POTENTIAL ASSESSMENT STUDY AT SHRIRAM FOUNDRY LIMITED, KOLHAPUR

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Trinity Engineers have an average energy bill of 3.13 Crores per year. Through this energy assessment study, ECPL has assessed a potential to reduce this bill by at least 1.12 Crores per annum. The investment proposed shall have an attractive payback of less than two years. This saving can be further enhanced by duplexing with coke less cupolas.

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PROJECT INTRODUCTION & PREAMBLE:

The efficient use of energy is one of the most important sustainable solutions that allows for economic growth while mitigating green house gas emissions, a key contributor to climate change. The Bureau of Energy Efficiency (**BEE**), Government of India, has taken a lead role in implementing programs to improve energy efficiency, which is one of the key missions of the **GOI** National Climate Change Action Plan.

Despite overall Indian reductions in aggregate energy intensity, the **SME** sector has fallen behind certain larger Indian industry benchmarks in terms of productivity, technology upgradation and energy efficiency (**EE**). While **EE** projects can offer very attractive returns and banks and institutions in India are increasingly willing to finance such **EE** projects, they have not become the norm in Indian **SME** sector despite the best efforts of numerous institutions and organizations over the years. There are clearly several issues/barriers that still need to be addressed before widespread **EE** adoption by **SMEs** is a reality.

The World Bank (**WB**), in conjunction with implementing partner **BEE**, is preparing a new Initiative on **Financing Energy Efficiency in SME** industrial clusters to help overcome some of these barriers. The main objective of this initiative is to improve energy efficiency and reduce **GHG** emissions from Small and Medium Enterprises utilizing increased commercial financing. The project will systematically support development of a large number of **EE** investment proposals under a programmatic approach to aggregate demand for **EE** investment in selected **SME** industrial clusters and will work to create a sustainable mechanism for identifying, preparing and financing these proposals at the local level. The above initiative envisions supporting certain specific industrial clusters in India through provision of assistance for completion of energy audits, preparation of DPRs and support in mobilization of financing from the Indian local banks to ensure that the identified EE measures are implemented. The ultimate goal of the project is to support development of a

large portfolio of **EE** projects in the selected clusters, and help improve market acceptance (both by SMEs and local banks) for this type of product.

World Bank (**WB**) has decided to retain the services of Energetic consulting Pvt. Limited (**ECPL**), an audit firm of repute (3 year award winner of MEDA for excellence in Energy audit area), for providing **EE** facilitation assistance to 5 **SME** units under the proposed **WB** scheme. **ECPL** is required to carry out 5 Potential assessment studies (**PAS**) and then carry out Detailed Energy Audits and develop Investment Grade Detailed Project reports (**DPR**) in 2 **SME** units out of 5 **PAS**. **ECPL** shall also assist the select units in preparation of application to be submitted to banks, if so desired by the units. **WB**'s ultimate objective is to develop bankable **EE** projects in 2 units (with capital expenditure of Rs. 25 Lacs or more) with simple payback period not more than 2 years for the aggregated **EE** measures and ensure that the projects are implemented and units start saving on their energy cost in most cost effective manner. **ECPL** is committed to provide advisory services to the select units during the entire project development cycle till commissioning. WB then proposes to scale up the entire efforts to @ 150 **PAS** and develop @100 bankable **EE** projects for implementation in foundry units in Kolhapur region.

Under the proposed project **WB** will provide entire facilitation, **at its own cost**, to select **SME** units, to address the current gap between energy auditors and bank loan officers and will demonstrate a viable mechanism of synergic tie up between **SMEs**, energy auditors, financial analysts/chartered accountants, local associations and local bankers. The project will also provide complete information on current **EE** lending schemes of Indian banks, to assist the **SME** units to take well informed decision for financing the **EE** project. The ultimate financing choice for identified investments under this project will be demand driven, and participating **SME** units will be free to obtain financing from any of the sources available to them- including their existing banks, new banks who are participating in the **GEF** Project, or other internal/external sources.

