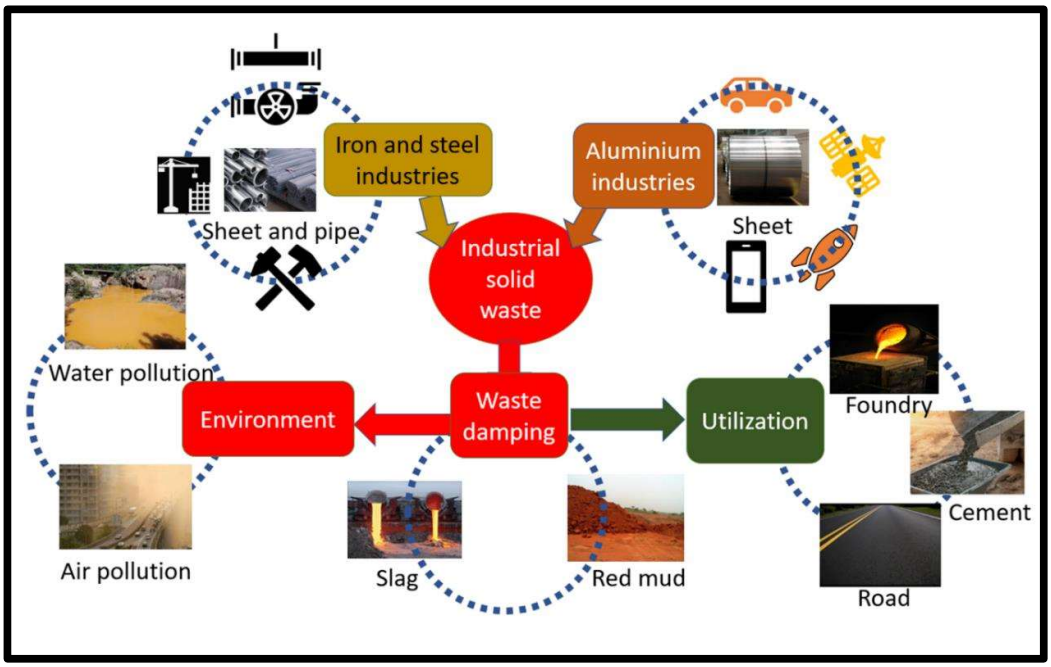
CHAPTER 1

INTRODUCTION



1.1 Introduction

According to the current scenario, Industrial solid waste is defined as a by-product of industrial growth. For the uplifting of the nation's economy, industrialization or urbanization is a must, especially for developing countries. However, on the other hand, industrialization causes serious problems in handling such waste. This waste is either dumped or thrown out in the open space, and environmental pollution is a major concern. Since it affects badly the fertility of agriculture lands as well. Figure 1.1 shows the generation of solid waste as a result of the development of ore for commercial products.

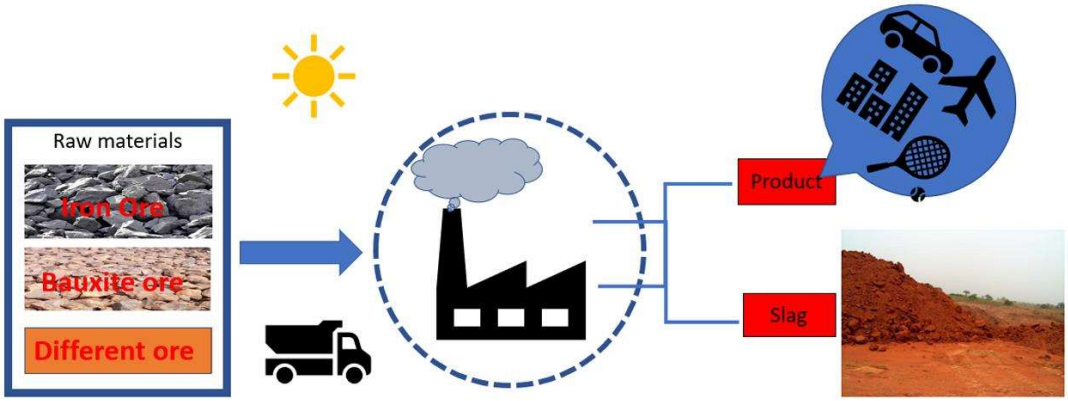


Figure 1.1: Industrial solid waste system

Industrial solid waste is a vital form of resource input for the overall growth of a developing and developed country.

