fig. 2 Needle Cock

1.1.3 Coal tar pitcher:-

By Product of distillation of petroleum production known as coal tar pitcher.

It's a hydrocarbon and has a diverse ambrosial, chemical shape. Because of its top transformation and replacement and liquidized halocarbons band, earlier it has apparent effect hexadic netting shape of graphitization; hence further the forming of correct graphite wing amid graphitization. Binder Pitcher substantiates to be the beneficial. It is the distillation vestige of petroleum production.

Pitch that has been impregnated is a unique variety that is a solid black substance at ambient temperature. With a lower softening point and lower QI content than Binder Grade pitch, it is made from coal tar processing.

Graphite electrodes are "impregnated" with impregnating pitch to boost electrical conductivity and durability while reducing porosity.

The following features are obtained through processing employing cutting-edge technology and rigorous quality control procedures: low volatile content, high fixed carbon, low ash content, no mesophase, good wettability, and good thermal stability during storage.

Fig.3 Coal Tar Pitcher

Source https://www.epsiloncarbon.com/our-solutions/coal-tar-derivatives

1.2 The Manufacturing Process of Graphite Electrodes

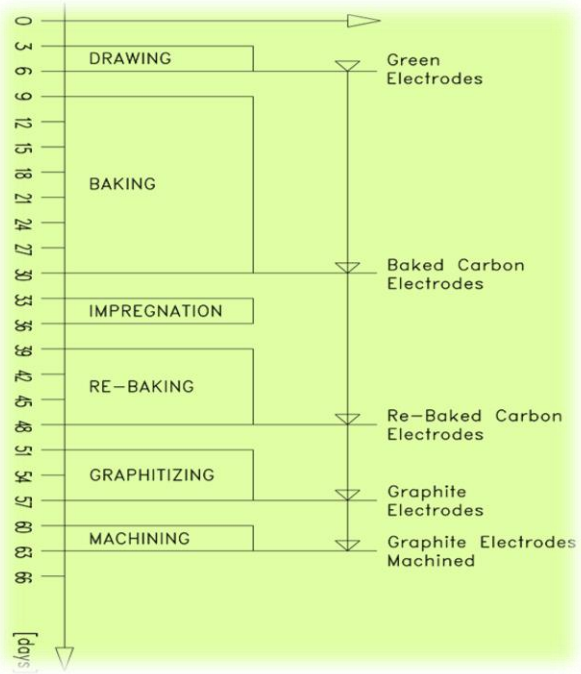

Fig.4 an Environmental Friendly Electrode Manufacturing Process (EFEMP) Production Time Scale

1.2.1 Mixing and Extrusion:-

The calinated petroleum coke is assorted with coal tar pitcher as a binder and other extra materials to made a similarty paste.

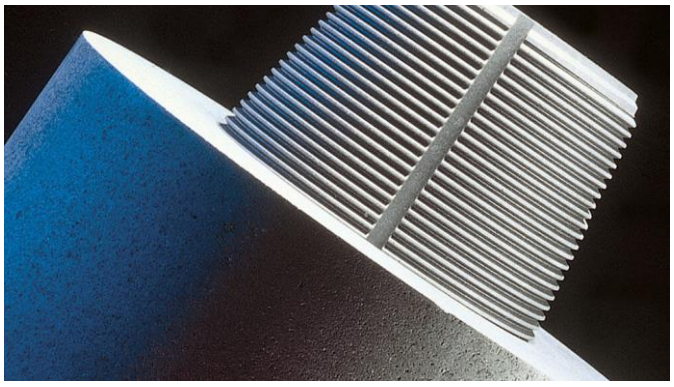

Fig.5 Eirich Pest Product

Source https://www.eirich.com/en/industries/carbon-paste

The paste of uniformity of all raw materials is bring inside the extrusion ram with help of belt conveyor.as per

set die and desired length green electrode extruded by piston from extrusion press.To completed extrusion process from similarity paste should be have viscosity at required 125 dc temperature in it.

1.2.2 Baking:-

In closed or open top ring furnaces, anode baking is done. To stop oxidation by leaking air and mechanical support, the anodes are positioned in pits and enclosed by packing coke. The hot gas flowing in the flues on both sides of the pit comes into indirect contact with the anodes, baking them.

