DETAILED PROJECT REPORT
ON
AIR PRE-HEATER USING HEAT PIPE HEAT EXCHANGERS
HOWRAH CLUSTER











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AIR PRE-HEATER USING HEAT PIPE HEAT EXCHANGERS

HOWRAH GALVANIZING AND WIRE DRAWING CLUSTER

BEE, 2010

Detailed Project Report on Air Pre-heater Heat Pipe Heat Exchangers for Galvanizing and Annealing Furnaces

Galvanizing and Wire Drawing SME Cluster,

Howrah, West Bengal (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No: ***HWR/WDG/HPE/10***

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Indian Institute of Social Welfare and Business Management(IISWBM) is also thankful to District Industry Center (DIC), Howrah chamber of Commerce & Industry(HCCI), Bengal National Chamber of commerce & Industry(BNCCI), Federation of Small & Medium Industry(FOSMI) and West Bengal Renewable Energy Development Agency(WBREDA) for their valuable inputs, co-operation, support and identification of the units for energy use and technology audit studies and facilitating the implementation of BEE SME program in Howrah Galvanizing and Wire Drawing Cluster.

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Indian Institute of Social Welfare and Business Management Kolkata

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List of Abbreviation

APH	Air Pre-heater
APHHPHE	Air Pre-heater employing Heat Pipe Heat Exchangers
BEE	Bureau of Energy Efficiency
CDM	Clean Development Mechanism
DPR	Detailed Project Report
DSCR	Debt Service Coverage Ratio
GHG	Green House Gases
GWh	Giga Watt Hours
HPHE	Heat Pipe Heat Exchangers
IRR	Internal Rate of Return
MT, MW	Million Ton, Mega Watt
NPV	Net Present Value
ROI	Return on Investment
SCM	Standard Cubic Meter
SHC Coal	Semi Hard Coke Coal
MoMSME	Ministry of Micro Small and Medium Enterprises
SIDBI	Small Industrial Development Bank of India
TPA	Ton per Annum

EXECUTIVE SUMMARY

Indian Institute of School Welfare and Business management (IISWBM) is executing BEE-SME program in the Galvanizing and Wire Drawing Cluster of Howrah, supported by Bureau of Energy Efficiency (BEE) with an overall objective of improving the energy efficiency in cluster units.

Howrah Galvanizing and Wire Drawing Cluster was one of the major clusters of Galvanizing and Wire-drawing in Howrah district of West Bengal. There are about 100 SMEs in Galvanizing and Wire-drawing sector of Howrah Cluster comprising about 50% galvanizing units and 50% wire drawing units. The units are constantly under threat of closure due to poor energy efficiency along with pollution issues and variability in demand. Improvement in energy efficiency would largely ensure sustainable growth of the sector, which needs a mechanism to identify technology and techniques for improving energy efficiency in these highly unorganized and so far uncared for industrial units.

Every galvanizing unit of the cluster has furnaces to melt zinc. Even some of the wire-drawing units have furnaces to perform annealing. Conventionally, the flue gas from these furnaces is simply allowed to escape, taking away a lot of unused heat. A part of the waste heat may be recovered by installing apparatus, such as, air pre-heater using heat pipe heat exchangers (applicable in those units where flue gas temperature does not exceeds 315 ^{o}C), where the secondary air to be used for combustion is pre-heated, thereby reducing fuel consumption.

Installation of one of the waste heat recovery systems i.e. installation of air pre-heater using heat pipe heat exchangers in the existing furnace would lead to fuel saving upto 4935 litre furnace oil per year.

This DPR highlights the details of the study conducted for assessing the potential for installation of heat pipe heat exchangers, possible energy saving and its monetary benefit, availability of the technologies/design, local service providers, technical features & proposed equipment specifications, various barriers in implementation, environmental aspects, estimated GHG reductions, capital cost, financial analysis, sensitivity analysis in different scenarios and schedule of project implementation.

This bankable DPR also found eligible for subsidy scheme of MoMSME for “Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises” under “National Manufacturing and Competitiveness Programme”. The key indicators of the DPR including the Project cost, debt equity ratio, monetary benefit and other necessary parameters are given in table:

S.No	Particular	Unit	Value
1	Project cost	₹ in lakh	3.73
2	Furnace Oil saving	litre/year	4935
3	Monetary benefit	₹ in lakh	1.68
4	Simple payback period	Year	2.22
5	NPV	₹ in lakh	2.37
6	IRR	%	27.67
7	ROI	%	25.74
8	DSCR	Ratio	1.84
9	CO_2 emission reduction	Ton/year	16
10	Process down time	Days	4

The projected profitability and cash flow statements indicate that the project implementation i.e. installation of heat pipe heat exchangers will be financially viable and technically feasible solution for galvanizing and wire drawing cluster.

ABOUT BEE'S SME PROGRAM

The Bureau of Energy Efficiency (BEE) is implementing a BEE-SME Programme to improve the energy performance in 25 selected SMEs clusters. Howrah Galvanizing and Wire Drawing Cluster is one of them. The SME Programme of BEE intends to enhance the awareness about energy efficiency in each cluster by funding/subsidizing need based studies and giving energy conservation recommendations. For addressing the specific problems of these SMEs and enhancing energy efficiency in the clusters, BEE will be focusing on energy efficiency, energy conservation and technology up-gradation through studies and pilot projects in these SMEs clusters.

***Major activities in the BEE -SME program are furnished below*:**

Activity 1: Energy use and technology audit

The energy use technology studies would provide information on technology status, best operating practices, gaps in skills and knowledge on energy conservation opportunities, energy saving potential and new energy efficient technologies, etc for each of the sub sector in SMEs.

Activity 2: Capacity building of stake holders in cluster on energy efficiency

In most of the cases SME entrepreneurs are dependent on the locally available technologies, service providers for various reasons. To address this issue BEE has also undertaken capacity building of local service providers and entrepreneurs/ Managers of SMEs on energy efficiency improvement in their units as well as clusters. The local service providers will be trained in order to be able to provide the local services in setting up of energy efficiency projects in the clusters.

Activity 3: Implementation of energy efficiency measures

To implement the technology up-gradation project in the clusters, BEE has proposed to prepare the technology based detailed project reports (DPRs) for a minimum of five technologies in three capacities for each technology.

Activity 4: Facilitation of innovative financing mechanisms for implementation of energy efficiency projects

The objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion.

1 INTRODUCTION

1.1 Brief Introduction about cluster

The Galvanizing and Wire-drawing cluster in Howrah district of West Bengal is a very large cluster. There are about 100 SMEs in the Howrah Cluster and comprising of about 50% galvanizing units and 50% wire drawing units. The units are constantly under threat of closure due to poor energy efficiency along with pollution issues and variability in demand. Improvement in energy efficiency would largely ensure sustainable growth of the sector. It needs a mechanism to identify technology and techniques for improving energy efficiency in this highly unorganized and so far uncared for industrial units.

The major raw materials for the Galvanizing industry are zinc, ammonium chloride, hydrochloric acid, and di-chromate powder. On the other hand, the raw materials used in Wire-drawing units are Mild Steel (MS) / Copper / Aluminium Wires of gauges varying from 14 to 4 gauge i.e. 1.6 to 5.1 mm dia., while Uni-Lab powder (made by Predington Company based in Bombay) or Grommet–44 is used for lubrication (eg.).

The main form of energy used by the cluster units are grid electricity, Furnace Oil, Coal, LPG and Diesel oil. Major consumptions of energy are in the form of Furnace Oil and Diesel. Details of total energy consumption at Howrah cluster are furnished in Table 1.1a and 1.1b:

Table 1.1a Details of annual energy consumption in the wire drawing units

S. No	Type of Fuel	Unit	Value	% contribution
1	Electricity	GWh/year	2.24	76
2	Wood	Ton/year	300	5
3	LPG	Ton/year	70.5	19

Table 1.1b Details of annual energy consumption in the galvanizing units

S. No	Type of Fuel	Unit	Value	% contribution
1	Electricity	MWh/year	867.3	13
2	Diesel	kl/year	19.2	2
3	Furnace Oil	kl/year	731.7	62.5
4	Coal	Ton/year	1161	18.5
5	Wood	Ton/year	600	4

Classification of Units

The Galvanizing and Wire Drawing units can be broadly classified on the basis of the following criteria:

1) Product wise
2) Production capacity wise

Products Manufactured

The galvanizing units can be classified on the basis of products into five basis groups. These are:

a) Units producing transmission tower structures
b) Units producing fastener items
c) Units producing angles and channels
d) Units working on scrap iron
e) Units producing wires