1.2 The Major Industrial Solid Waste

- Coal Ash

The principal industrial by-products of the burning of coal in thermal power plants are coal fly ash and bottom ash. Around 72% of the energy in India is produced by thermal power plants that burn coal, according to data from the Central Electricity Authority (CEA) of that nation. Indian coal was shown to produce ash in the range of 30% - 45% when

compared to imported coal, which has an ash concentration of 10% - 15%. By 2035, it is projected that the world's energy consumption will have increased by 30% [1–4].

- Iron and Steel Slag

Blast furnace slag (BS) and steel slag are the by-product of the iron and steel industry generated during the smelting process and are considered as smelting waste. These slags are approximated around 80% - 90% of the total metallurgical slag[5].

- Phosphogypsum

Phosphogypsum is a by-product of the phosphoric acid industry and considers an industrial solid waste created during the wet manufacture of phosphoric acid. Each tonne of phosphoric acid is generated by the 5 tonnes of phosphogypsum [6].

- Red Mud

Red mud (RM) is a by-product of the alumina extraction process in the aluminium industries. Every tonne of alumina extraction results in one to two tonnes of red mud [7].

- Lime Mud

Lime mud is the solid waste generated in the paper industry during the recovery of alkali. Calcium carbonate is the primary component of this waste. Every tonne of pulp produced generate 0.5 tonnes of lime mud [8].

- Sludge

Sludge is the by-product gathered at various stages of wastewater treatment. Both substances of agricultural value and contaminants, which typically include pathogens, organic pollutants, and heavy metals, are present in them.

1.3 Utilization of solid waste beneficial

- Economical

- Environmental
- Natural resource
- Waste disposal
- Cost
- Raw materials

1.4 Statement of the problem

An improvement in the living standard and rise in the population index is facilitated by an increase in consumption of resources which leads to the generation of a huge amount of waste day to day life, which has become one of the major problems for the nations for the effective sustainable management of these waste as shown in figure 1.2[9]. The management of waste at generation, storage, landfilling, transportation, processing, utilization, etc. in an environmental manner in order with health, economic, natural resource conservation, etc. To ensure effective waste management, the Indian Ministry of Environment and Forests (MoEF) issues solid waste management (SWM) regulations under laws from 2000 and 2015 [10,11].

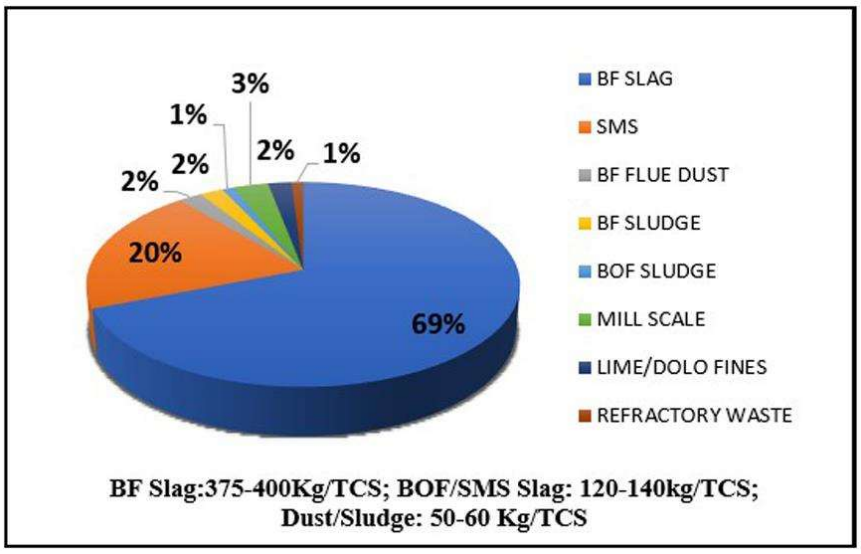


Figure 1.2: Steel slag generation in India[9]