A stakeholder workshop was organized by Association to present this new initiative and to solicit response from key SME Forging units in Pune region to participate actively in this WB initiative and take the advantage of soft costs being supported by WB/GEF project to implement the EE project in the SME unit, subject to off course, it being techno-commercially attractive.

FACILITY DESCRIPTION:

Shriram Foundry Pvt. Ltd, Kolhapur, is one of the leading manufacturing firms having production capacity of average 910 MT per month. The facility mainly has induction furnaces (2 numbers), cupola 2 (2numbers). Additionally, three air compressors, cooling water system including cooling water pumps for panel cooling and furnace cooling, lighting and blowers are part of electrical facility. The facility also has a machine shop where large numbers of small motors are used for individual machines with some of the machines having hydraulic systems.

PRESENT ENERGY SCENARIO:

Following table shows energy consumption and production in the plant.

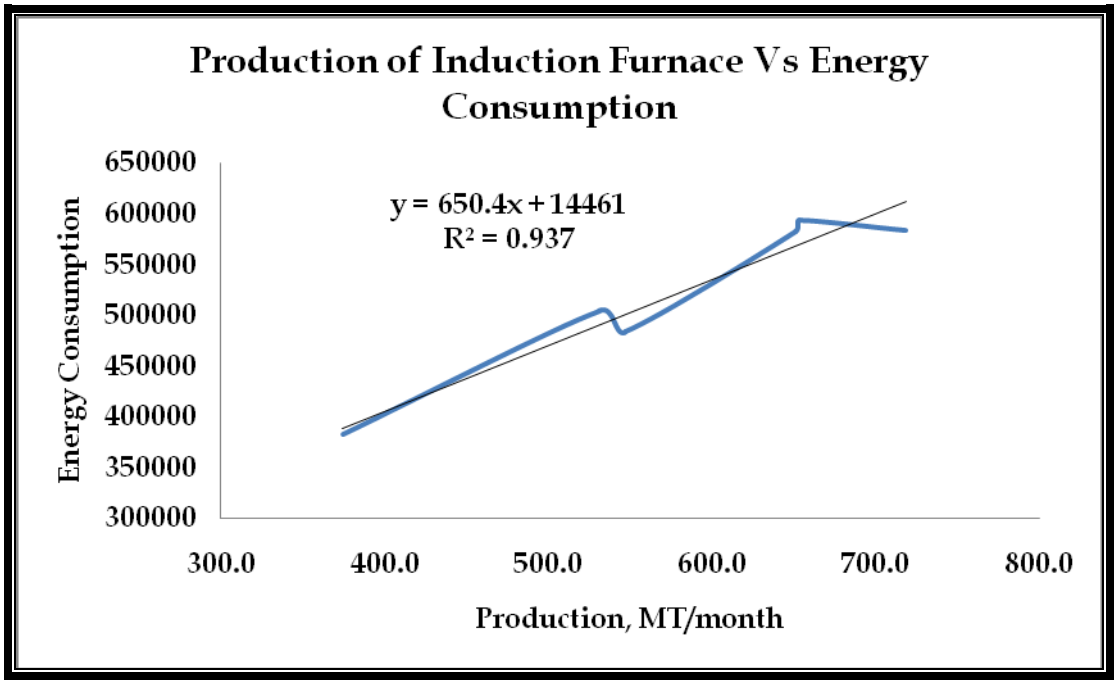
Month	CI Melting	S.G. Melting	Total Melting, MT	Unit Consumption	Unit Consumed /MT of Melting
Aug08-Sept08	191.2	527.7	718.8	583635	811.9
Sept08-Oct08	260.9	270.6	531.5	503970	948.2
Oct08-Nov08	270.0	276.6	546.6	483105	883.9
Nov08-Dec08	134.5	518.9	653.4	593865	908.9
Dec08-Jan09	189.0	462.1	651.1	582090	894.0
Jan09-Feb09	214.6	159.9	374.5	381960	1020.0
SUM	**1260.2**	**2215.7**	**3475.9**	**3128625.0**	**5466.9**
AVERAGE	**210.0**	**369.3**	**579.3**	**521437.5**	**911.2**

There are two cupolas though installed are presently not in use. Hence data of coke consumption is for year 2007-08.