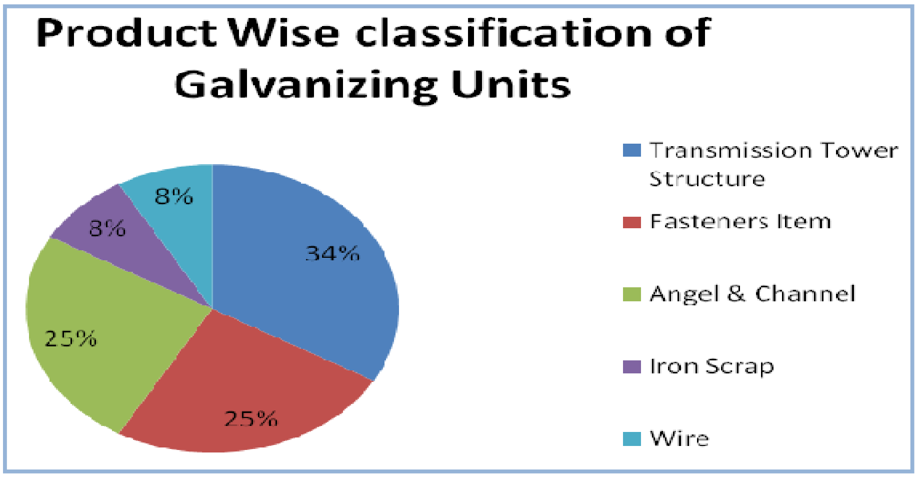


Figure 1.1: Product Wise Classification of Galvanizing Units

Similarly, the wire drawing units are mainly classified into the following categories on the basis of products manufactured as units, which produce:

a) MS wire
b) Copper Wire
c) High carbon wire
d) Aluminium wire

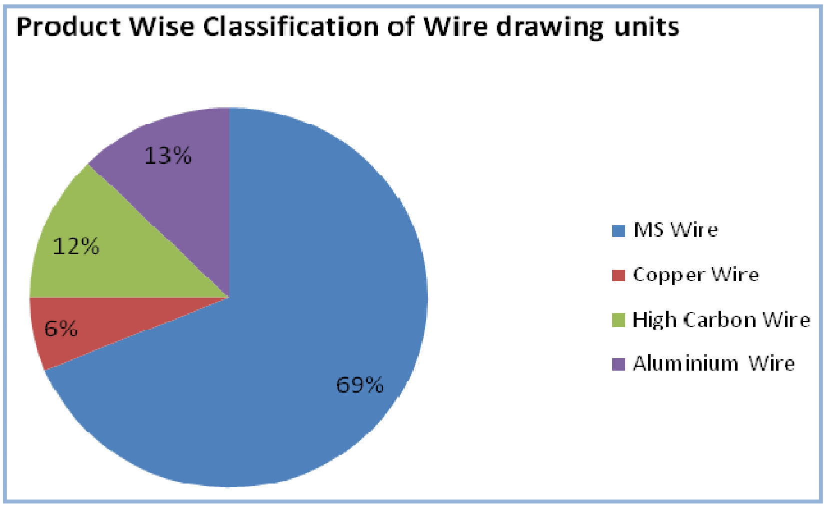


Figure 1.2: Product Wise Classification of Wire-drawing Units

Capacity wise production

In both Wiredrawing and Galvanizing units in Howrah, the production capacity has been found to vary more than 10 folds. In the units, where detailed audit has been performed, there are Wire-drawing units producing as low as 241 Ton/year to as high as 3500 Ton/year. Similarly, the production from Galvanizing units, where audit was performed, has been found to be within the range of 890 to 7500 Ton per annum. Both the Galvanizing and the Wire Drawing units have been classified on the basis of production into three categories, namely 1-500 TPA (calling micro scale), 500-1000 TPA (small scale) and above 1000 TPA (medium scale) capacities.

The distribution of units of Galvanizing and Wire Drawing industries has been depicted in Figures 1.3 and 1.4:

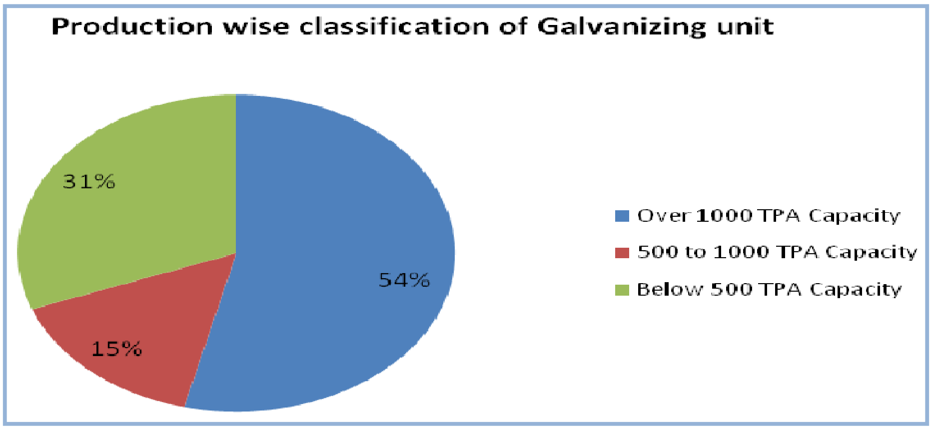


Figure 1.3: Production Wise Classification of Galvanizing Units

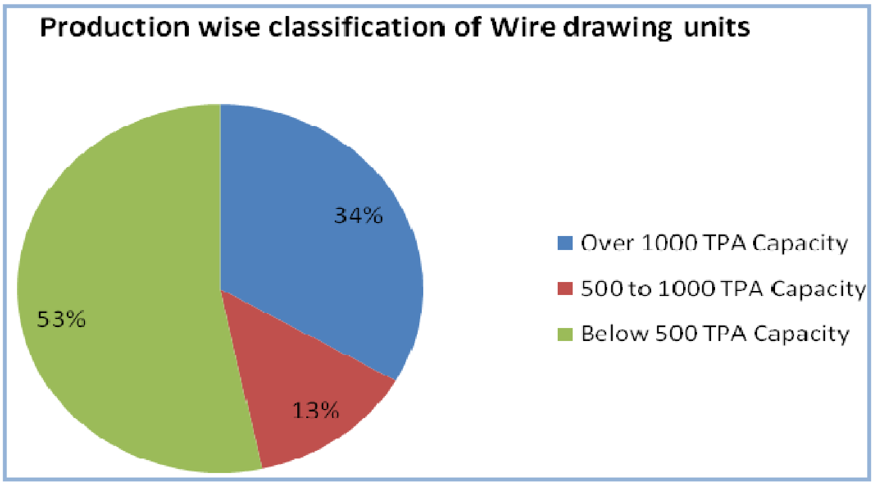


Figure 1.4: Production Wise Classification of Wire-drawing Units

Energy usages pattern

Average yearly electricity consumption in Wire Drawing unit ranges from 820 to 700 MWh depending on the size of the unit. In thermal energy, solid fuel such as wood and gaseous fuel like LPG are used in annealing furnaces in some of the units. The LPG consumption in a typical unit is about 135000 kg/year. The wood consumption in a typical unit is about 300 Ton/year.

Average yearly electricity consumption in a galvanizing unit ranges from 60 thousands to 3 lakh kWh depending on the size of the unit and type of operations performed. In thermal energy, furnace oil is primarily used in the galvanizing furnaces since it is reasonably cheap. The use of FO ranges from 50 to 450 kl/year. The use of diesel oil ranges from 1.3 to 19.2 kl/year and is used in either drying the job or pre-heating flux solution. SHC coal is also used for the purpose of drying the job and ranges from 150 to 800 MT/year. Wood is used in some larger units, which have facilities for running processes other than galvanizing. It can typically use 600 MT/year of wood.

General production process for the wire drawing units

The wire about to be drawn is first put into an annealing furnace. The annealed wire is then put into drums for coiling. Thereafter, the wire is put through dies of various sizes interspersed by sets of coiler drums.

These drums are driven by electric motors that are of induction type. The chemical used for lubricating the wire through the die is mainly wire-drawing powder (as it is commonly termed in the wire-drawing industry). The finished products of MS Wires are stacked on a steeper from where finished goods are dispatched to the end customers, after dipping in to a rustpreventive oil solution, which protects the final product from corrosion for up to one-and-half month. The finished wire products are mainly supplied to downstream industries such as galvanisers, electrical manufactures and the local market.

General production process flow diagram for drawing wires is shown in Figure 1.5.