1.5 Significance of Scope

As silica sand is globally becoming scarce to fulfill even the primary resource requirements such as construction, foundry, glass industries, etc. The government, various non-government organizations, and research institutes are striving to identify alternative materials to partially or fully replacement of silica sand. Foundry industries are considered one of the major consumptions of silica sand as a mold material as per figure 1.3, for 1-ton metal casting required 4-5 tons of sand. Silica sand is being used by a majority of foundry industries in India. In industries, the mold materials can be either metallic or nonmetallic. The casting in India has increased by 200% from 2011 to 2019, Silica sand is the natural resource most widely used in sand casting as a mold material. Due to ease of availability, low cost, possibility of reclamation, etc. silica sand is used in sand casting. For reclamation of the sand intended to remove the surface deposits should ideally be removed to recover the usable sand. In the case of molds, a decrease in the amount of loosely bound dead clay is sufficient to allow for its reuse as green sand. Foundry industries cast ferrous or nonferrous alloy, in which metal melt to a liquid state then pour liquid metal into a mold, and solidification takes place[12–15]. Solidification is the nucleation of solid particle and their growth. In the sand mold casting, solidification starts from the surface of the mold wall and grain growth takes toward the center of casting, where the equiaxed grain formation takes place. It is due to the movement of an atom from a high free energy state to a low free energy state [16–19].

The solidification rate at which casting solidifies influences cast properties such as metallurgical and mechanical properties. The pouring temperature, thermal conductivity, heat capacity, and mold material all affect how quickly liquid solidify [20,21]. One of the factors determining the rate of solidification is the temperature gradient between the mold and the molten metal; when the gradient is low, the rate of solidification is slower, and

when the gradient is large, the rate of solidification is faster. Fine grain structure forms as a result of rapid solidification. One of the key factors affecting an alloy's mechanical properties is its grain size[16,22].

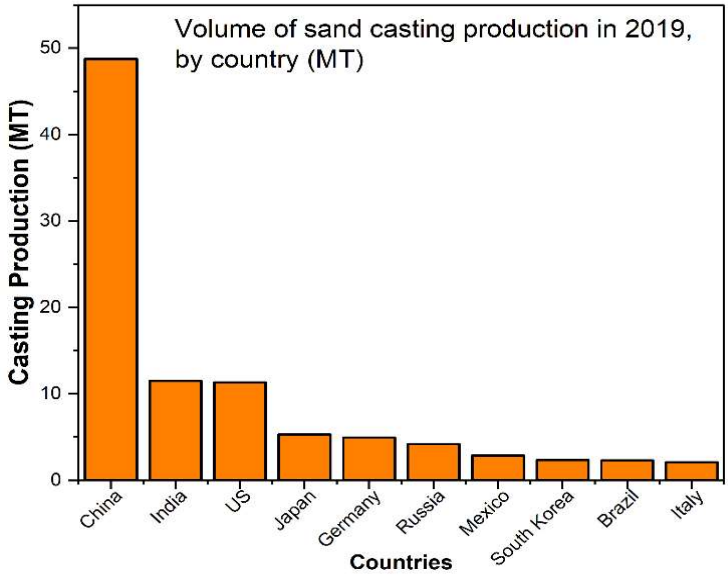


Figure 1.3: Volume of the global casting production[23]

