Scope of Investment Castings Supported by Survey of Foundries in Rajkot Cluster

Amit Sata[1] and Mayur Sutaria[2]

[1]Associate Professor, Mechanical Engineering Department, B. H. Gardi College of Engineering & Technology, Rajkot, Gujarat
E-mail : ameet_sata2000@yahoo.com, [2]Associate Professor, Mechanical Engineering Department, Charotar University of Science and Technology, Changa, Anand, Gujarat

Investment casting process enables economic manufacture of intricate parts with high geometric accuracy and good surface finish, and is especially preferred for hard-to-machine metals like alloy/stainless steels and superalloys used in aerospace, defence and medical applications. An investment casting foundry offers significantly higher value addition than a typical ferrous foundry using sand casting process. The process of wax pattern fabrication, shell making, dewaxing, and pouring is however, quite complex, and requires a high level of skill. There are more than 1600 investment casting foundries worldwide producing castings worth over 10 billion US dollars (2008 data). India is credited to have originated the lost-wax process, which is still used in many clusters for making idols and ornamental castings. There are however, only about 200 industrial investment casting foundries in India, compared to over 4500 sand and die-casting foundries. Nearly one third of these (investment casting) foundries are located in Rajkot region of Gujarat.

This paper presents the results of a recent survey of investment casting foundries in Rajkot cluster to understand their capacity, capabilities, utilisation, and challenges to achieve global competitiveness. Key factors included are casting quality, quantity, delivery and value addition. The survey covered 20 foundries (nearly one third of those in Rajkot). These were approached in person to get answers to a specially designed questionnaire. The detailed results and their analysis are presented in this paper. This provides decent insight of the investment casting foundries in Rajkot cluster, offering a benchmark for comparison with similar foundries in other clusters and countries.

Keywords: Investment casting, Industrial survey, Benchmarking, Quality.

Introduction

Investment casting is one of the oldest known manufacturing processes. Investment casting is also known for its capability to produce engineering and non-engineering components with good surface finish and dimensional accuracy. India is credited to have originated the investment casting process. Investment casting process was mainly employed to make idols in its early days. The applications of investment castings have been increased since its beginning. The application of modern investment casting process is extended to manufacture automobile components, chemical processing equipment, ornaments (decoration and jewelries). Investment casting industries are also capable of manufacturing high valued components which are mostly used in aerospace, bio-medical and defence industries.

The *investment* term derived from the conventional moulding process in which plaster (stucco) like material is invested over an assembly of wax patterns. These patterns duplicate the final desired product. Generally, investment casting process is comprised of following sub-processes.

- **Wax Pattern Fabrication**: Industrial wax is prepared and injected into a die. These patterns are cleaned and assembled to make a tree.
- **Shell Making**: This tree (assembly of wax patterns) is repeatedly dipped into slurry of fine and coarse sand particles to make a shell.
- **Dewaxing**: The shell is dried and then heated to melt out the wax. This shell is preheated to increase its strength, and prepared for pouring of molten metal.
- **Pouring and Ejecting**: The metal/alloy is melted and poured into preheated shell. The molten metal is allowed to be solidified, and ejected from shell through knockout.

Investment castings achieve higher value addition than typical ferrous foundry castings because the process is quite complex and requires high level of skills as these sub-processes further depend on design, material and process parameters of wax, shell as well as metal/alloy. These parameters are generally tuned by virtual (simulation) or real experiments to achieve desired quality. Manufacturing of the defect-free castings along with reasonable properties within small lead time is still a challenge for investment casting foundries. The maximum utilisation of installed capacity of the industrial investment casting setup is also one of most challenging tasks in the current competitive global market.

This paper represents the scope of investment castings worldwide as well as India especially in Rajkot cluster. This paper also covers the results of a recent survey of investment casting foundries in Rajkot cluster to understand the capability and challenges to achieve global as well as local competitiveness as Rajkot Investment Casting Cluster is very important engineering cluster in the country. The status of investment casting in comparison with sand and die-casting foundries is discussed in the next section. It follows the status of investment casting in India, and the results of recent survey of investment casting foundries in Rajkot.