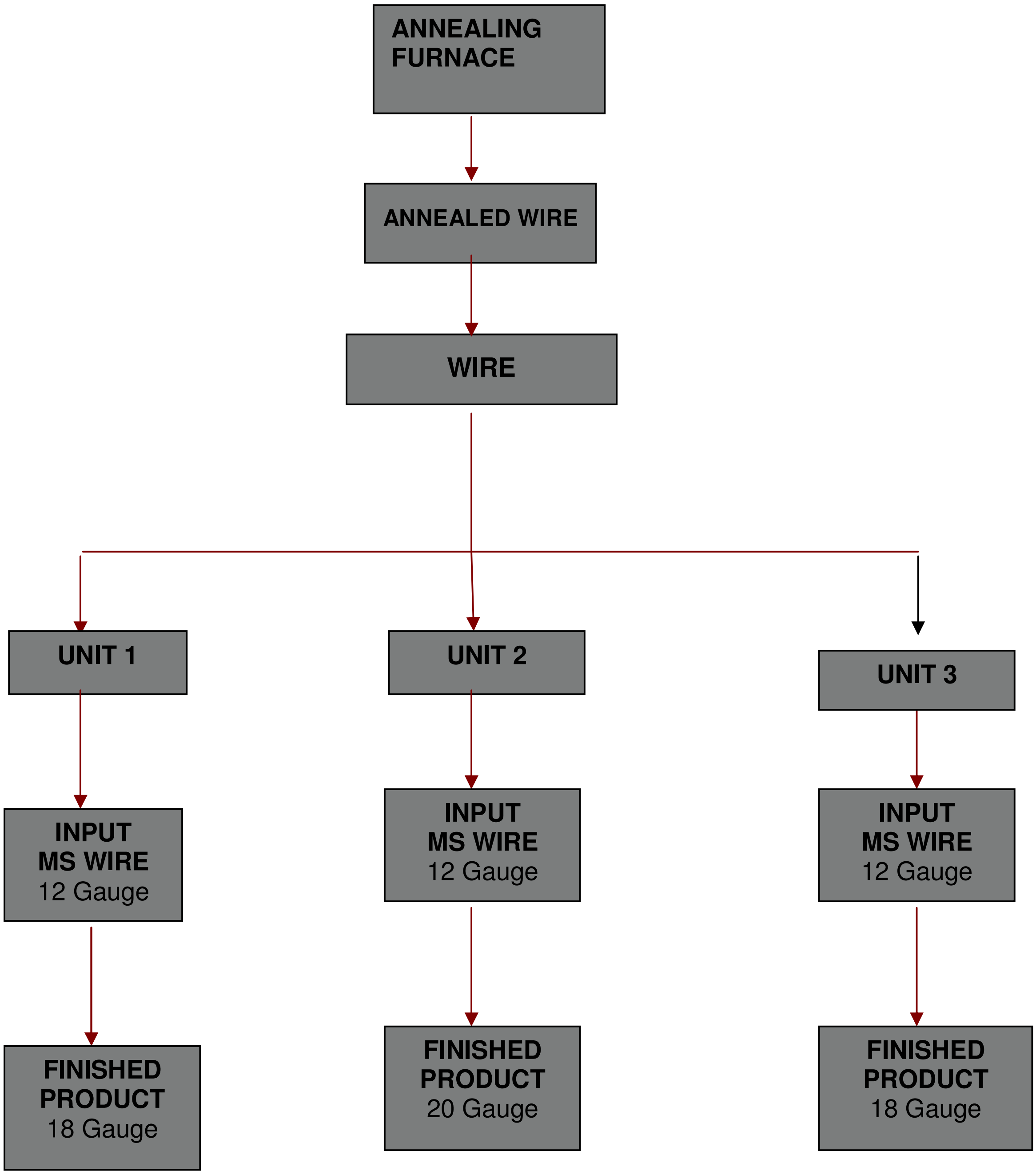


Figure 1.5 Process flow diagrams for a typical wire drawing unit

General production process for the galvanizing units

In a typical galvanizing unit, the production process involves seven stages as is shown in the schematic diagram in Figure 1.6. First the job or the raw material, which is to be galvanized is dipped in dilute acid solution and termed acid pickling. After the acid pickling process, the job is rinsed in plain water to remove any acid layer present on the job surface. Thereafter, the job is moved onto a SHC coal or diesel or FO based drying bed or flux solution for preheating and drying purpose. This helps produce a uniform layer of zinc on the job surface when the job is dipped in the zinc bath. Then after the drying process is over, the job is dipped into the zinc bath for galvanizing where a layer of molten zinc is deposited uniformly over the job surface.

When the job is taken out of the zinc bath, ammonium chloride powder (the fluxing agent) is sprayed over the job to remove the impurities and other dust particles remaining over the surface. Then the job is dipped in plain cold water for cooling. This process is termed as water quenching. After completion of the water-quenching process, the job is dipped into dichromate solution to give a glazing effect to the job galvanized. The description of the above galvanizing process is depicted in the Figure 1.6 process flow diagram.

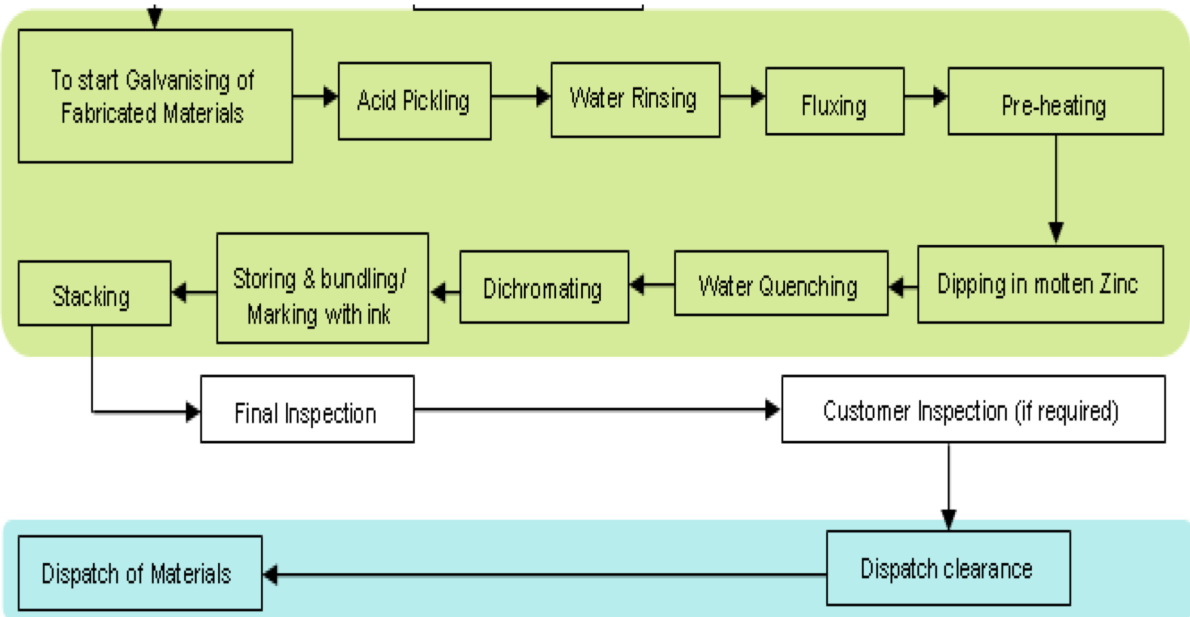


Fig 1.6: Process Flow diagram for a typical galvanizing unit

1.2 Energy performance in existing system

1.2.1 Fuel consumption

Average fuel and electricity consumption in typical wire drawing units is given in Table 1.2 and that of galvanizing units is given in Table 1.3. A small unit is defined to be a unit with production between 500 and 1000 TPA and medium to be greater than 1000 TPA. The micro units are defined to have capacity less than 500 TPA.

Only the larger wire drawing industries have furnaces and also perform annealing. Among the wire drawing units audited, only one, which was also larger used wood for annealing. Further, most of the wire drawing units produces MS wires.

Table 1.2 Average fuel and electricity consumption in typical wire drawing units

Scale of Unit	Micro	Small	Medium		
Energy	Electricity (kWh/ yr)	Electricity (kWh/ yr)	Electricity (kWh/ yr)	LPG (Ton/yr)	Wood (Ton/yr)
MS wire	101486	209216	266889	NA	300
Copper wire	NA	NA	295310	70.5	NA
High carbon wire	NA	NA	1088751	NA	NA
Aluminium wire	NA	NA	266889	NA	NA

Table 1.3 Average fuel and electricity consumption in typical galvanizing units

Scale of Unit	Small			Medium				
Energy	Electricity	Furnace Oil	Diesel Oil	Electricity	Furnace Oil	Diesel Oil	SHC coal	Wood
	(kWh/ yr)	(l/yr)	(l/yr)	(kWh/ yr)	(l/yr)	(l/yr)	(kg/yr)	(kg/yr)
Transmission Tower Structure	NA	NA	NA	59346	85195	NA	NA	NA
Fasteners Item	107670	132000	19200	109883	112500	NA	21000	NA
Angle & Channel	NA	NA	NA	35491	165000	NA	150000	NA
Wire	NA	NA	NA	302013	165000	7040	NA	600000

1.2.2 Average annual production

Annual production in terms of TPA is taken in case of wire drawing units. The micro units are defined to have production less than 500 TPA, small to be between 500 and 1000 TPA and medium to have production higher than 1000 TPA.