1.6 Aim and Objective of the present work

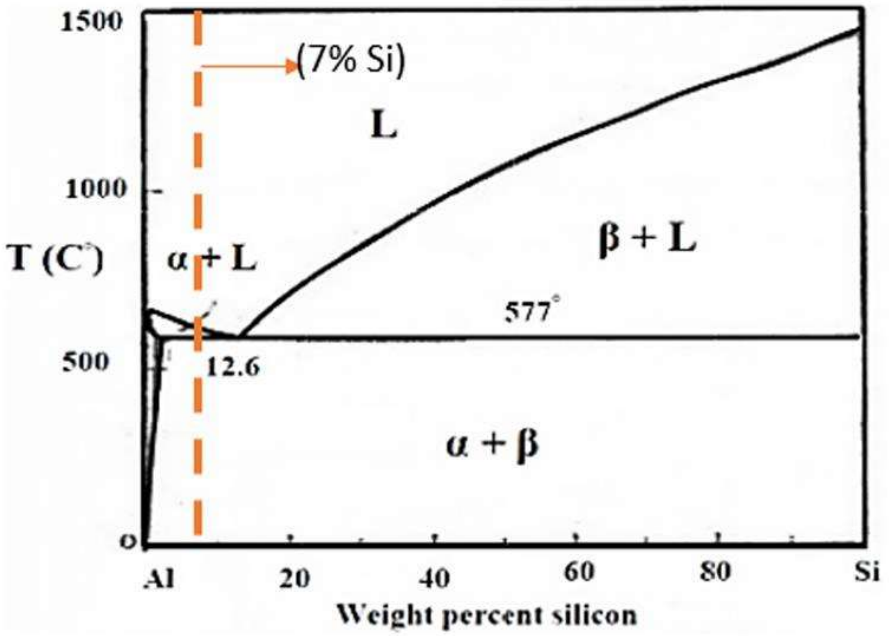


Figure 1.4: Phase diagram of Al-Si alloy

Al-Si alloy had been targeted for the present research work, the phase diagram of which is being as below in figure 1.4, the microstructure (7% Si) mainly consists of a primary phase (α-Al), eutectic mixture of Al–Si and primary silicon phase[24–27]. The vertical line corresponding to 7% Si is shown because alloys studied in the present investigation have around 7% Si therein.

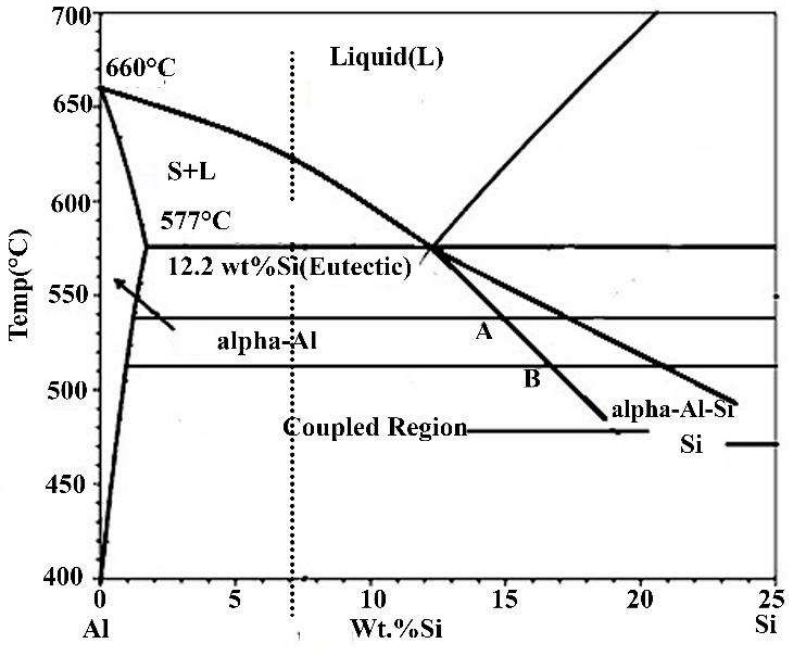


Figure 1.5: Asymmetrical phase diagram of Al-Si and coupled region

Within the phase diagram, the coupled regions show the existence of two phases viz α-aluminium and silicon as shown in figure 1.5. In the case of a symmetrical phase diagram, the coupled region is also symmetrical in nature. In the case of the aluminium-silicon phase diagram, silicon tends to grow in an anisotropic manner to give faceted crystals. Also, the silicon phase requires more undercooling for its growth. So far as the eutectic temperature is concerned, it is suppressed and the eutectic composition is shifted towards the silicon side of the aluminium-silicon phase diagram.

The Present investigation aims to cast A319 alloy using the industrial solid waste mold as well as to compare the results with silica sand mold. The mold was prepared by the waste with the aim to replace silica sand mold partially or fully. The prepared mold was tested by various testing techniques to decide its performance in comparison with the traditional sand mold. The cast alloy was characterized with respect to microstructural features, solidification behaviour, mechanical properties, and tribological behaviour.