20. POTENTIAL FOR LOW CARBON TECHNOLOGY TRANSFER IN INDIAN INVESTMENT CASTING UNITS

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Low carbon technology transfer is a highly complex process associated with various challenges and barriers. One of the significant barriers is a lack of information in terms of technical needs and conditions of the receiver country. Such information is essential in evaluating the possibility and potential for low carbon technology transfer. Technology to be transferred should ideally suit the technological, economical, social as well as political conditions of the receiver country in order to maximise the impacts of technology transfer.

Therefore, in order to better understand the technological background in India, which is one of the most important countries in the low carbon technology transfer context, we have conducted field investigations for five carbon intensive investing casting units in Rajkot. The results have indicated: (i) the possibility and potential for low carbon technology transfer lie in both physical and informational assets; and, (ii) the potential for low carbon technologies clearly exists in India. Our survey has found that by replacing the existing ACs used mainly for the drying process of investment casting units, India as a whole can potentially cut 140 kt-CO_2 $year^{-1}$ of carbon emissions, while reducing the energy costs by Rs. 498 million a year.

Key Words : *low carbon, technology transfer, India, investment casting*

1. INTRODUCTION

India is among the fastest growing economies in the world today. Economic growth in India over the coming 20 years is expected to exceed the average level of the world economy, boosting a continuous increase in primary energy demand[1]. While such economic development may offer a great opportunity for poverty eradication, it will sharply increase carbon emission levels unless properly designed in line with sustainable development. This sharp increase in carbon emission levels will result in a climate change outcome that will seriously endanger future environmental quality and human wellbeing. The threat of climate change is already tangible around the region. Thus, achieving environmentally sound development in India is an important policy issue.

Among the various potential measures, low carbon technology transfer is considered to be one of the most important means in achieving environmentally sound development. However, although the issue has been discussed in the relevant international communities including UNFCCC process for decades, it is still widely recognised that the transfer needs to be accelerated even further in achieving the sustainable development goal.

Technology transfer is a highly complex process associated with various challenges and barriers. One of the significant barriers is a lack of information in terms of technical needs and conditions of the receiver country. Such information is essential in evaluating the possibility and potential for low carbon technology transfer[2]. Technology to be transferred should ideally suit the technological, economical, social as well as political conditions of the receiver country in order to maximise the impacts of technology transfer[2,3,4].

Therefore, the aim of this paper is to contribute to a better understanding of current conditions of India, with a focus on the technological aspect.

2. METHODS

A field investigation was conducted in December 2011 for five investment casting (lost wax process) units in Rajkot, located in the state of Gujarat, India.

Investment casting industry was chosen for our case study since it is not only energy intensive, but it is also among the most important and fastest growing industries in India[5].

One of the important features of the investment casting industry in India is its geographical clustering. Amongst the various investment clusters in India, Rajkot cluster consists of the largest number of units (about 65 to 70 units), and is known for having a domestic diesel engine industry as a major end-use market[6) 7)].

Table 1 summarises the production flow of the investment casting units as well as the major energy consuming equipments and their energy sources associated with each process.

Table 1 Different processes of investment casting and major energy consuming equipment(s) and their energy source associated with each process.

	Equipments used	Energy source
1. Wax molding	air compressor	electricity
2. Assembly		
3. Coating		
4. Drying	AC, dehumidifier	electricity
5. Dewaxing	boiler	natural gas, wood
6. Shell baking	preheating furnace	natural gas, carbon black
7. Casting (batch tapping)	induction furnace	electricity
8. Release		
9. Cleaning	air compressor	electricity

The induction furnace stands out in terms of energy cost. Managers of the units replied that the induction furnace accounts for 30% to 70% (average 44%) of the total energy cost. Air conditioners (AC) are also responsible for a considerable portion of the energy cost; 15% to 28% (average 21%). AC are used to control the temperature of the room mainly for the drying process in order to prevent wax melting which can cause adverse effects to the quality of the products. Temperature is generally maintained around 25 degrees C and needs to be controlled continuously 24 hours a day throughout a year.

Therefore, this paper focuses on the above two energy intensive equipments: induction furnace and AC. In order to evaluate the current technical conditions and potential in terms of technology transfer for these equipments, baseline data were collected using the following methods: 1. walk-through investigations; 2. gathering official documents such as equipment invoice and gas/electricity bills; and, 3. questionnaires and interviews with the managers and engineers of the units.

3. RESULTS

The results of the survey have been separately documented for induction furnaces and air conditioners.

(1) Induction Furnace

The results are summarised in Figure 1 and Table 2.