YEAR	Month	Total Melting, MT	Coke Used, MT
2007	APR.	927.9	100
	MAY.	1041.9	113
	JUN.	1025.8	111.5
	JUL.	1028.7	112
	AUG.	926	100.6
2008	APR.	1011	109.9
	MAY.	1245.6	135.8
	JUN.	1249.8	135.8
SUM		**8456.7**	**918.6**
Average		**1057.1**	**114.8**

ANALYSIS OF DATA:

The average production volumes are 580 MT per month. There is a definite trend in the electrical energy consumption. The regression coefficient (R^2) is 0.937, which means that the data is not representative. This can be understood differently by understanding the nature of energy consumption. There is a definite energy relationship between production and melting (induction furnace) but the other energy consumption areas of the facility are not as linear and proportionate. This is due to the nature of their working. For example, air compressors are not linearly connected with the melting rates of the induction furnace. The graph, in a limited sense, is representative with this understanding. It can be concluded, though not decisively, that the energy consumption in the induction furnace is around 650.4 kWh per MT whereas the fixed monthly energy consumption of the entire facility is around 14461 kWh per month. Average overall energy consumption is in the range of 521440 kWh per month and the fixed component thus becomes 3%



RECOMMENDATIONS:

Energy consumption in the foundry is at Cupola (coke consumption) and Induction furnace (electrical energy consumption). Energy conservation opportunities in fuel are centered on improving energy efficiency by recouping waste heat from hot gases coming out of Cupola and converting carbon monoxide coming out of cupola. There is another way to reduce energy cost by substituting Coke by cheaper fuel like coal or briquettes.

Electrical energy conservation, however, is a function of power quality improvement and operating practices improvement.

Alternatively, overall system efficiency can be improved by shifting to captive generation of electricity by using Producer Gas fired generator sets. Though highly capital intensive this option has substantial energy conservation potential. Following chapter provides energy saving potential of each of the ideas and also their budgetary cost benefit analysis:

1. Hot Blast Cupola:

Flue gases coming out of the Cupola are at 600 deg C and are vented to the atmosphere (through a venturi scrubber). Fresh air gets mixed with the hot flue gases at the charging door and the whole heat is lost by dilution. This heat can be recouped by installing an air pre-heater where hot pre-heated air shall be admitted to cupola for combustion of coke.

It is recommended to install a recuperator to recoup waste heat and utilize it in the furnace through combustion air preheating. It is possible to increase temperature of the combustion air from ambient upto 300 deg C. This combustion air shall then require lesser fuel to achieve desired temperatures, thus resulting in energy conservation.

Typical case coke to metal ratio is 1:9 where around 110 kg coke is required per ton for melting. Please note that this consumption does not

include fuel requirement for ovens and/or ladle preheating. This also does not include fuel required for startup operations.

Combustion air shall take up 10% of the total heat fed to the system, around 11 kg coke/MT, resulting in loss equivalent to Rs. 220 per ton. This loss can be saved by providing recuperator without any other modification or alteration.