Fig.7 Baking Ring Pit Furnace

https://www.researchgate.net/figure/A-horizontal-anode-baking-furnace-in-operation.

Fig.6 CPC Grain for Baking

There are mainly 4 type of baking furnaces are in use:

1.2.2.1 Conventional type furnace:-

Baking process is an unique process of baking is of conventional type baking for nipples and,

1.2.2.2 RH (Riedhammer) Ring furnace:-

Conventional baking ring pit furnaces for electrodes baking.

The electrodes are filled in a bricks made pit and its filled with the resister grain of cpc from top to bottom of pit and covered by top cover and with help of burner and oil fired nozzles and guns give direct heating inside of pit and its cooling and exhaust maintained with help of exhaust and booster fans burner manifold regulate with help of compressor and ldo pumps.

Temperatures of the all pits maintained up to 800°C,and Electrodes have a density around 1,56 – 1,61 kg/dm3.

1.2.2.3 Car Bottom furnace:-

Fig.8 Re-Baking Car Bottom Furnace

Here the Baked electrodes are re baked inside of furnace horizontally getting indirect heat from furnace combustion chamber and burner manifolds a circulation of heating and coolng maintained with help of heat exchangers, cooling towers and fans and pumps.

1.2.3 Impregnation:-

It's a Process to 25 nalys the generate porosity during baking process and because of residuals gases and moisture

Fig.9 Impregnated Electrode for Re-Baking

The baked electrodes are impregnated under vacuumed in autoclave after preheating with a specific coal tar pitcher at temperature range of 250°C to provide more

density and higher carbon pickup. Overall mechanical strength and thermal conductivity

1.2.4 Re-baking:-

A cocked electrodes are again baked to enhance carbonization pickup for maximum Graphitzation, With help of stainless steel (seggers, cars, and pans).

To avoid the oxidation and to maintain electrode uniformity oxygen and heating and cooling curve maintained as per required process parameters .

Impregnated pitch is required indirect heating around 800 degree centigrade to convert in graphite from carbon after combustion of volatiles thus at that stage Re-Baking has been done and no un burn volatiles remains and the desired density of the electrode has in the range of 1.68 to 1.76 kg/dm^3.

Fig.10 Re-Baking Tunnel Kiln Process

1.2.5 Graphitization:-

An LWG furnace in manufacturing of graphitized electrodes and anodes is the last process to convert Re-Baked coked carbon into graphite at 3300℃ this process is known as Graphitization.

Fig. 11 Graphitization

1.2.6 Product Finishing and Machining Shop (PFMS):-

Graphitized electrodes and anodes are cooled as per cooling cycle time and send for different machining processes; following process were carried out in product finishing process.

Fig.12 Machined Electrode Taped with Nipple
Source https://www.dancarbon.com/graphite-elec

1.2.6.1 Scrapping:-

It is a machining for surface 26analysed26s and removal of unwanted carbon grainuals from electrodes and anodes surfaces.

1.2.6.2 Facing:-

It is a machining of anodes and electrodes faces to removal of extra carbon grianuals .

1.2.6.3 Turning:-

smoothing and removal of extra graphite from electrodes and anodes to maintain desired length as well as required diameter as per standard operating procedures and customer requirements

for example aelectrode having 600 mm of diameter and length of 3000 mm.

1.2.6.4 Boring:-

It's a Centre hole as per given tolerances for making thread and socket for jointing electrode with each other with help of nipple in eaf.

1.2.6.5 Socketing:-it's a process of machining to make nipples and electrode sockets.

Fig.13 Machine Electrode with Socket threads

1.2.6.6.Threading:-it's a process in boring for machining to make threads in electrode.

Fig.14 Machine Electrode with Socket and nipple threads

Source https://www.dancarbon.com/graphite-elec

II. METHODS AND MATERIAL

High-quality calcined needle coke is used to make graphite electrodes. The machine breaks the needle coke, sifts it, and then proportions it to the recipe's specifications. After batching, the raw material is heated and combined with a specific amount of asphalt while being kneaded to create a plastic paste, extruded from the extrusion press as per customer needs and requirements cut in desired shapes, and cooled into a bathing pond then further processed for baked and filled its porosity by impregnation pitched and Re-Baked product as per quality parameters and Electrode Baked 2 times, Once Re-Baked and Impregnated 2 times.