Investment Casting in the World

The 47th Casting Census (2012-13) conducted by Modern Casting, USA reported 50,000 sand and die casting foundries and their total production is approximately 100.8 metric tonnes worldwide. However, considering unlisted foundries, this number may reach to approximately 55000 foundries.

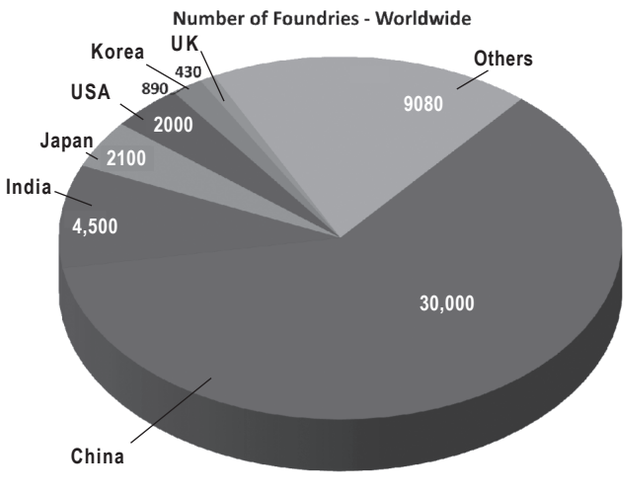

Fig. 1: Distribution of foundries across the world.

These foundries largely produce industrial castings of grey cast iron (nearly fifty per cent of total production). China is the leading manufacturer of castings followed by USA and India[4]. The Asian countries considered to be the largest producer of industrial castings with approximately 67% of total world casting production[4]. The distribution of metalcasting foundries across the world is shown in Fig. 1[4].

In comparison to the sand and die-casting foundries in the world, investment casting foundries are very less in number (not more than 3.5 % of total number of foundries).The distribution of nearly 1600 investment casting foundries worldwide is shown in Fig. 2[6]. Approximately, 75% of these investment casting foundries are in Asian countries. However, North America is the largest single producer of investment casting with almost 37% of the world sales while Asian countries' sales is approximately 33% (2011 data)[6].

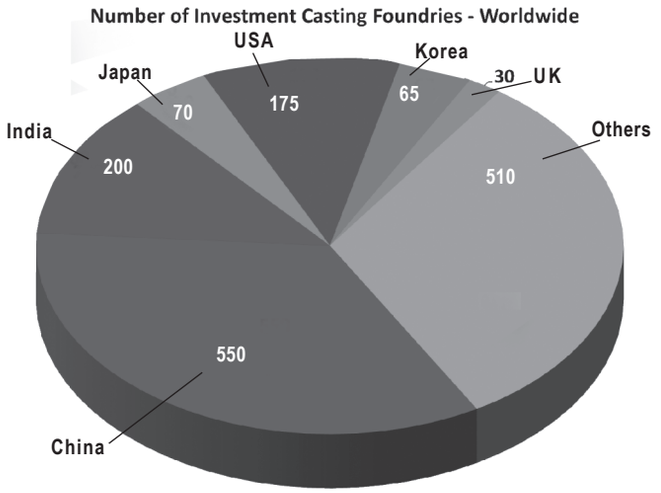

Fig. 2: Distribution of investment casting foundries across the world.

World investment casting sales is continuously growing since 2002 and reached approximately 11 billion US dollars (2011 data). These include high valued castings (aerospace, defence and industrial gas turbines), automotive and other sectors (commercial and medical)[6]. The western region of world dominates in *high valued castings* while eastern region dominates in *automotive* sector. The rapid development of high-tech equipment in Asian countries encourages the demand of investment castings in Asia. China is one of the largest investment casting producers in Asia with approximately 550 foundries producing investment castings for aerospace and automotive sector[8]. Japan is also one of the most emerging producers of investment castings

with approximately 70 foundries. Japan is mainly producing investment castings for automotive turbocharger, gas turbines and bio-medical[7]. Korea is manufacturing industrial castings for automotive and valve industries with approximately 65 foundries[2].