Table 1.4 Typical average annual production in wire drawing units

S. No.	Type of Industry	Production (in TPA)		
		Micro scale	Small scale	Medium scale
1	MS wire	100	600	2000
2	Copper wire	NA	NA	1000
3	High carbon wire	NA	NA	1000
4	Aluminium wire	100	NA	700

Table 1.5 Typical average annual production in galvanizing units

S. No.	Type of Industry	Production (in TPA)		
		Small scale	Medium scale	Large scale
1	Transmission Tower Structure	NA	NA	1969
2	Fasteners Item	200	890	4320
3	Angel & Channel	150	NA	3750
4	Wire	NA	NA	3650

1.2.3 Specific energy consumption

Specific energy consumption both electrical and thermal energy per Ton of production for galvanizing and wire drawing units are furnished in Table 1.6 below:

Table 1.6: Specific Energy Consumption in Galvanizing and Wire-drawing Units

Parameter		Unit	Specific Energy Consumption		
			Min	Max	Average
Galvanizing	Electrical	kWh/Ton	5.12	120	46.15
	Thermal	kCal/Ton	200370	579600	385978
Wire Drawing	Electrical	kWh/Ton	30	868	308
	Thermal	kCal/Ton	135	511	323

Specific energy consumptions are found to vary widely for wire-drawing and galvanizing processes in the Howrah cluster as shown in the above table. This is because of the variation in size of units, size & type of job, fuels types and volume of process, as, for example, some of the Galvanizing units, manufacturing the microwave tower and high-tension electricity transmission towers, have extensive fabrication activity as a part of the process.

1.3 Existing technology/equipment

1.3.1 Description of existing technology

In a typical galvanizing unit, the percentage of the furnace oil cost among the entire fuel bill is 73% and costs approximately ₹ 37 lakh per year. Fuel efficiency of the furnaces could have been improved by recovering part of the waste heat in the flue gas to pre-heat the combustion air by raising its temperature at least by 110 deg C from ambient without any modification in the burner. On the contrary significant amount of heat is wasted through flue gas at a temperature of 300 deg C (fig. 1.7) much higher than the temperature required for pre-heating the combustion air in a heat pipe heat exchangers which is absent in existing technology in the cluster. The waste can be equivalent to 6651 litre of oil (or 16062 kg of coal) per year.

Similarly, in case of wire drawing units, having annealing furnaces, either electricity or wood is used as a fuel. While the case of electric furnace has been dealt in separate DPR, the use of APHHPHE in case of wood fired annealing furnace could be dealt as has been discussed in the present DPR.

The primary use of the furnaces in galvanizing units is to melt zinc into which the job to be galvanized is dipped. IS: 2629 – 1985 suggests temperature of the zinc vat as 440 - 460 deg C. The heat loss calculations are shown below:

Table 1.7: Heat loss calculation

Particular	Unit	Value
Flue gas temperature	deg C	300
Mass flow of flue gas (from measurement)	kg/kg of fuel	21.72
Specific heat of flue gas	kcal/kg/deg C	0.24
Allowable exhaust temperature of flue gas	deg C	190
Temperature drop	deg C	110
Heat loss	kcal/kg of fuel	573
Total oil consumption	l/yr	120480
Total oil consumption	kg/yr	112046
Heat loss per year	kcal/yr	64248302
Gross Calorific Value of oil	kcal/kg	10500
Equivalent oil loss	kg/yr	6119
Equivalent oil loss	litre/yr	6651
Gross Calorific Value of coal	kcal/kg	4000
Equivalent coal loss	kg/yr	16062

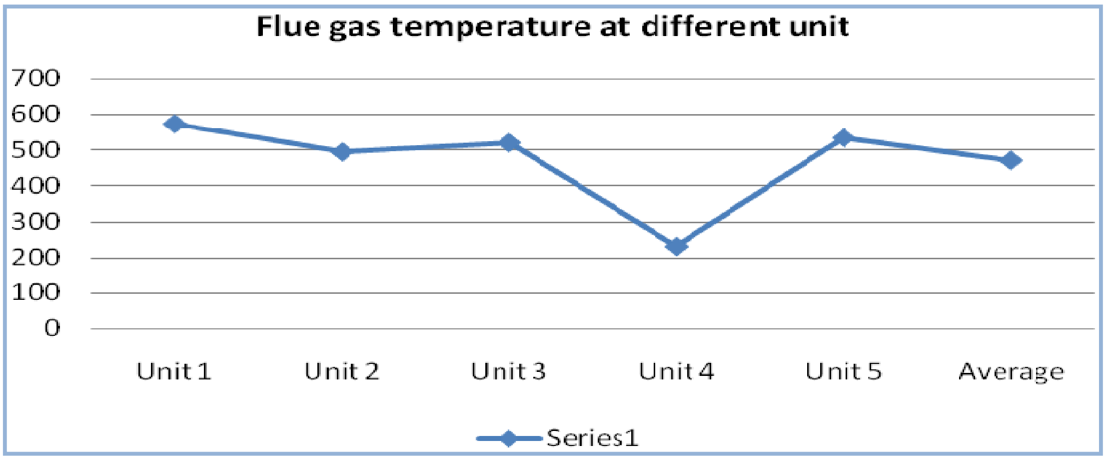


Fig 1.7: Flue gas temperature at different unit

Table 1.8 Cluster specifications of present furnaces

S. No.	Parameter	Detail
1	Manufacturer	Local
2	Dimensions	1.06 m x 0.66 m x 0.76 m to 6.8 m x 0.86 m x 0.86 m
3	Average F.O. consumption	31 to 42 litre/hr
4	Temperature of zinc vat	460 deg C to 490 deg C
5	Capacity of vat	5 to 13 Ton
6	Typical wall temperature	90 to 150 deg C
7	Ambient temperature max	30 deg C

Energy charges

The cost of furnace oil is ₹ 34 per litre. Demand charge is ₹ 220 per kVA in WBSEDCL and CESC.

1.3.2 Role in process

Furnaces heat up the crucibles, locally known as zinc vat, in which zinc is melted. The job to be galvanized is dipped in the molten zinc during the hot dip process. IS: 2629 – 1985 suggests temperature of the zinc vat as 440 - 460 deg C.

1.4 Baseline establishment for existing technology

1.4.1 Design and operating parameters

The typical furnaces used at present in the galvanizing and wire drawing units releases waste flue gas at temperature ranges between 300 - 470 deg C. The typical specific energy consumption for galvanizing has been found to be 1997934 kcal /Ton.

Table 1.9 Present furnace specifications

S. No.	Parameter	Detail
1	Manufacturer	Local
2	Dimensions	104 inch X 96 inch X 39 inch
3	Average F.O. consumption	42 litre/hr
4	Temperature of molten zinc	480 deg C
5	Capacity of vat	5 Ton
6	Typical wall temperature	90 deg C
7	Ambient temperature max	30 deg C

The average operating hour of furnace was found to be about 12 hours per day X 240 days per year = 2880 hours per year. There were two burners in zinc vat furnace and using furnace oil in this furnace.

Furnace Oil consumption in the galvanizing furnaces depend on the following parameters

a) Condition of the walls and insulation

b) Size of the job to be galvanized

c) Amount of excess air provided for combustion.

d) Amount of zinc to be heated

Fuel requirement in the galvanizing plant depends on the production. Detail of fuel consumption in a typical unit is given in Table 1.10 below:

Table 1.10 Fuel consumption at a typical galvanizing unit

S. No.	Energy Type	Unit	Value
1	Electricity	kWh/yr	107670
2	Furnace Oil	litre/yr	120480

1.4.2 Operating efficiency analysis

Operating efficiency for a normal furnace is found to be in the range of 10 to 20%. The table in annexure 1 shows calculations of efficiency by the direct and the indirect methods.

1.5 Barriers in adoption of proposed equipment

1.5.1 Technological barrier

In Howrah cluster, the technical understanding of the wire drawing process has been excellent with several committed technical personnel having detailed know-how of the processes involved. However, traditional thinking and applying what others in the business are doing is a trend found to be prevalent over innovative thoughts. For example, although there is a huge potential for recovering the waste-heat of flue gas, no unit was found to use the same for pre-heating of combustion air. Indeed there is committed effort on the part of the management in such units to grasp alterations which may give them benefits however with the caveat that the advantages be proven without any doubt.

People are generally reluctant to invest in an experimental scheme particularly if the sufficient savings are not guaranteed. Hence, finding the first person, who is willing to implement heat pipe heat exchangers would be the clue to widespread application of economically viable energy efficiency practices in the cluster. While carrying out the audits and presenting the energy audit reports to the units, in the discussion with the plant owners & other personnel, many of them agreed with many of the identified energy saving measures and technologies. Since use of heat pipe heat exchangers was totally absent before the present project activity in the Howrah cluster, rather it involves significant investment, the idea though was welcome, the units showed a tendency to fabricate their own such system by their known local fabricators, to develop very cheap, non-durable and inefficient air pre-heating system.

1.5.2 Financial barrier

Finance for heat pipe heat exchangers in Galvanizing Units could be an issue for two reasons: (1) smaller units prefer cheaper solutions rather than long-term cost-effective energy efficient technologies, and (2) even medium sized units look for proven technologies successfully implemented in the cluster. A mention must be made of SIDBI whose schemes have attracted attention, can potentially encourage them to take meaningful risk and can play a catalytic role in the implementation of the measures, i.e. installation of air pre-heater system.

