OPTIMIZATION OF SODA ASH ENVIRONMENTAL IMPACT USING LCA TOOL

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ABSTRACT

Soda Ash also known as Sodium Carbonate (Na_2CO_3) is an alkali chemical refined from the mineral Trona or naturally occurring Sodium Carbonate- bearing brines, the mineral Nahcolite or manufactured from one of several chemical processes. Soda Ash is mainly produced by Solvay Process also called Ammonia Soda Process. It is having Industrial as well as Domestic application. It is used for the manufacture of Glass, Sodium Salts, Soap, Pulp & Paper, Cellulose and Rayon, Cleaning Compounds, Water Softening Chemicals. Domestic application includes its use as Washing Powder by Laundries and Washerman. Solvay Process requires Fuel, Raw Materials and Utilities. During this production process there are various Emissions and Environmental Impact. Recent technologies and advancements are predominant in reducing this Soda Ash Environment Impact. Current scenario shows that LCA is a very Handy tool which can be used to study and track the current status of Soda Ash Environment Impact. It also helps us in conducting Optimization studies and Reducing the Soda Ash Environment Impact.

Keyword:- *Soda Ash, Solvay Process, Environment Impact, LCA, Optimization*

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1. Soda Ash[1]

Soda ash is the trade name for sodium carbonate, a chemical refined from the mineral trona or sodium-carbonate-bearing brines (both referred to as "natural soda ash") or manufactured from one of several chemical processes (referred to as "synthetic soda ash").

Soda ash, which is one of the most important of all chemical products and is a starting material in producing many other chemicals, is produced in the largest amounts compared with other soda products. It is an essential raw material in glass, chemicals, detergents, and other important industrial products.

1.1 Soda Ash Process[2]

a) Trona and nahcolite based process
b) Nephelinesyenite process
c) Carbonation of caustic soda
d) Solvay process

1.2 Solvay Process[2]

The Solvay process, also called ammonia soda process, uses salt (NaCl) and limestone ($CaCO_3$) as raw materials. Ammonia, which is also used in the process, is almost totally regenerated and recycled. The main advantage of this process is the availability of the raw materials, which can be found almost everywhere in the world and therefore allows operating production units relatively close to the market.

The Solvay process produces “light soda ash”, with a specific weight or pouring density of about 500 kg/m^3. It is used in that form mainly for the detergent market and certain chemical intermediates.

"Light soda ash" is transformed by recrystallization firstly to sodium carbonate monohydrate, and finally to "dense soda ash" after drying (dehydration). Dense soda ash has a pouring density of about 1000 kg/m^3. It is used mainly in the glass industry. Dense soda ash can also be produced by compaction.

Some producers have made several modifications to the original process. The main ones are:

- The "dual process", which allows production units to co-produce in nearly equal quantities ammonium chloride, which is used as a fertilizer in rice cultivation. There are several plants in the world which are working with that process. Most are situated in China.
- The "Akzo" or "dry lime" process, which uses dry lime instead of lime milk for ammonia recovery