The demand for the investment castings is very high in aerospace sector in western countries while it is continuously growing in automotive sector in eastern countries. It also appears to have more worldwide demand in the area of bio-medical. Investment casting predicted to have good performance in upcoming years and is set for strong future especially in Asian countries.

Investment Casting in India

The metalcasting is very well-established manufacturing sector in India. India is 3rdlargest casting producer in the world[4]. The various types of castings (ferrous and non-ferrous) including automobile, locomotive, pumps, compressors, diesel engines, heavy duty machineries etc. are manufactured in India. There are approximately 4500 foundries in India.

In India, foundries are distributed in geographical clusters. Some of the major foundry clusters are Belgaum, Batala/ Jalandhar, Coimbatore, Howrah, Kolhapur and Rajkot. Each cluster is known for some specific end-use castings[5]. For example, Howrah cluster is famous for man-hole castings, Rajkot cluster is for diesel engine and automotive castings etc. The Indian casting production rate increased by 22% while worldwide casting production rate of increase is 13.7%. The market share of Indian foundry industry is approximately 10% of global market[5].

There are about 200 industrial investment casting foundries in India, in comparison with over 4500 sand and die-casting foundries. Casting production has grown in most of the investment casting foundries in previous years. Investment casting business in India is increased by approximately 10-12% in the year 2011[3]. Many of these foundries are equipped with modern wax injection machine and robotic shelling system.

Indian investment casting foundries majorly manufacture industrial valves, pumps and machinery which cover approximately 44% of Indian investment casting market. India is the sixth largest passenger vehicle producer in the world, therefore the investment casting of automotive components reached approximately 30% of the total production of investment castings in India[4]. It is also forecast that Indian investment casting producers will be very busy with new opportunities due to growth in global market as well as economy of India. Most of the Indian investment casting foundries are located in Rajkot cluster, Kolhapur cluster and Coimbatore cluster.

Recently, the survey was conducted in investment casting foundries of Rajkot cluster as it is representing nearly one third of the investment casting foundries (approximately 70 foundries) in India. The main objective of the survey is to understand the capacity and capabilities of the investment casting foundries in Rajkot cluster. The survey was also focused on finding the utilisation of installed capacity and areas of improvement to achieve success in global market. The details of survey and its results are discussed in next section.

Survey of Investment Casting Foundries in Rajkot Cluster

As discussed earlier, Rajkot is an important cluster of foundries in the country, and known for its entrepreneurship. The Rajkot cluster is also known for manufacturing automobile spares. There are approximately 2200 engineering units in the cluster with over 500 foundry units for sand and die castings. The sand casting foundries are well-known for manufacturing of castings for diesel engines. These foundries sell their castings to multinational companies of Europe, Middle East, and Southeast Asia. These foundries are majorly distributed across two industrial zones namely Metoda and Shaper. Most of the investment casting foundries in Rajkot cluster mainly manufactures commercial castings (pumps and valves) while around 10-15% foundries are manufacturing high quality automotive and aerospace castings.

The survey covered 20 foundries (nearly equal in both zones of Rajkot cluster) that is nearly one third of those in Rajkot. The list of these foundries is given in Table-1. These were approached in person to get answers to a specially designed questionnaire. The questions were in three parts. The first part was meant to get a snapshot of the foundry capacity, included questions related to production capacity (tonnes per year), utilisation (percentage), and proportion of domestic sales and exports (in terms of percentage of weight as well as value). It also represents key factors including quality, quantity, delivery and value addition.