1.5.3 Skilled manpower

Technical personnel employed in the units are generally skilled works but not engineers to be able to fully appreciate the maintenance practices for higher energy efficiency. Thus the production process remains traditional. This is one of the main hindrances in adopting newer technology. Specialized training between the workforce and local experts is necessary, after installation of heat pipe heat exchangers, to circumvent the problem significantly. Such training in other units would accelerate effective dissemination process to harness the replication potential in the various units. The gains obtained upon installation of heat pipe heat exchangers by one plant can inspire other units, whose flue gas temperature does not exceeds 315 deg C, to follow suit.

2. PROPOSED EQUIPMENT FOR ENERGY EFFICENCY IMPROVEMENT

2.1 Description of proposed equipment

2.1.1 Details of proposed equipment

All the galvanizing units and some wire drawing units have furnaces in them. Some of these furnaces let flue gases out at temperature 300 deg C, which simply escape to the environment. The heat in the flue gas could be recovered to pre-heat the combustion air. The present efficiency of these furnaces is typically in the range of 10-20%. If the secondary combustion air to the furnace is pre-heated using the air pre-heater employing heat pipe heat exchangers (APHHPHE), the furnace requires less fuel.

APHHPHE is a very efficient lightweight compact waste heat recovery system. It is a self-contained passive energy recovery device. Typical finned hot flue gas to air heat pipe heat exchangers comprise of number of tubular gravity assisted finned heat pipes arranged in staggered pitch, depending upon the application. A partition divides the exchanger into two sections, thus ensuring the separation of supply air and exhaust flue gas flows. Each heat pipe is an individual heat exchanger not dependent on any other part to ensure operation. The exchanger formed by these heat pipes is a counter flow design. In operation, exhaust hot gas is passed across one section of the exchanger (exhaust side) and supply air is ducted in counter flow direction across the other section (supply side). Heat is transferred from the hot gad stream to the cold supply air stream by the heat pipes. One of the advantages of the heat pipe heat exchanger is its ability to operate without cross contamination between the two streams.

Apart from this, its other advantages in comparison with conventional heat exchangers are as follows:

- Large quantities of heat transported through a small cross-sectional area with no additional Power input to the system
- Independent operation of each individual pipe hence each unit is less vulnerable to failure
- Less pressure drop of fluid
- Absence of moving parts, high reliability, simpler structure and smaller volume, thereby ensuring little maintenance
- High efficiency ensuring minimal loss of waste energy
- Recovers heat and reduces the environmental pollution levels
- APHHPHE reduces the fuel consumption

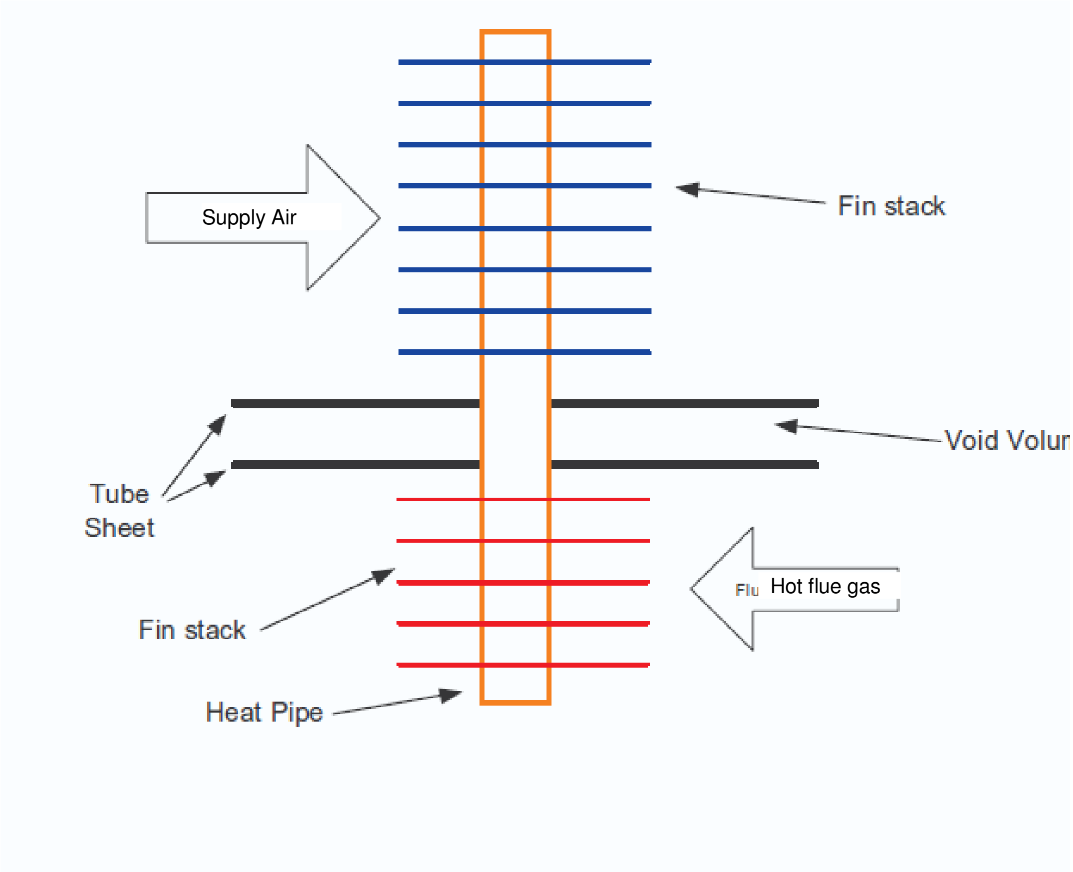


Fig. 1.8: Schematic of Heat Pipe Heat Exchanger

It may be noted that flue gas after installation of APHHPHE would be released at 190 deg C which is having further potential to recover the waste heat. The present limitation of preheated air temperature not to exceed 120 deg C for the burners in use, which could be achieved in near future through improvement in such burners so that further recovery of waste heat would be possible leading to higher Financial Parameters.

2.1.2 Equipment/ technology specification

The furnaces used typically dump flue gases at temperatures of 300 deg C. The APHHPHE recovers a part of the heat.

Table 2.1 Technical specification of a heat pipe heat exchangers

S. No	Parameter	Detail
1	Manufacturer	Manor Enterprises
2	Dimension of the APHHPHE	1 m x 1 m x 1.5 m

S. No	Parameter	Detail
3	Average F.O. consumption	42 liter/hr
4	Air mass flow rate	833 kg/hr
5	Temperature of fresh air at the APH inlet	30 deg C
6	Temperature of combustion air at the APH outlet	140 deg C
7	Typical temperature of flue gas going into APH	300 deg C
8	Typical temperature of flue gas coming out of APH	190 deg C

Further details of APHHPHE saving calculation are shown in Annexure 3.

2.1.3 Integration with existing equipment

The flue gas coming out of the furnace is passed across one section of the exchanger (exhaust side) and supply air is ducted in counter flow direction across the other section (supply side). Heat is transferred from the hot airstream to the cold airstream by the heat pipes. This apparatus could be installed separately and would not effect the operation of the furnace in any way.

The following are the reasons for selection of this technology

- Large quantities of heat transported through a small cross-sectional area with no additional Power input to the system
- Independent operation of each individual pipe hence each unit is less vulnerable to failure
- Less pressure drop of fluid
- Absence of moving parts, high reliability, simpler structure and smaller volume, thereby ensuring little maintenance
- High efficiency ensuring minimal loss of waste energy
- It will reduce the total amount of fuel required
- It reduces the GHG emissions
- This project is also applicable for getting the carbon credit benefits
- Simpler and compact design requires lower initial investment

2.1.4 Superiority over existing system

Use of this technology reduces the amount of fuel required in the furnace due to pre heat of combustion air with the help of waste heat. Running cost and process cost of the plant reduces thereby unit price of the product reduces.

2.1.5 Source of equipment

There are many vendors for such technology. It has successfully been adopted and implemented throughout the country and benefits reaped been established beyond doubt. There are no concerns of scarcity of such devices and the prices are reasonable as well.

2.1.6 Availability of technology/equipment

Suppliers of this technology are available at local level as well as at international level very easily. Many of the suppliers took initiative in reaching out to the industry representatives and informing them about the utility of such devices.

2.1.7 Service providers

Details of technology service providers are shown in Annexure 7.

2.1.8 Terms and conditions in sales of equipment

30% of the charges would have to be paid upfront and the rest along with the taxes would have to be paid while sending the pro-forma invoice prior to dispatch. Further the warranty period extends upto 12 months from the point of delivery for any inherent manufacturing defect or faulty workmanship.

2.1.9 Process down time

The down time might be four days for making changes to the flue gas line and install the APHHPHE. Detail of process down time is given in Annexure 6.

2.2 Life cycle assessment and risks analysis

Life of the equipment is about seven years. Risk involves in the implementation of proposed project is to avoid any leaks on the inner channel to avoid mixing of the flue gas with the fresh air going in. Such leaks can affect the combustion process severely.