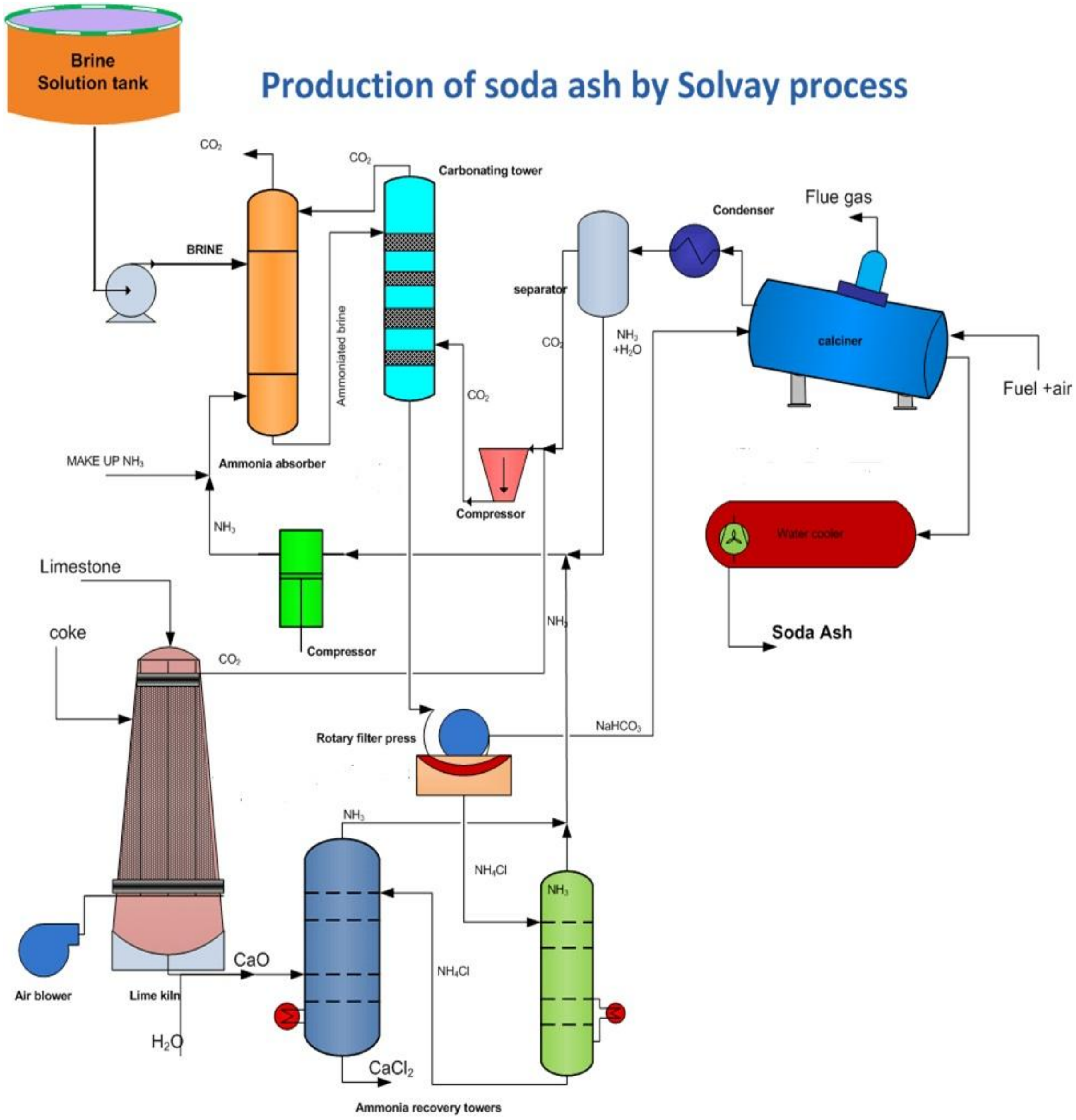

Fig-1: Solvay Process Diagram

1.3 Uses of Na_2CO_3 in Industrial Sectors[3]

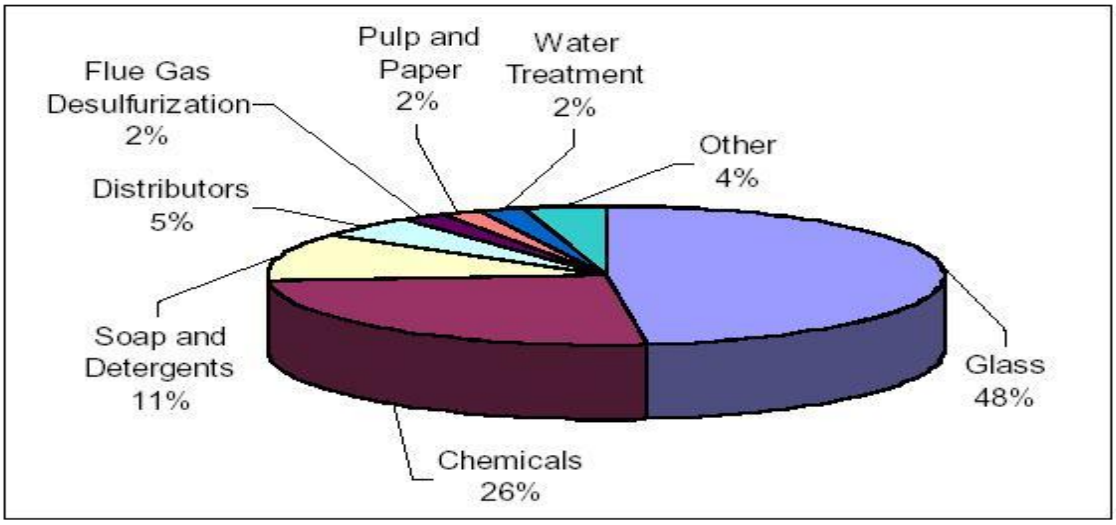

Fig-2: Uses of Soda Ash

2. Life Cycle Assessment

2.1 Brief History, Recent Development Of LCA[4,5]

Most sources trace the origins of LCA back to a study conducted by Harold Smith, project general manager for the Douglas Point Nuclear Generating Station, Canada. At the World Energy Conference in 1963, Smith reported his calculation of cumulative energy requirements for the production of chemical intermediates and products. Later in the 1960s, several global modelling studies were conducted which lead to further uptake of the early resource analysis techniques (the pre-cursors to LCA). In particular, the publication of The National Academy of Science's Resources and Man (1969), Meadows' book The Limits to Growth (1972) and the Club of Rome's document A Blueprint for Survival (1972) resulted in predictions of the effects of the world’s changing population and the expansion of industrial processes on demand for finite raw materials and energy resources.

Below is a brief history of the development of LCA from that point to the present day. Further background and information can be found in EPA (2006), Chapter 1, Pages 4&5 and Baumann and Tillman (2004) Chapter 2.

- In 1969, Coca-Cola studied alternative beverage containers.
- Resource and Environmental Profile Analysis (REPA) or Ecobalance (in Europe) done by private consulting firms, pioneered by Franklin & Hunt, the consultants for the Coca-Cola study.
