CHAPTER 1

INTRODUCTION

The production of iron castings began in the late Middle Ages. Later on, steel casting became an industrial process in the 19^{th} century, and now, in the 20^{th} century, light metal casting is becoming increasingly important (Trager, 1985). The casting process involves the controlled pouring of molten metal, of the correct composition and at a suitable temperature, into specially shaped molds. These molds consist of particulate refractory material (foundry sand) that is bonded together to retain its shape during handling and pouring or may be permanent (e.g. metallic) as in die casting. Permanent molds are limited by the size and complexity of the casting and therefore most metal castings are produced in sand molds. In all cases, however good the quality of the metal cast, the resultant casting will be no better than the mold into which it is poured. The mold controls the outside shape and dimensions of the casting, the cores control the inside shape and dimensions. The sands, binders and molding/coremaking processes therefore control a most important part of the process of metal casting i.e., the production of an accurate finished mold that is able to withstand the thermal, mechanical and chemical effects of molten metal when castings are poured. The type of sand mold and cores used will depend on the alloy cast, the size and complexity of the casting and on the production facilities available (Parkes, 1970).

There are a wide range of sand molding and coremaking processes available. Molds can be produced from clay bonded sands (called green sand) or from chemically bonded sands. Cores are invariably produced from chemically bonded sands because chemical bonding produces much stronger sand compacts than clay bonds. Chemically bonded sands develop their strength either by the use of thermosetting resins or by the use of resin and catalyst (cold set) systems.

The present work deals with the "Shell Process" which is based on the use of thermosetting synthetic resins. This process is especially applicable to the production of small accurate castings such as automotive and motor cycle parts. This process is used for both molds and cores in a number of Thai iron foundries The mold or core is made as a shell 1/4 to 3/8″ (6 to 10 mm) in thickness.

A refractory sand, usually silica or zircon which is coated with a thermosetting resin is formed around a suitable heated pattern or core box. This causes the resin to change from a thermoplastic to a thermosetting condition thus ensuring the shape formed is retained without distortion. It is the thermosetting nature of the resin that forms the basis of the shell mold and coremaking processes.

The Shell Process has become widely used for the production of casting in all types of metals and alloys, both ferrous and non-ferrous. These include aluminium and copper based alloys, all grades of cast iron, SG iron, low-medium carbon steels, high alloy, stainless and manganese steels. Its main application is in the mass production of casting to "near net shape" particularly small to medium sized ferrous castings. The numerous advantages of the process, and particular disadvantages, have been well documented in the literature (Curtis, 1990).

The advantages of this process can be summarized as:

a) No preparation or mixing equipment required. Shell sand can be delivered in various forms ready for use, and under normal conditions it has indefinite sand, core and mold storage life. The dry, free flowing product produces moulds and cores with uniform mechanical strength.

b) Capital investment for molding and closing equipment is relatively low compared with other processes and there are lower handling costs for sand and molds.

c) Small space requirements for a given production level. The comparatively small size of molds and their lightweight enables optimum use of floor space.

d) Unskilled labour can operate the process. With the minimum of training, an operator can quickly produce precision molds because of the consistency and reproducibility of the process.

e) Good casting surface finish and definition.

f) Low sand/metal ratio.

Limitations are as follows:

a) Expensive metal patterns. However, in other process the use of metal patterns is becoming more widespread with the advent of high volume processes and automatic molding.

b) High initial cost of the molding material has to be balanced against in-house mixing costs and low sand/metal ratio. The judicious use of hollow cores and contoured molds can more than compensate for sand costs.

c) Heating is required. Cold set processes might be thought of as minimizing energy costs, but may incur higher costs from environmental considerations (extraction and scrubbing). With the Shell Process, fume and smoke can usually be dealt with by normal extraction. The cost of heating is also offset by the small space requirements and low sand usage.

d) The Shell Process is limited in casting weight. With the advances in coated sand technology and mold "back up" systems, the size and scope of the process is continually being improved. Casting weights in up to 80 kilograms and overall dimensions of 1000 mm can be made and it is with the larger cast weight that shell is becoming more economical in producing high quality castings.

In recent years the Shell Process has continued to remain its competitiveness in spite of large increases in costs of petrochemicals and energy. The decline in tonnage of castings produced in Shell has been far less dramatic when compared with castings produced by other methods, and with the investment in research development and production facilities that is taking place, the Shell Process is considered to have a stable future.

The Thai foundry industry has been gradually developing to meet the growing demands of both home and export customers. The main products produced in Thai foundries are parts and engines for agricultural and industrial machines, automotive parts, pipes and fitting etc. There have been predictions in Thailand that market demand for castings such as the parts for automobiles, motorcycles, air conditioners, manifolds, camshafts, and crankshafts will increase in the near future. To meet increasing demands for quality for such parts the Shell Process is becoming more widely used in Thai foundries for both core and mold production. Hence, there is a need to produce foundry resins in Thailand to decrease import costs and to improve economic performance. The current resins produced in Thailand have limited properties and are considered to be variable in performance and quality by the foundry industry. They appear to be suitable for the production of small cores but do not give sufficient strength properties to enable their use in molds. Some casting factories in Thailand, therefore, use expensive imported resin coated sand for mold fabrication, leading to undesired overall higher costs of production. Thus, if low cost Thai resins and high cost imported resins (approximately twice the price of Thai resins) can be blended together to produce consistent resin coated sand for mold production, there will be a decrease in the use of imported resins and a reduction in the overall cost of mold and core production.

For these reasons, the objectives of this study were:

a) To establish a better understanding of the general properties and characteristics of Thai and imported resins

b) To study the bonding characteristics and mechanical properties of resin bonded sands using the Shell Process.

c) To determine optimum blends of Thai and imported resins to suit particular applications.

This requires the design and construction of a small laboratory scale sand mixer which was used to prepare resin coated sand mixes based on blends of Thai and imported resins.

In this thesis, Chapter 2 provides a review of casting processes, the use of chemically bonded sands, and in particular the Shell Process and associated resins. The factors which govern the strength and other significant properties of Shell molds and cores are reviewed and discussed in detail. Chapter 3 provides an account of the design and construction of the lab scale mixer-coater together with the experiment procedure used in the subsequent characterization of the properties of the blends produced. Chapter 4 presents the experimental results together with a discussion of their practical significance. Conclusions of significant observations from this study are summarized in Chapter 5 and recommendation for future work are made in Chapter 6.