2.3 Suitable unit for Implementation of proposed technology

Suitable unit for implementation of this technology is galvanizing units as most of them are having the flue gas temperature out of the furnace at 300 deg C on an average. Suitable unit for implementation of this technology is a galvanizing unit having the production capacity of about 2399 Ton/yr and having total furnace oil consumption of about 120480 litres per Year.

3. ECONOMIC BENEFITS FROM PROPOSED TECHNOLOGY

3.1 Technical benefit

3.1.1 Fuel saving

Installation of air pre-heater would save more than 4935 litres of furnace oil over a year.

3.1.2 Electricity saving

This technology does not contribute to savings of electricity.

3.1.3 Improvement in product quality

The quality of the product would still remain the same. It shall have no impact on the galvanizing process but merely make it more efficient.

3.1.4 Increase in production

The production will remain the same as in present.

3.1.5 Reduction in raw material

Raw material consumption is same even after the implementation of proposed technology.

3.1.6 Reduction in other losses

It does not effect on the modes of heat lost but merely recovers the heat dumped into the flue gas.

3.2 Monetary benefits

The monetary benefits of the unit are mainly due to reduction in the furnace oil consumption by 4935 litre/yr. This amounts to monetary savings of ₹ 1.68 lakh /yr. A detailed estimate of the saving has been provided in the Table 3.1 below:

Table 3.1 Energy and monetary benefit

S.No	Parameter	Unit	Value
1	Present furnace oil consumption in a typical unit	litre/year	120480
2	Cost of furnace oil	₹ /litre	34
3	Savings in furnace oil by using APH	litre/year	4935
4	Monetary savings due to FO saving	₹ /year	167790
5	Total monetary benefit	₹ /year (In lakh)	1.68

Further details of total monetary benefit are given in Annexure 3.

3.3 Social benefits

3.3.1 Improvement in working environment

Reduction in furnace oil consumption would probably not change the working environment apart from making the management happier.

3.3.2 Improvement in workers skill

The workers would probably not find too much of a difference in the day to day operation of the device. Hence their skills are probably going to be unaffected.

3.4 Environmental benefits

3.4.1 Reduction in effluent generation

There would be less effluent generation since there would less fuel burned in the furnace.

3.4.2 Reduction in GHG emission

The measure helps in reducing CO2 emission is about 16 T/yr, as 3.24 ton of CO2 would be reduced for a reduction of 1 ton of FO consumption. Reduction of GHG emissions leads to improved environment as well as better compliance with environmental regulations and makes the project eligible for benefit under Clean Development Mechanism [CDM].

3.4.3 Reduction in other emissions like SO_X

Significant amount of SO_X will be reduced amounting to 31.18 kg/yr due to reduction in energy consumption, as 0.006318 kg of SO_X would be reduced for a reduction of 1 kg of FO consumption.

4 INSTALLATION OF PROPOSED EQUIPMENT

4.1 Cost of project

4.1.1 Equipment cost

The cost of APH is ₹ 2.91 as per the quotation provided by the vendor provided at Annexure 8.

4.1.2 Erection, commissioning and other misc. cost

The installation & other costs could amount to a further ₹ 82135. Details of project cost are furnished in Table 4.1 below:

Table 4.1 Details of proposed technology project cost

S.No	Particular	Unit	Value
1	Cost of APH	₹ in lakh	2.91
2	Cost of Installation	₹ in lakh	0.4
3	Taxes & other misc. cost	₹ in lakh	0.42
4	Total cost	₹ in lakh	3.73

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

The entrepreneur shall have to pay 25% of the total amount, i.e. ₹ 3.73 lakh, upfront which amounts to ₹ .93 lakh. The rest could be arranged as loans.

4.2.2 Loan amount

Loan amount would be 75% of the project cost, i.e. ₹ 3.73 lakh, which amounts to ₹ 2.80. There are loans available for buying such equipments from SIDBI and from the MSME of the Government of India, which have 25% subsidy in some schemes.

4.2.3 Terms & conditions of loan

The interest rate is considered at 10%, which is SIDBI's rate of interest for energy efficient projects. The loan tenure is 5 years excluding initial moratorium period is 6 months from the date of first disbursement of loan.

4.3 Financial indicators

4.3.1 Cash flow analysis

Profitability and cash flow statements have been worked out for a period of 8 years. The financials have been worked out on the basis of certain reasonable assumptions, which are outlined below.

The project is expected to achieve monetary savings of i.e. ₹ 1.68 lakh/yr.

- The Operation and Maintenance cost is estimated at 4% of cost of total project with 5% increase in every year as escalations.
- Interest on term loan is estimated at 10%.
- Depreciation is provided as per the rates provided in the companies act.

Considering the above mentioned assumptions, the net cash accruals starting with ₹ 0.97 in the first year operation and gradually increases to ₹ 5.11 at the end of eighth year.

4.3.2 Simple payback period

The total cost of implementing the proposed technology is ₹ 3.73 and monetary savings is ₹ 1.68 per year. Hence the simple payback period works out to be 2.22 years.

4.3.3 Net Present Value (NPV)

The net present value of the investment works out to be ₹ 2.37.

4.3.4 Internal rate of return (IRR)

The internal rate of return of the project would be 27.67%.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 25.74%.

Details of financial indicator are shown in Table 4.2 below:

Table 4.2 Financial indicators of proposed technology/equipment

S.No	Particulars	Unit	Value
1	Simple Pay Back period	Years	2.22
2	IRR	%	27.67
3	NPV	₹ in lakh	2.37
4	ROI	%	25.74
5	DSCR	Ratio	1.84

4.4 Sensitivity analysis

A sensitivity analysis has been carried out to ascertain how the project financials would behave in different situations like when there is an increase in fuel savings or decrease in fuel savings. For the purpose of sensitive analysis, two following scenarios has been considered

- Optimistic scenario (Increase in fuel savings by 5%)
- Pessimistic scenario (Decrease in fuel savings by 5%)

In each scenario, other inputs are assumed as a constant. The financial indicators in each of the above situation are indicated along with standard indicators.

Details of sensitivity analysis at different scenarios are shown in Table 4.3 below:

Table 4.3 Sensitivity analysis at different scenarios

Particulars	IRR %	NPV ` in lakh	ROI %	DSCR
Normal	27.67%	2.37	25.74%	1.84
5% increase in fuel savings	29.89%	2.69	26.00%	1.94
5% decrease in fuel savings	25.41%	2.05	25.46%	1.75

4.5 Procurement and implementation schedule

Total procurement and implementation schedule required for proposed project are about 9 weeks and details are given in Annexure 6.

ANNEXURE

Annexure -1: Energy audit data used for baseline establishment

Calculation of efficiency of the furnace by the direct method

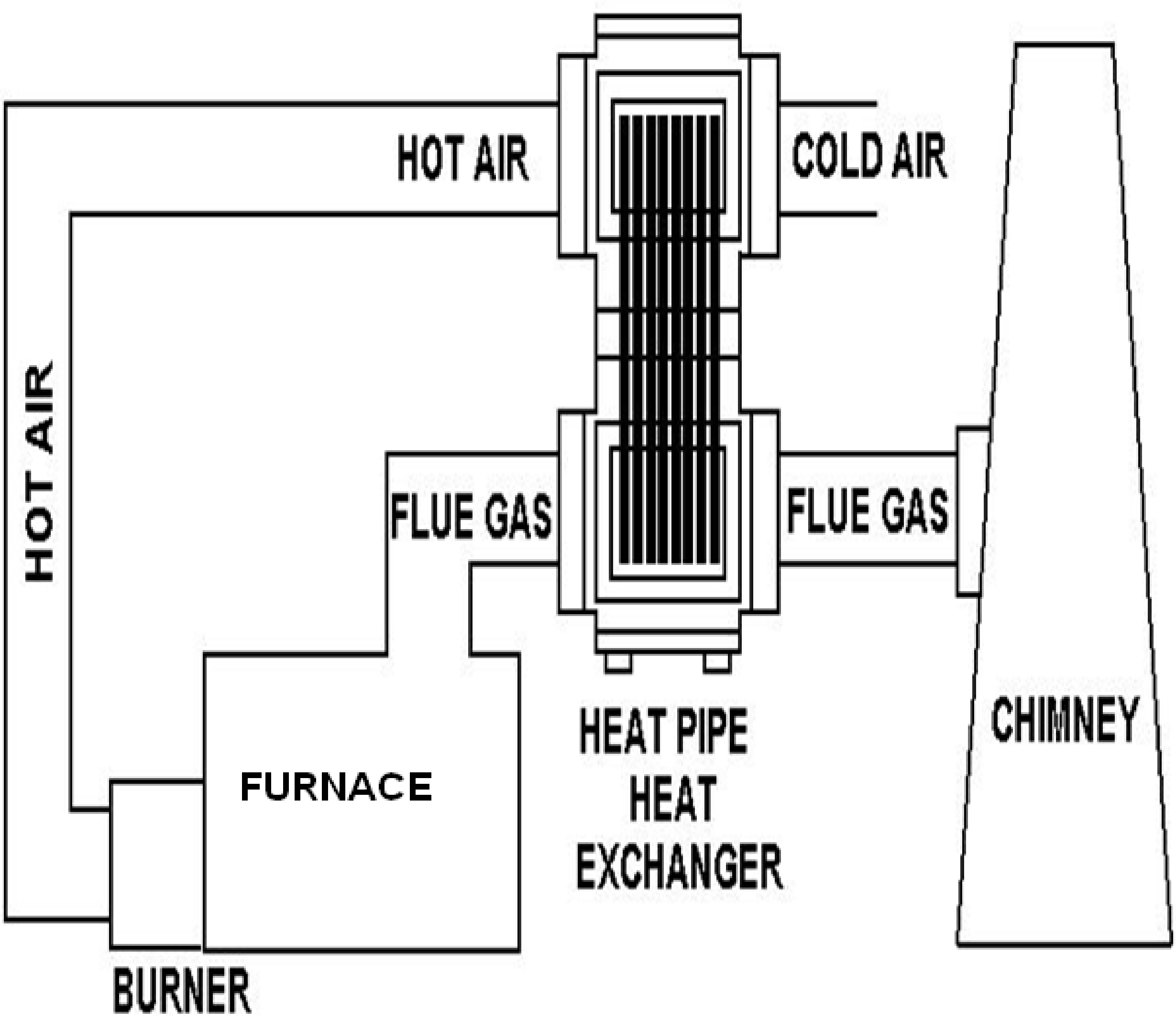
Parameter	Unit	Value
Production	kg/hr	833
Annual Production	Ton/yr	2399
GCV of furnace Oil	kCal/kg	10500
Amount of FO required annually	litre/yr	120480
Sp. Gravity of FO	-	0.93
Amount of FO required annually	kg/yr	110842
Energy burnt from FO annually	kCal/yr	1163836800
Energy burnt from FO annually	kJ/yr	4888114560
Zinc VAT temperature	deg C	480
Heat taken by zinc	kJ	46969205
Heat taken by iron	kJ	461425356
Heat taken by Metals	kJ/MT	205392
Heat utilized	kJ/yr	552061087
Efficiency	% age	10.40