- During the early seventies, Boustead and Hancock in the UK and Sundstrom in Sweden developed their own models of cradle-to-grave analysis. Boustead's first work looked at the industrial system that produced plastic and glass milk bottles. Sundstrom assessed the energy requirements of beer packaging alternatives.
- Between 1970 and 1975, approximately 15 REPAs were performed and a standard methodology began to develop, with the packaging industry particularly interested.
- In the 1980s and early 1990s, numerous REPAs were carried out with contradicting results and no commonality.
- In 1990, a REPA by Franklin &Assoc finds disposable nappies (diapers) are preferable to reusable cloth nappies.
- In 1991, a REPA by Lehrberger& Jones finds cloth nappies preferable.
- In 1992, a REPA by A.D. Little finds disposable nappies preferable.
- During the 1990s, SETAC (Society of Environmental Toxicology and Chemistry) and ISO (International Organization for Standardization) worked together to develop ISO 14000 standards for the life cycle assessment.
- In 2006, ISO updates Standards 14040 and 14044.
- In 2008, after consultation, BSi publish PAS 2050:2008, ‘Specification for the assessment of the life cycle greenhouse gas emissions of goods and services’ to aid Carbon Foot-print practitioners.

- Most Recently “Cradle-to-Gate” Life Cycle Assessment is undergoing for Soda Ash Manufacturing at Mithapur Chemical Complex using Ga-Bi Software of PE International for various environmental impacts of Soda Ash manufacturing like to further improve our operational and product sustainability after completing the LCA for Fertiliser Production.

2.2 Definition[6]

Life Cycle Assessment: A systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle.

Life Cycle: Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal.