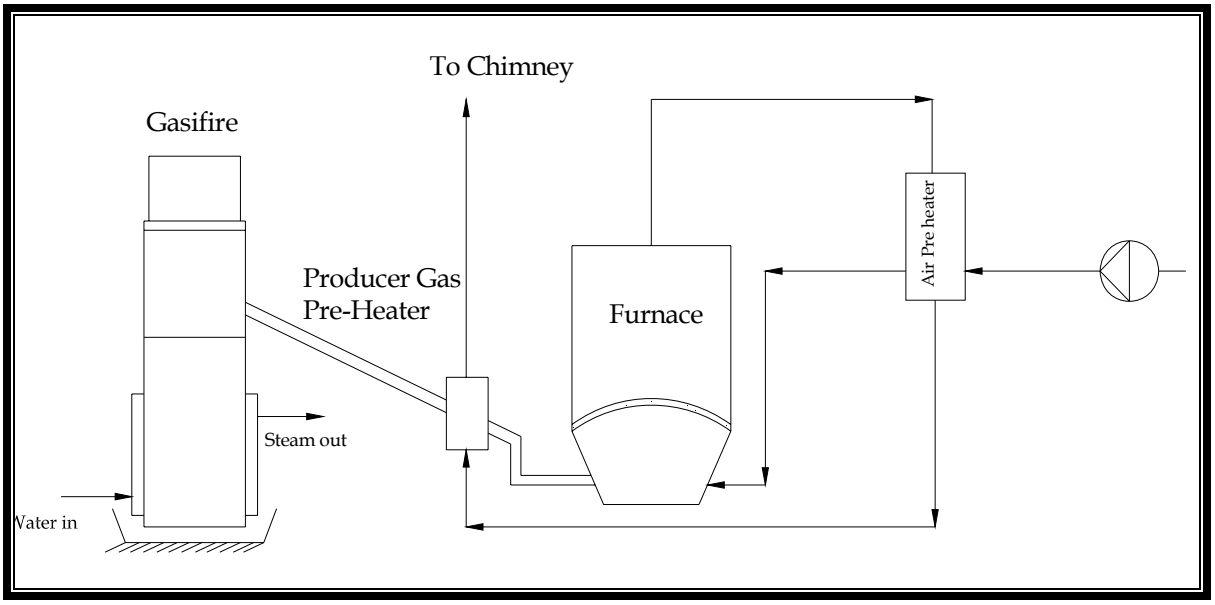
Year	Month	Total Melting, kg/month	Saving potential Rs. / Month @ Rs. 220 per MT Hot Blast Cupola
2007	April	927.9	204138
	May	1041.9	229218
	June	1025.8	225676
	July	1028.7	226314
	August	926	203720
2008	April	1011	222420
	May	1245.6	274032
	June	1249.8	274956
AVERAGE		**1057**	**232559**

From the above table is observed that the overall potential to save is in the range of Rs. 27 lacks per annum on the basis of production volumes of the year 2007-08. The investment is estimated to be in the range of 10 Lacks and the overall payback period shall be one year or less. It should be noted that the investment numbers can change depending upon the design specs.

2. Energy Cost Reduction through Coke Less Furnace With Producer Gas:

Coke, as a fuel can be replaced by coal fired Producer Gas. This gas, which is mixture of carbon Monoxide and Hydrogen, is generated at site by incomplete combustion of coal. There are several advantages of PG over coke viz;

1. Reduction in fuel cost
2. Reduction in loss due to un-burnt Carbon Monoxide
3. Reduction in sulphur pick up loss due to sulphur free fuel
4. Clean, pollution free combustion



From the above figure it is clear that the present cupola can be used as a producer gas generator and PG thus generated shall be used as a fuel in a new coke less furnace. This arrangement helps to ensure that the present cupola remains unaltered and still used productively.

DESIGN BASIS: 1000 kg metal production per hour

- **Heat input by Coke** **: 8,80,000 kcal**
- **Coke firing** : 110 kg
- Heat gain by metal : 3,66300 kcal (41.6%)
- Heat lost in FG : 2,12,468 kcal (24.1%)
- Heat loss due to CO formation : 3,01,232 kcal (34.3%)
- % Carbon converted to CO : 40%

These losses, particularly due to flue gases and carbon monoxide can be reduced substantially by use of PG plants. The PG plant actually generates carbon monoxide from the carbon available and further fires it in the furnace for heat generation. The flue gas losses are minimized by installing recuperator on the flue gases and preheating the air to a temperature of 300 deg C to ensure high flame temperatures. Typical application calculation suggests that 110 kg of coke is replaceable by 110 kg of coal, thereby reducing the present operating cost from ***Rs. 2200 per MT*** to ***Rs. 1100 per MT.***

Considering average 1000 MT of production volumes, the operating cost reduction is expected to be Rs. 132 Lac per annum. Capital investment for the entire project would be in the range of Rs. 150 Lacks with a payback period of around one year.