Calculation of efficiency of furnace by the indirect method

Parameter	Unit	Value
Flue gas temperature	deg C	300
Ambient temperature	deg C	30
Specific gravity of furnace oil	-	0.92
Average FO consumption	litre/hr	42
Average FO consumption	kg/hr	38.6
GCV of FO	kCal/kg	10500
Average oxygen percentage in flue gas	% age	4.5
Excess Air	% age	27.27
Theoretical air required to burn 1 kg of oil	kg	15
Total air supplied	kg/kg of oil	19.09
Mass of fuel (1kg)	kg	1
Actual mass of air supplied/kg of fuel	kg/kg of oil	20.09
Specific heat of flue gas	kCal/kg/deg C	0.24
Temperature difference	deg C	270

Parameter	Unit	Value
Heat loss	kCal/kg of oil	1302
Heat loss in flue gas	% age	12.4
Moisture in 1kg of FO	kg/kg of FO	0.15
GCV of FO	kCal/kg	10500
Evaporation loss due to moisture content in FO	% age	1
Amount of hydrogen in 1 kg of FO	kg/kg of FO	0.1123
GCV of FO	kCal/kg	10500
Loss due to Evaporation of water formed due to Hydrogen in FO	% age	6.79
Loss through furnace walls	% age	9.2
Unaccounted for heat loss	% age	51
Total Heat loss	% age	80.4
Furnace Efficiency	% age	19.6

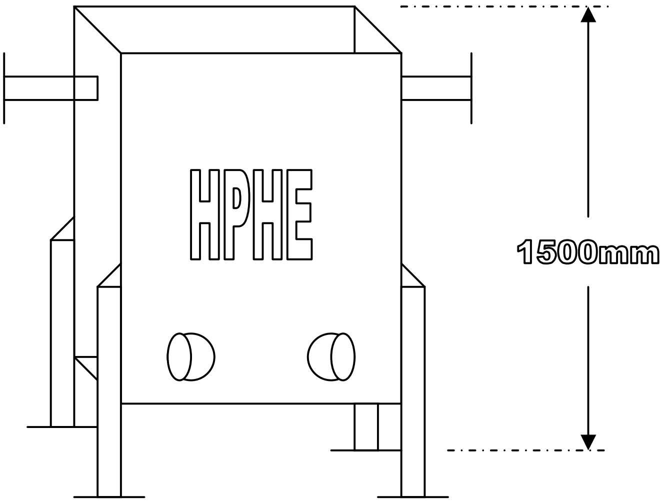
Annexure -2: Process flow diagram after project implementation

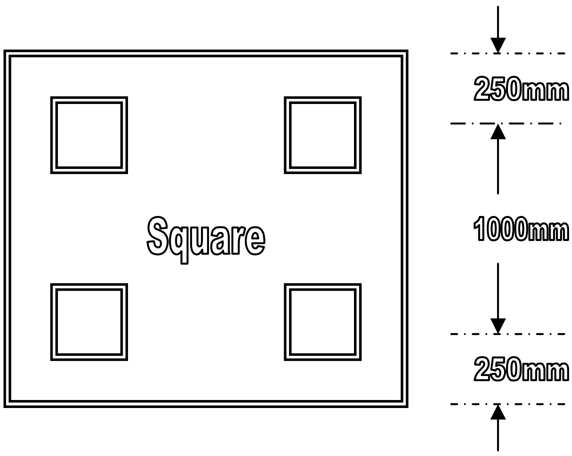


Annexure -3: Detailed technology assessment report

Particulars	Units	Value
Fuel consumed	kg/hr	39
Air mass flow rate	kg/hr	833
Temperature of the combustion air at APH inlet	deg C	30
Temperature of the combustion air at APH outlet	deg C	120
Gain in temperature of supply air	deg C	90
Specific heat of combustion air	kCal/kg/deg C	0.24
Heat savings	**kCal/hr**	**mxCpx∆t=17993**
Flue gas mass flow rate	kg/hr	872
Temperature of the flue gas at APH inlet	deg C	300
Temperature of the flue gas at APH outlet	deg C	200
Temperature difference	deg C	100
Specific heat of flue gas	kCal/kg/deg C	0.23
Heat available from flue gas (partially delivered to combustion air)	**kCal/hr**	**mxCpx∆t=20056**
GCV of furnace oil	kCal/kg	10500
Furnace oil savings	kg/hr	1.71
Cost of furnace oil	₹/litre	34
Specific gravity of furnace oil		0.93
Operating hours per day	hr/day	12
Annual operating day	day/yr	240
Annual operating hours	hrs/yr	2880
Annual furnace oil savings	kg/yr	4590
Annual furnace oil savings	litre/yr	4935
Annual cost savings	**₹/yr**	**167790**
Total investment	₹(in lakh)	3.73
Estimated life of system	Yrs	7
Simple payback	year	2.22

Annexure -4 Drawings for proposed electrical & civil works





Annexure -5: Detailed financial analysis

Assumption

Name of the Technology	**Heat Pipe Heat Exchanger**		
Details	*Unit*	*Value*	*Basis*
No of working days	Days	240	
No of Shifts per day	Shifts	1	
No. Of operating Hours per day	Hrs.	12	
Proposed Investment			
Equipment cost	₹ (In lakh)	2.91	
Installation cost	₹ (In lakh)	0.40	
Other cost	₹ (In lakh)	0.42	
Total investment	₹ (In lakh)	3.73	
Financing pattern			
Own Funds (Equity)	₹ (In lakh)	0. 93	Feasibility Study
Loan Funds (Term Loan)	₹ (In lakh)	2.80	Feasibility Study
Loan Tenure	yr	5	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	66	Assumed
Interest Rate	%/yr	10	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	4	Feasibility Study
Annual Escalation	% age	5	Feasibility Study
Estimation of Revenue			
Saving in furnace oil	liter/yr	4935	
Cost of FO	₹/ litre	34	
St. line Depn.	% age	5.28	Indian Companies Act
Depreciation in the first year	% age	80	Income Tax Rules
Income Tax	% age	33.99	Income Tax

Estimation of Interest on Term Loan

Years	*Opening Balance*	*Repayment*	*Closing Balance*	*Interest*
1	2.80	0.24	2.56	0.32
2	2.56	0.48	2.08	0.23
3	2.08	0.52	1.56	0.19
4	1.56	0.60	0.96	0.13
5	0.96	0.64	0.32	0.07
6	0.32	0.32	0.00	0.01
		2.80		

WDV Depreciation

Particulars / years	1	2
Plant and Machinery		
Cost	3.73	0.75
Depreciation	2.98	0.60
WDV	0.75	0.15