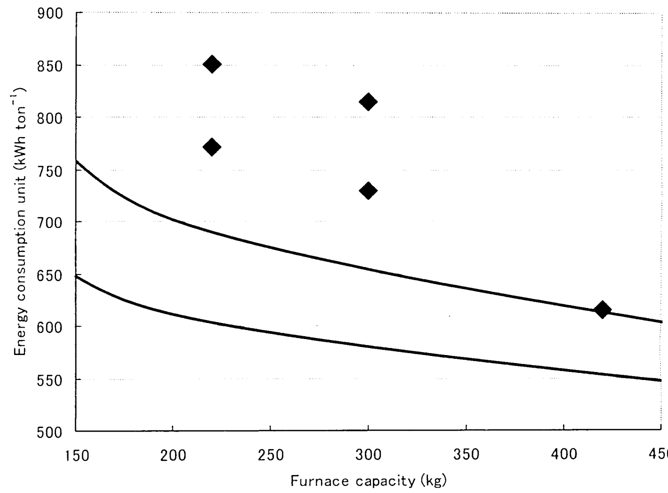

Figure 1 Capacity of furnace (kg) and energy consumption unit (kWh ton^{-1}) of the induction furnaces studied in the survey (batch type tapping). Lines indicate the approximate range of performance in Japan for non-batch type tapping.

Table 2 Yield rate and rejection ratio of the five units.

	Yield rate (%)	Rejection ratio (%)
Unit A	40	4.2
Unit B	42 - 51	3
Unit C	45 - 52	1.75
Unit D	40	9
Unit E	38	3

Energy consumption unit ranged from 615 kWh ton^{-1} to 851 kWh ton^{-1} (average 757 kWh ton^{-1}). Yield rate and rejection ratio both appeared to have relatively lower figures; ranging from 40% to 52% (average 43%) and from 1.75% to 9% (average 4%), respectively.

(2) Air Conditioner

There were 20 ACs in total used for the production purpose. These all run on electricity and were domestic brand. The results of the ACs studied in the survey are summarised in Figure 2. Rated cooling capacities are those indicated by the manufacturers. COPs were estimated presuming the power factor to be 85%.

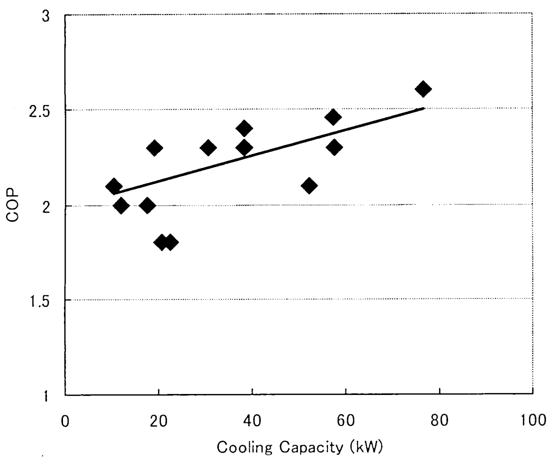

Figure 2 The rated cooling capacity (kW) and COP of the ACs investigated in the survey.

The range of cooling capacity of the existing ACs was 10.5 kW to 76.7 kW (average 36.8 kW). COP ranged from 1.8 to 2.6 (average 2.2). COP appeared to be better in the larger cooling capacity (R^2 = 0.3785).

4. Discussion

There were several interesting findings and implications from the results.

The efficiency of induction furnaces used in Rajkot units was already at the level equivalent to that of Japan. There were about 100 kWh ton^{-1} difference in performance between India and Japan (Figure 1). However, this can be explained by the difference in the type of tapping (direct comparison was not possible due to the lack of batch type tapping data of Japan). All five units studied were undertaking batch type tapping which takes 45 to 100 minutes. This time is equivalent to approximately 40% to 50% of the total operation time (PO-to-PO). Therefore, considering that the batch type tapping is inevitable due to their products and pertaining heat loss during this additional operation time, a 100 kWh ton^{-1} difference is understandable.

However, yield rate and rejection ratio appeared to be lower compared to that of Japan. Although the actual current figures in Japan are not clearly known, they can be presumed to be around 55% and 1.3%, respectively (K. Sekimoto 2012, pers. comm., 28 Mar.). In fact, deep shrinkages were clearly apparent in the products of Rajkot units (Figure 3). Therefore, technology transfer regarding induction furnace should put more emphasis on know-how (*i.e.*, *Kaizen*) to improve these figures and not on the equipment (*i.e.*, induction furnace) itself (K. Sekimoto 2011, pers. comm., 26 Dec.). For example, better material and usage of exthothermic powder might be one of the options. However, this should be done in a try-and-error process.

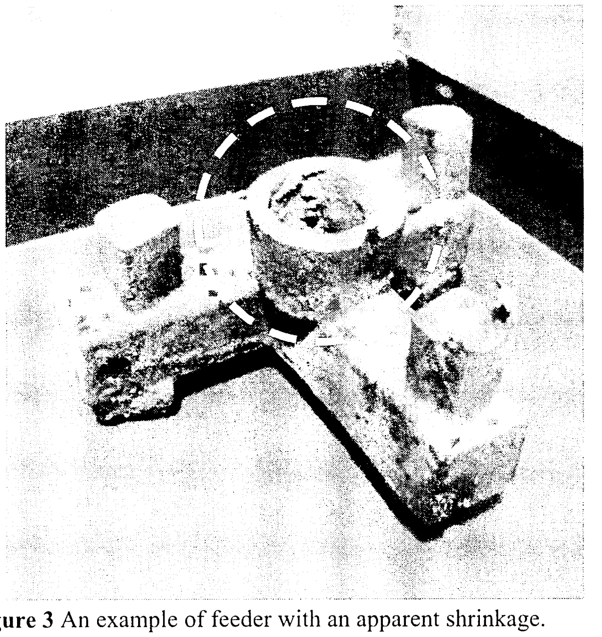

Figure 3 An example of feeder with an apparent shrinkage.