2.3 Methodology[5,7]

With the growing popularity of LCA, together with the growing number of variants on the original theme, it became apparent that standardisation of methodology was required to provide confidence in the results a study would yield. Since 1997, the ISO 14040 series has provided guidelines on each step required for an LCA. Within the series, ISO 14040 is concerned with the principles and framework of LCA and identifies four main phases required to conduct an LCA. These phases are:

1. **Goal and scope definition** for the system to be assessed.
2. **Inventory analysis** involving the compilation of data on all the inputs and outputs of the system that occur within the system boundary as defined in 1.
3. **Impact assessment** in which the output of the inventory is manipulated in order to extract data on the magnitude and significance of the potential environmental impacts.
4. **Interpretation** involving the evaluation of the findings from either the inventory stage or impact assessment stage (or both) based on methodology defined in the scope to reach a set of conclusions.

2.4 Benefits and Limits of LCA Methodology

LCA is the only tool that can be used for product comparisons over the whole life cycle. The main benefits from using this methodology have been highlighted by ISO and SETAC as:

- Quantifying material and energy efficiency for a system.
- Identifying improvement opportunities and trade-offs.
- Illuminating hidden or unrecognized issues.
- Promoting a wider communication about how to compare and improve highly complex and difficult to analyze industrial systems.

However, LCIA addresses only the environmental issues that are identified in the goal and scope, therefore, is not a complete assessment of all environmental issues. Furthermore, LCIA is fundamentally an analysis of inputs from and outputs to the environment rather than an analysis of the actual environmental consequences or effects from a system. Impact Assessment modeling in LCA involve in some cases highly simplified assumptions about complex environmental processes (e.g. eco-toxicity) and there are also difficulties in dealing with spatial, temporal and dose-response issues.

Therefore, even for comparisons it has been suggested complementing LCA results with absolute approaches of other techniques, (e.g. risk assessment). The system-wide, relative LCA approach can be seen to identify and analyse possible system issues and trade-offs, where absolute tools would analyse in detail the issues raised by LCA.

Others limitations of the methodology include the uncertainty of the results due to data gaps, data uncertainties, methodological choices and values. However, these are relevant also for other environmental tools.

3. Review

- D.A.Georgakellos in 2002 stated that Life cycle assessment (LCA) is a technique for holistic environmental assessments of products and processes. The unique feature of this methodology is its focus on the entire life cycle of a product, from raw material extraction to final disposition. In order to assess the role of LCA in environmental manage- ment, a comprehensive overview of its theoretical background (including recent aspects of its principles and framework) is presented in this paper. From this overview it is obvious that, in spite of its drawbacks, LCA is recognized as a valuable methodology in environmental management, capable of analysing and assessing in a scientifical way the environmental consequences of various products and activities[8].
- Michael Z. Hauschild in 2009 stated that LCA is a tool used to assess the environmental impact & resources being used in the entire life cycle of product. There is a signifant development in the Methodologies of LCA and it is broadly applied in practice. The aim of the paper is to provide a review of recent development of LCA methods in terms of Goal and Scope definition, Inventory Analysis, Life Cycle Impact Assessment and Interpretation. Finally they have discussed about the recent developments in relation to some of the Strength and Weakness of Life Cycle Assessment[9].
- Jeroen B. Guinee, ReinoutHeijungs and GjaltHuppes in 2010 published that Environmental life cycle assessment (LCA) has developed fast over the last three decades. Whereas LCA developed from merely energy analysis to a comprehensive environmental burden analysis in the 1970s, full-fledged life cycle impact assessment and life cycle costing models were introduced in the 1980s and 1990s, and social-LCA and particularly consequential LCA gained ground in the first decade of the 21stcentury. Many of the more recent developments were initiated to broaden traditional environmental LCA to a more compre- hensive Life Cycle Sustainability Analysis (LCSA). Recently, a framework for LCSA was suggested linking life cycle sustainability questions to knowledge needed for addressing them, identifying available knowledge and related models, knowledge gaps, and defining research programs to fill these gaps. LCA is evolving into LCSA, which is a transdisciplinary integration framework of models rather than a model in itself[10]

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