Projected Profitability ₹ (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8
Fuel savings	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Total Revenue (A)	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Expenses								
O & M Expenses	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21
Total Expenses (B)	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21
PBDIT (A)-(B)	1.53	1.52	1.51	1.51	1.50	1.49	1.48	1.47
Interest	0.32	0.23	0.19	0.13	0.07	0.01	-	-
PBDT	1.21	1.29	1.33	1.38	1.43	1.48	1.48	1.47
Depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
PBT	1.01	1.09	1.13	1.18	1.23	1.28	1.28	1.27
Income tax	-	0.23	0.45	0.47	0.49	0.50	0.50	0.50
Profit after tax (PAT)	1.01	0.86	0.68	0.71	0.75	0.78	0.78	0.77

Computation of Tax ₹ (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	1.01	1.09	1.13	1.18	1.23	1.28	1.28	1.27
Add: Book depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Less: WDV depreciation	2.98	0.60	-	-	-	-	-	-
Taxable profit	(1.78)	0.69	1.33	1.38	1.43	1.48	1.48	1.47
Income Tax	-	0.23	0.45	0.47	0.49	0.50	0.50	0.50

Projected Balance Sheet

Particulars / Years	1	2	3	4	5	6	7	8
Liabilities								
Share Capital (D)	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Reserves & Surplus (E)	1.01	1.87	2.55	3.26	4.00	4.78	5.56	6.33
Term Loans (F)	2.56	2.08	1.56	0.96	0.32	0.00	0.00	0.00
Total Liabilities (D)+(E)+(F)	4.50	4.87	5.03	5.15	5.25	5.71	6.49	7.26

Assets	1	2	3	4	5	6	7	8
Gross Fixed Assets	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73
Less Accm. depreciation	0.20	0.39	0.59	0.79	0.98	1.18	1.38	1.57
Net Fixed Assets	3.53	3.33	3.14	2.94	2.74	2.55	2.35	2.15
Cash & Bank Balance	0.97	1.54	1.90	2.21	2.51	3.16	4.14	5.11
TOTAL ASSETS	4.50	4.87	5.03	5.15	5.25	5.71	6.49	7.26
Net Worth	1.94	2.80	3.48	4.19	4.94	5.72	6.49	7.27
Debt Equity Ratio	2.74	2.23	1.67	1.03	0.34	0.00	0.00	0.00

Projected Cash Flow

₹ (in lakh)

Particulars / Years	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Sources									
Share Capital	0.93	-	-	-	-	-	-	-	-
Term Loan	2.80								
Profit After tax		1.01	0.86	0.68	0.71	0.75	0.78	0.78	0.77
Depreciation		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total Sources	3.73	1.21	1.05	0.88	0.91	0.94	0.98	0.98	0.97
Application									
Capital Expenditure	3.73								
Repayment Of Loan	-	0.24	0.48	0.52	0.60	0.64	0.32	-	-
Total Application	3.73	0.24	0.48	0.52	0.60	0.64	0.32	-	-
Net Surplus	-	0.97	0.57	0.36	0.31	0.30	0.66	0.98	0.97
Add: Opening Balance	-	-	0.97	1.54	1.90	2.21	2.51	3.16	4.14
Closing Balance	-	0.97	1.54	1.90	2.21	2.51	3.16	4.14	5.11

IRR

₹ (in lakh)

Particulars / months	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Profit after Tax		1.01	0.86	0.68	0.71	0.75	0.78	0.78	0.77
Depreciation		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Interest on Term Loan		0.32	0.23	0.19	0.13	0.07	0.01	-	-
Cash outflow	(3.73)	-	-	-	-	-	-	-	-
Net Cash flow	(3.73)	1.53	1.29	1.06	1.04	1.01	0.99	0.98	0.97
IRR	27.67%								

NPV	2.37

Break Even Point

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Variable Expenses								
Oper. & Maintenance Exp (75%)	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16
Sub Total*(G)*	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16
Fixed Expenses								
Oper. & Maintenance Exp (25%)	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Interest on Term Loan	0.32	0.23	0.19	0.13	0.07	0.01	0.00	0.00
Depreciation *(H)*	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sub Total (I)	0.56	0.47	0.42	0.37	0.31	0.25	0.25	0.25
Sales (J)	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Contribution (K)	1.57	1.56	1.55	1.55	1.54	1.54	1.53	1.52
Break Even Point (L= G/I)	35.51%	30.09%	27.21%	23.78%	20.10%	16.54%	16.15%	16.39%
Cash Break Even {(I)-(H)}	22.94%	17.48%	14.56%	11.07%	7.34%	3.72%	3.27%	3.45%
Break Even Sales (J)*(L)	0.60	0.50	0.46	0.40	0.34	0.28	0.27	0.28

Return on Investment

₹ (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8	Total
Net Profit Before Taxes	1.01	1.09	1.13	1.18	1.23	1.28	1.28	1.27	9.48
Net Worth	1.94	2.80	3.48	4.19	4.94	5.72	6.49	7.27	36.82
									25.74%

Debt Service Coverage Ratio

₹ (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8	Total
Cash Inflow									
Profit after Tax	1.01	0.86	0.68	0.71	0.75	0.78	0.78	0.77	4.78
Depreciation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	1.18
Interest on Term Loan	0.32	0.23	0.19	0.13	0.07	0.01	0.00	0.00	0.95
Total (M)	1.53	1.29	1.06	1.04	1.01	0.99	0.98	0.97	6.91

DEBT

Interest on Term Loan	0.32	0.23	0.19	0.13	0.07	0.01	0.00	0.00	0.95
Repayment of Term Loan	0.24	0.48	0.52	0.60	0.64	0.32	0.00	0.00	2.80
Total (N)	0.56	0.71	0.71	0.73	0.71	0.33	0.00	0.00	3.75
	2.72	1.80	1.51	1.42	1.43	2.99	0.00	0.00	1.84
Average DSCR (M/N)	1.84								

Annexure:-6 Procurement and implementation schedule

Sl. No.	*Activities*	*Weeks*								
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Ordering & Delivery of the APHHPHE									
2	Replacing the flue gas pathway									
3	Installing the APHHPHE									

Break up of shutdown period of plant required for Operation of APHHPHE

Sl.No	*Activity*	*Days*
1	Prepare the pathway for the flue gas to go	2
2	Install the air APHHPHE and connect the secondary air into it	2

Day wise break up of shut down period for installation of APHHPHE

Sl.No	*Activity*	*Day*			
		1	*2*	*3*	*4*
1	Marking the pathway for the flue gas				
2	Dismantling of existing pipeline				
3	New ducting & piping arrangement for flue gas				
4	Installation of APHHPHE				
5	Connect secondary air to APHHPHE				
6	Instrumentations and trial				

Annexure -7: Details of technology service providers

erson and No.
70557041 20 24531417, 538617 nanorenterprises

Annexure -8: Quotations or Techno-commercial bids for new technology/equipment

MANOR ENTERPRISES
180 Ratna Deep L.B.S.Road
Navi Peth Pune 411030
TEL 91 20 24531417, 24533102
FAX 91 20 24538617
Email: info@manorenterprises.com

Ref.No. ME/NB/HP/WB/01/11-12 9th April 2011

To,
Indian Institute of Social Welfare & Business Management
Management House, College Square West,
Kolkata- 700073

Kind Attn. Mr. Debdut Sarkar

Subject: - Proposal for Heat Pipe Heat Exchanger Waste heat recovery.

Dear Sir,
We highly appreciate your interest shown in our technology for Heat Pipe Heat Exchanger system.
Our offer and plant data as indicated by you:

Type of Fuel	F.O
Flue Gas temperature IN ° C	300
Flue Gas temperature OUT ° C	190
Air inlet temperature to APH ° C	30
Air outlet temperature form APH ° C	140
Recovered Kcal/hr	**21991**
Recovered FO in lt/hr	**2.3**

We are sure this will suffice your requirements of superior quality heat recovery system at affordable price.

However, please feel free to call us for any queries. We are always at your disposal.

Thanking you and assuring the best services at all the times, we remain.

Yours sincerely,
For Manor Enterprises

Shekhar Kulkarni

MANOR ENTERPRISES
180 Ratna Deep L.B.S.Road
Navi Peth Pune 411030
TEL 91 20 24531417, 24533102
FAX 91 20 24538617
Email: info@manorenterprises.com

We are pleased to submit our offer as under,

1. Supply of Heat Pipe Heat Exchanger with following specifications:
   Heat Pipe Heat Exchanger type HPHE.
   Material of heat pipes: SS 304

2. **Price:**
   A. Heat Pipe Heat Exchanger Air Preheater: - **Rs.2,90,586/-**
   Combine APH module is suitable for the F.O

3. **Payment** : 30 % advance along with Purchase Order
   : 70 % against Proforma Invoice before dispatch.

4. **P & F** : 2% Extra.

5. **V.A.T.** : 2% against form "C" or 12.5% MVT Extra.

6. **Excise** : As applicable (Nil at present)

7. **Delivery** : 4 - 8 weeks from the date of receipt of confirmed purchase order along With advance.

8. **Guarantee** : 1 year from date of supply for all manufacturing defects.

9. **Validity** : 30 days from the date of this proposal.

10. **Transport** : Extra at actual.

11. **Jurisdiction**: Disputes if any, arising out of the contract, shall be subject to Pune Jurisdiction.

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