3. Energy Cost Reduction Through Divided Blast Cupola:

It can be seen in the recommendation 2 that major energy loss is due to conversion of 40% carbon to CO rather than CO_2. This loss can be prevented by providing air at two different points and ensuring combustion of CO to CO_2 above the combustion zone.

Several studies have been done on the DBC and their collective information is available with post implementation status. Following table shows results from one of the implementation reports:

- Charge coke consumption : 9.1%
- Ash in coke : 11.4 %
- Melt temperature at spout : 1377 o C to 1528 ° C
- Temperature of flue gas (below charging door) : 350 o C to 400 ° C
- Ferro-Silicon consumption : 0.21 % of metallics
- Ferro-Manganese consumption : 0.13 % of metallics
- Rejected castings : 7 % (atleast)

The specifications of the DBC were as follows:

- No. of cupolas : Two
- Desired melting rate : 2.8 tph (tonne per hour)
- Operation : Continuous
- Desired metal temperature at spout : 1425 oC to 1475 oC
- Typical melting campaign duration : 8 - 10 hours

	Consumption before, % of metal charged	**Consumption after, % of metallic charged**	**Savings after implementation of DBC**	**Approx. Coke cost (Rs/tonne)**	**Monetary savings Rs/tonne of molten metal**
Coke usage	9.1%	7.8%	30%	18,000	234
Ferro-silicon	0.21%	Nil	100%	63,000	132
Ferro- manganese	0.13%	Nil	100%	60,000	78
Total savings (material + energy)					444
Less: Additional power consumption in blower					(26)
Net savings (material + energy)					418
Reduced rejects					
Savings per 1% reduction in rejects					225
Reject levels: before 7%, after 5%					
Total savings (2% reduction in rejects)					450
TOTAL COST SAVINGS					**868**

Note: Case study of Shining Engineers & Founders, Rajkot

The overall monetary gain @Rs 868 per MT per month translates to Rs. 104 Lacks per annum for 1000 MT per month of melting and the cost of modifications are expected to be in the range of Rs. 80 Lacks with a simple payback period of less than 10 months.

4. Producer Gas Fired Generator Set:

Induction furnace is the other energy consuming system in the foundry where energy efficiency is relatively optimum. The scope for improvement by design of Induction Furnace is very expensive and does not payback within acceptable period.

It is therefore proposed that producer gas fired generator is the best solution for energy cost reduction and GHG emission reduction. Agro residue based briquettes can be used as a source of primary energy for power generation. The power generation cost can be brought down to Rs. 3.5 per unit. From the bill analysis the maximum electricity consumption of plant is 593865 units/month i.e. 1000 Unit/hr. It is possible to consider a generator of 1.5 MW capacities to meet the entire factory demand, including electrical gadgets and machinery. The capital investment for the generator sets would be in the range of Rs. 3 Crores. Considering Rs. 1.5 per unit as saving and last year power scenario the annual saving is worked out as below:

Month	CI Melting	S.G. Melting	Total Melting, MT	Unit Consumption	Saving, Rs. /month
Aug08-Sept08	191.2	527.7	718.8	583635	875452.5
Sept08-Oct08	260.9	270.6	531.5	503970	755955.0
Oct08-Nov08	270.0	276.6	546.6	483105	724657.5
Nov08-Dec08	134.5	518.9	653.4	593865	890797.5
Dec08-Jan09	189.0	462.1	651.1	582090	873135.0
Jan09-Feb09	214.6	159.9	374.5	381960	572940.0
AVERAGE	**210.0**	**369.3**	**579.3**	**521437.5**	**782156.3**
Total For Six Month					**4692937.5**
Expected Saving Per Annum					**9385875.0**

(Since only six months data is available expected saving is doubled of total for six month)

The simple pay back due to this option works out to 38 months. The project may be viable considering additional benefits like loss due power cut.

5. Use of Induction Furnace Only For Holding:

From given data, 910 MT/month is the production from the induction furnace. It is recommended to use this furnace only for holding the molten mass (Duplexing). Following example will indicate the saving due to use of induction furnace for duplexing.