In contrast to the induction furnace, the efficiency of the ACs appeared to have more room for improvement. Whereas even the best COP found during the survey was 2.6 (average 2.2), the minimum COP standard of Japan in the year 2007 (Top Runner Standard; the current standard is higher than the 2007 standard. However, COP is not used in the latest standard and thus direct comparison is not possible) for the similar type (4.0 kW to 28.0 kW; there is no standard for ACs over 28.0 kW) of ACs is 2.71.

A simple calculation was conducted to estimate the potential impacts of replacing the existing ACs with those used in Japan for all five units surveyed. We chose gas heat pump (GHP) ACs for this estimation, since natural gas is considered cleaner and is one of the most promising energy sources of the near future. The results are shown in Table 3.

Table 3 The performance of existing ACs and potential GHP ACs.

	Unit A	Unit B	Unit C	Unit D	Unit E
Existing ACs					
energy consumption (MWh yr^{-1})	1365	974	1666	1476	2891
CO_2 emission ($t\text{-}CO_2\ yr^{-1}$)	284	203	347	307	602
Energy cost (1000 Rs. yr^{-1})	1856	1418	2206	1901	4113
Potential ACs					
energy consumption (MWh yr^{-1})	547	427	560	733	1208
CO_2 emission ($t\text{-}CO_2\ yr^{-1}$)	111	87	114	149	246
Energy cost (1000 Rs. yr^{-1})	1252	966	1268	1625	2693
Reduction potential					
energy consumption (MWh yr^{-1})	819	547	1107	742	1684
CO_2 emission ($t\text{-}CO_2\ yr^{-1}$)	173	116	233	158	356
Energy cost (1000 Rs. yr^{-1})	605	451	938	276	1420

Note: Units and assumptions used in the calculation are as follows:
CO_2 emission form grid electricity generation: 0.93 $t\text{-}CO_2\ MWh^{-1}$
Grid electricity cost (VAT included): approximately 6 Rs. kWh^{-1}
Natural gas cost (VAT included): approximately 28 Rs. SCM^{-1}
Full load equivalent operation hours of existing system: 5,000 hours $year^{-1}$

In all five units surveyed, our estimation has indicated a considerable potential for low carbon technology transfer in terms of not only CO_2 emission reduction, but also energy cost as well. Both CO_2 emissions and energy costs were found to have the potential to be cut by nearly half — up to 33% of the current existing levels. This is an important finding because one of the largest barriers in transferring low carbon technologies is the cost and commercial viability pertaining to the transfer[8].

Although the exact number of investment casting units in India is not exactly known, we made a rough estimation using the ratio of investment casting units among the foundry units in Rajkot (approximately 13.5%; 65 to 70 units out of 500 foundry units are investment casting units)[6) 7)]. According to Metalworld[6)] there are more than 5,000 foundry units in India, with a majority of them falling under the category of small-scale industry similar to the five units which were investigated in this study. Since the average CO_2 reduction among the five units were 207 $t\text{-}CO_2\ year^{-1}$, taking the above figures, nationwide CO_2 reduction potential can be estimated to be approximately 140 $kt\text{-}CO_2\ year^{-1}$. Similarly, in terms of total energy cost, more than Rs. 498 million could potentially be reduced. Further, it must be noted that this estimation is rather conservative since the estimation does not include larger units. Moreover, considering the rapid growth of the foundry industry in India, the potential impact of low carbon technology transfer can be expected to be larger[5)].

5. Conclusions

The aim of this study was to delineate current technological needs and conditions of India which is one of the largest and most important carbon emitting countries in the world. Although our investigation was conducted for a limited number of investment casting units, the study implied a different potential for different equipments. Whereas the efficiency of induction furnaces was found to be already equivalent to that of Japan, air conditioners for use in the drying process were found to be having relatively more potential for improvement. In fact, a rough calculation has shown the potential for reducing 140 $kt\text{-}CO_2\ year^{-1}$ while saving approximately Rs. 500 million $year^{-1}$ for one type of Japanese air conditioner. In terms of induction furnace, although the equipment itself is already efficient, relevant Japanese know-how (*i.e.*, *Kaizen*), such as material and usage of exthothermic powder, appear to be still useful for further improvement. Thus, it is also important to note that the low carbon technology for transfer should not be limited to physical asset, but informational asset could be equally important as well.

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