The second part covered key details of capability of foundries in terms of range of metals, casting weight, critical limits (such as minimum wall thickness), types of customers (application sectors). It also covers the details about manufacturing process, including type of equipment, level

Table-1 : List of Foundries Participated in Survey

Sl. No.	Name of Investment Casting Foundry	Industrial Zone
1	Alpha Casting Private Limited	Metoda
2	BB Technocast Private Limited	Metoda
3	Crystal Investment Casting Private Limited	Metoda
4	Delta Casting Private Limited	Metoda
5	Himac Casting Private Limited	Metoda
6	Iceberg Investment Casting Private Limited	Metoda
7	Impel Casting Private Limited	Metoda
8	Invent Casting Private Limited	Metoda
9	NV Technocast Private Limited	Metoda
10	Prime Technocast Private Limited	Metoda
11	Satyay Casting Private Limited	Metoda
12	Vertex Foundries Private Limited	Metoda
13	Amtech Casting Private Limited	Shapar
14	Arrow Cast Private Limited	Shapar
15	Gujarat Alloys Private Limited	Shapar
16	Jagdish Casting Private Limited	Shapar
17	Manek Investment Casting Private Limited	Shapar
18	Precision Technocast Private Limited	Shapar
19	Prevail Technocast Private Limited	Shapar
20	Solar Technocast Private Limited	Shapar

of automation, and critical parameters (such as shell baking temperature). The last part of the questionnaire solicited information related to casting quality, including the major defects encountered and their frequency of occurrence. The survey result and its analysis to get insight is discussed in next section.

Analysis of the Survey

The survey provided some valuable insights of the present scenario of the investment casting foundries of the Rajkot cluster. The results are further focused on three aspects: capacity, capability and challenges. The results of the survey covering the above three aspects of investment casting foundries in Rajkot cluster are discussed here.

Capacity

The capacity of each of the investment casting foundries is recorded from survey. Then the minimum, maximum and average values of capacity are calculated from the entered data of each foundry. In the same manner, the data related utilisation of installed capacity (in terms of percentage utilisation) was also collected from industrial survey. The minimum, average and maximum values for capacity of investment casting foundries participated in the survey and their utilisation of capacity is shown in Fig. 3 (a) and (b).

The average capacity of these foundries was found to be

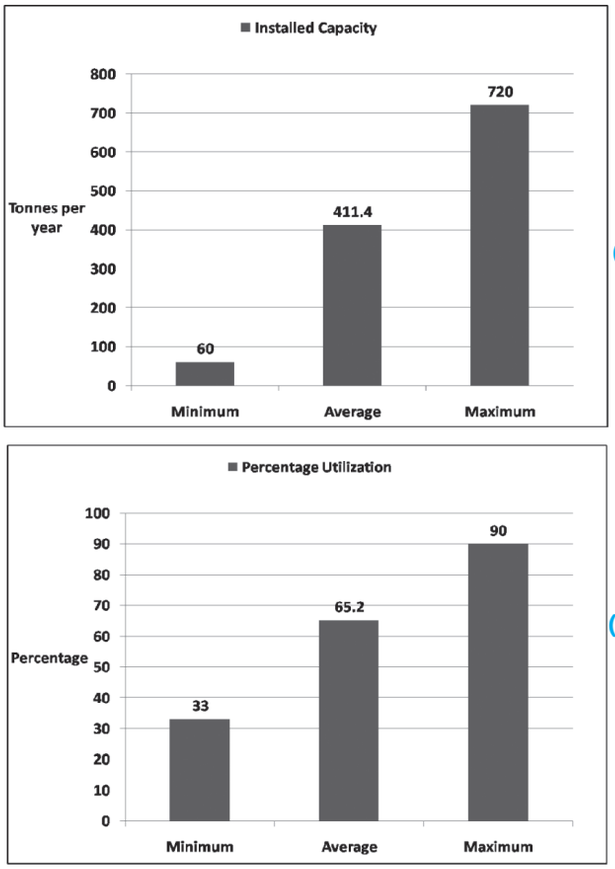

Fig. 3: Results of Survey – (a) Installed Capacity (b) Percentage Utilisation.