The power consumption works out to 650 kWh per MT of melting. If coke is used in the cupola, as per standard industrial norm the coke requirement will be in the range of 90 to 110kg/MT.

Melting temperature achievable by cupola is lesser than required. Hence the melted mass can be transferred to induction furnace (Duplexing) which will consume less electrical energy i.e. 50kWh/MT. The total operating cost will be **Rs.1350 per MT** of melting.

The operating cost of electricity is **Rs. 3250 per MT** of Melting in induction furnace.

This means a saving of Rs. 1900 per MT of melting. Considering 910 MT/month of melting, the expected saving works out to 207 lacks per annum. The investment required for installation of new furnaces will be150 lakes. The simple payback works out to 9 month.

6. Lighting Energy Controller:

The plant lighting load is around 17 kW (based on the data provided by plant personnel) which corresponds to 20 kVA equivalent load. Considering 10 hours per day of light burning hours, the average energy bill of lighting would be Rs. 2.6 Lacks per annum out of which 25% can be reduced by installing lighting controller panel on the lighting feeders. Typical cost of the system would be Rs. 1.1 Lacks depending upon number of panels required. The payback period is expected to be in the range of 2 years or less. Vendors have been informed to contact facility and provide exact quotation.

7. Power Quality Improvement:

Induction furnaces have peculiar issues relating to power quality. Total Harmonic Distortion (THD), an indicator of disturbance in the system due to non-sinusoidal waveforms in current and voltage, has a major bearing on the energy loss. Harmonics are generated due to frequency modulation in the power circuit of the induction furnace resulting in around 10% THDV and 100% THDi. In-depth measurements are required for a designed solution to this problem. Combination of active and passive harmonic filters would be needed to limit the THD levels to acceptable norm.

It is inferred from the data available that there is a potential to save energy to the tune of 3.55 lacks kWh per year at an investment of Rs. 23 lacks. The monetary gain due to this investment is expected to be Rs. 17.74 lacks/annum with a simple payback period of 16 months.

It must be noted that exact energy saving potential shall be known only after detailed energy measurements during the DPR stage.

8. Oxygen Enrichment of Air:

This is one of the proven techniques to improve efficiency of furnaces, particularly where the temperature requirements are above 600°C. Conceptually, every kg of oxygen required for combustion is associated with 3.27 kg of nitrogen in air. This nitrogen does not contribute to chemical reaction with carbon from fuel but carries heat at very high temperature (around 1000 °C) amounting to huge heat loss.

It is possible to enrich atmospheric air oxygen content from 23.6% to 35% thereby reducing energy loss by 15%. Cost benefit analysis of this suggestion can be worked out only after detailed study as nitrogen separated from air is available to replace compressed air and composite benefit should be considered.

CONCLUSION

There are several opportunities for the units to reduce their energy cost substantially. Innovation would be the essence of such implementation project. Demonstration projects shall be implemented in this phase of pilot study and the benefits shall be showcased.

Summary of all ideas for energy conservation are as follows:

PARTICULARS OF PROPOSED RECOMMENDATION	INVESTMENT	SAVING POTENTIAL	SIMPLE PAYBACK,	GHG Reduction Potential, ton of CO_2
	Rs. Lacks	Rs. Lacks/annum	Months	
Waste Heat Recovery though recuperator	10	27	5	405
Energy cost reduction through Producer Gas	NA as cupolas are not in use			NA
Divided Blast Cupola	80	104	9	1560
Producer gas fired DG set	300	93.85	38	NA
Using PG fired Cupola Melting and induction furnaces for holding	150	207	9	3312
Lighting energy controller	1.1	0.63	21	10.1
Power Quality Improvement	23	17.74	16	284
Oxygen enrichment of air	NOT QUANTIFIED			NA

Some of the above figures are overlapping in nature. The exact savings due to this energy saving ideas can not be work out unless DPR is prepared. Though the figures indicated in the savings and investment column are fairly indicative, the basis of calculations is data provided by the unit. It is essential to verify the data through detailed measurements by auditors at the DPR stage and design the solutions in consultation with the plant management.