The EB2RB1I2 Coked products are electrified and heated to a temperature of 3300 °C in the graphitized resistance furnace, where the carbon is transformed into graphite after the structure of its atoms is altered to take on a certain crystal form.

https://www.dancarbon.com/q/graphite-electrode

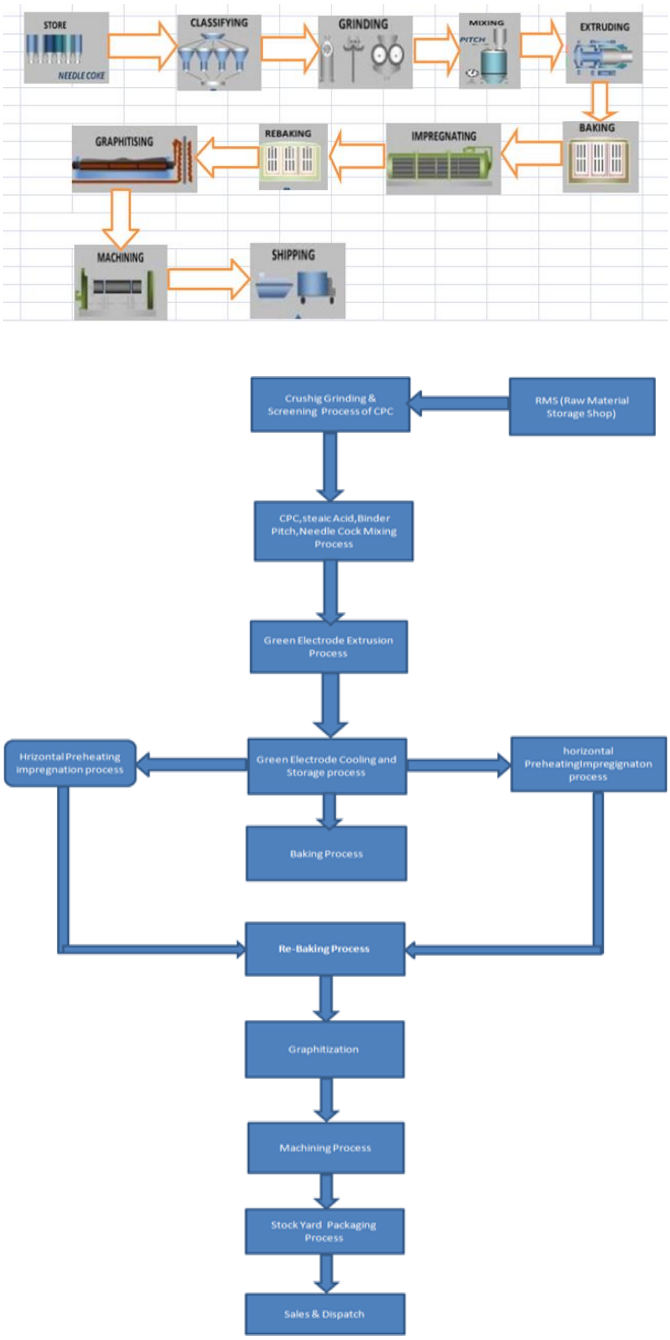

Fig.5 An Overview on Designing an Environmental Friendly Electrode Manufacturing Process (EFEMP)

III. CONCLUSION

After reviewing all the major manufacturing technology and techniques for graphite electrodes and anodes, it is thus seen that Electrodes and anode making employs costly equipment and require far more precision control. But the electrode achieved through this stage contains uniform properties, length, and diameter.

These (ECGEMT) Eco-friendly carbon graphite electrode manufacturing technologies and techniques produced a standard product of Graphitized Electrode (GA) and Graphitized Anode (GA) for EAF electric arc furnaces in steel manufacturing and aluminum manufacturing in the global world.

Graphitized electrodes and anode contain Better thermal and electrical conductivity with low resistivity, thermal sock stability along with precise machining accuracy, according to the quality of Graphitized electrodes classified as Regular Power or General Power Electrode (RP), High Power Electrode (HP), Ultrahigh Power Electrode (UHP), Impregnation Power Graphite Electrode (IP), Special Power Graphite Electrode (SHP) and High-Density Graphite Electrode (HD).

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