411.4 tonnes per year; and their average utilisation was 65.2%. The data related to export of investment castings (in terms of percentage of weight of casting exported to total weight of castings produced) from all investment casting foundries participated in survey was collected. It was found to be in the range of 10% to 80%. The investment casting foundries of Rajkot cluster are exporting approximately 40% of their castings.

Capability

The data related to metals handled by the foundry as well as application sectors of investment castings were collected. The capability of investment casting foundry in terms of typical wall thickness as well as the minimum and maximum weight of castings was also asked and collected. The average lead time for supplying new product and method of pouring (in terms of manual or automatic) were also investigated from the investment casters.

It was found out that most of these foundries manufacture stainless steel parts (like valves) and supply to automotive and chemical industries. These foundries typically produce castings of 2-10 kg with 4-50 mm of wall thickness. The

average lead time for supplying a new order is approximately 4/5 weeks. The minimum and maximum values of casting weight, wall thickness and lead time of these foundries are also shown in Fig. 4. Most of the foundries employed manual pouring system for pouring molten metal in a preheated shell. They maintained the shell backing temperature in range of 900 ^{0}C to 1600 ^{0}C.

Challenges

The challenges in terms of overall rejection along with rejection at the end of each sub-process, occurrence of

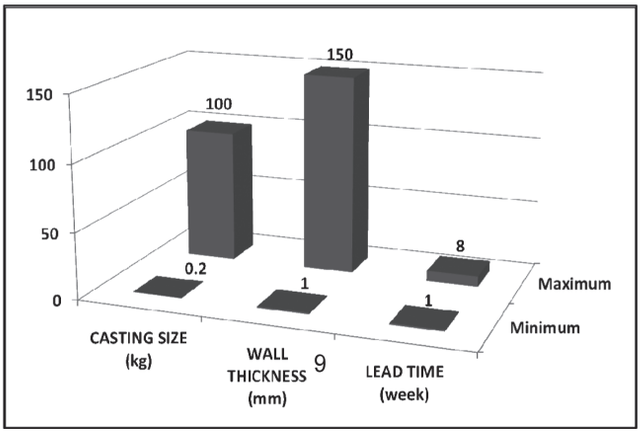

Fig. 4: Results of Survey – Casting weight, wall thickness and lead time.

major defects (in terms of dimensional, external, internal or shape-related defects) were investigated for foundries. The average rejection rate was found to be 6%. These foundries faced major rejection during casting and fettling stage. The most occurring defects include shrinkage porosity and shell inclusions (internal defects).

Conclusions

This paper focused on the status and opportunities of investment castings in the world as well as Indian market. As discussed earlier, investment casting industries are having good and strong future in the world as well as in Asian countries especially in India. Rajkot cluster is having approximately one third of total investment casting foundries in India. Investment casting foundries of Rajkot cluster currently focus on the manufacturing of valves and automobile components although they are capable of manufacturing value-added castings namely aerospace, defence and bio-medical castings.

Rajkot cluster investment casting foundries are not utilising their installed capacity of manufacturing castings. The survey shows that on an average these foundries are utilising approximately 65% of installed capacity. Rajkot cluster is required to put some efforts towards manufacturing of castings for aerospace, defence and bio-medical industries by enhancing the capability of manufacturing castings of superalloys, as these foundries are currently manufacturing industrial castings of stainless steel for automobile and chemical industries. Also, these foundries need to focus towards the reduction of lead time for supplying new investment castings. It can be improved by employing advanced technologies such as Rapid Prototyping to reduce the lead time in manufacturing of investment castings. It is also necessary to adopt automatic pouring system in foundries as most of the foundries employ manual pouring system. Rajkot cluster foundries also need to focus on reduction of rejection at casting and fettling stages. The rejection rate of these foundries can also be reduced by employing casting simulation; although the applications of simulation software in investment casting foundries in Rajkot cluster is yet to be explored.

This investment casting survey in Rajkot cluster yielded good insights about the future scope of the improvements. It is also helpful in providing a benchmark for comparison of these foundries with other foundries in other regions of India.

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