Report

Energy Audit

Conducted at

XXX Foundry

Period: Dec 2013 – Jan 2014

Audit Conducted by:

MICROAIDS Pune.

Executive Summary.

Possible savings

Summary of possible energy savings						
Sr No	Energy Saving Opportunity Description	Annual Savings	Achieve-ability Factor	Corrected Annual Savings	Approx Investment	Approx Payback in months
A	Eliminating Rejection	58,26,072	25%	14,56,518	0	0
B	Optimizing Cooling Water Operations	30,82,904	90%	27,74,613	44,00,000	19
C	Eliminating Mismatch	40,41,776	35%	14,14,622	0	0
D	Improving Insulation	103,15,070	40%	41,26,028	55,00,000	16
E	Blower Optimization	38,49,984	75%	28,87,488	35,00,000	15
Totals		**271,15,805**		**126,59,269**	**134,00,000**	**13**

Electrical

1) At Plant it is noticed that the electrical load at plant is increasing throughout year 2013 and now has reached the sanctioned contract demand. Some of the HT side electrical components were undersized to handle this load and this was causing tripping / blow off etc.

2) Outdoor HT distribution yard is very near to shot blasting setup and at times misbehaves due to dust and moisture accumulation. Dust accumulation should be avoided in this case.

3) All furnace transformers and Utility transformers are loaded almost 100% and more. Your load pattern has typical duty cycle due to batch processing. This helps in avoiding overheating of transformers. However all transformers generate >10% voltage harmonic distortion at their respective secondary sides due to this excessive loading.

4) The voltage harmonic distortion associated with quantum of nonlinear load – furnaces and VFDs, contribute in demanding huge distorted current from MSEDCL and present HT PCC harmonic distortion is close to 26%. Your compliance limit as per supply code 2005 is 10% and we are of the opinion that you should aim at 8%.

5) Due to enhanced load, it is becoming increasingly difficult to maintain power factor at unity while controlling the current harmonics. Please note that these two parameters are interrelated and current harmonics amplify if power factor is corrected using only capacitors. Loss of incentive per month for last 3 months is over Rs.3 L per month.

6) As an immediate major we recommend that the 400KVAR tuned filter panel should be modified to “Detuned” and installed across auxiliary transformer secondary. This can take feedback from main HT PCC so that the correction would try to ensure HT PCC or Billing power factor at unity. This will ensure maximum power factor incentive is available in MSEDCL bill.

7) We are of the opinion that Auxiliary transformer at present is exposed to 94% loading, most of which is nonlinear. As rest of LT load is furnace load, power factor correction is given only at this transformer secondary. The data recording has shown that this transformer handles 45% current harmonic distortion and about 200Amps 5^{th} harmonic (250Hz) current. All this is resulting into VOLTAGE DISTORTION of 6 to 10%. This distorted voltage is fed to other linear load, which also take distorted current. This is further reflecting into HT side current distortion.

8) Machine shop load is only 2% of total loading. It is recommended that the reactive power correction may be given at load end using detuned filters. 100 KVAR x 2 panels with suitable steps may be connected in close loop so that it will offer some amount of harmonic filtering and unity power factor.

9) Nonlinear load on this auxiliary transformer should be optimized and all unwanted VFDs should be removed. Considering your existing contract demand, you may start all motors up to 10KW using DOL starters and all motors up to 40KW by STAR DELTA starters. Any motor with rating above this may have SOFT STARTER. VFDs should be used only in those cases where you require frequent speed changes and / or there is frequent load variation. This optimization along with corrective steps as in 7 and 8 above would reduce harmonics handled by this auxiliary transformer. They should be measured and then further mitigation strategy may be decided. Kindly note that after implementing all this, if we do not see remarkable improvement in VOLTAGE DISTORTION, then you will have to reduce the load on this transformer by adding another Aux transformer. Another point to be noted is unless specifically told while designing, these standard transformers deliver maximum efficiency between 60 to 75% loading and efficiency drops if load is more.

10) As per measurements and estimation the electrical distribution loss within the plant is about 2000 units per day, which is 2.5% of your daily consumption. Given the location of transformers and furnaces, the only avoidable loss is loss in SERVO STABILIZERS. According to us this must be around 500 units or Rs.4000 per day – Rs.100000 per month. As per 24 hours recording the HT voltage remains within -2.5% to +7.5% around nominal 33KV. We advise that you may try bypassing the stabilizer for one furnace, observe the performance for a month and then decide about balance furnaces.

11) Earthing results in HT yard are not satisfactory at few places. (Refer detail report). It is recommended that referring to soil resistivity and maximum earth fault current, earthing requirements should be recalculated using basics and such earthing system should be installed at site. Such system should avoid joining dissimilar metals and also should keep all earthpits accessible for testing in GRID as well as in ISOLATED condition.

12) Rest of the HT equipment was tested along with major cables, all relays were calibrated and tested and are found in satisfactory condition.

Furnace utilities

1) Furnaces require water cooling for “Induction coil cooling” and “Electronic Panel Cooling”. We have analyzed these cooling requirements from basics and found that total electrical load can be reduced to about **13KW from present 65KW**. All pumps are equipped with VFDs. We advise that **after obtaining concurrence from furnace manufacturer**, you may down size pumps and avoid using VFDs.

2) All furnaces are equipped with “fumes extraction blowers and scrubber systems”. The air handling parameters were measured while the systems were working. The blower motors are equipped with VFDs. The optimization is explained in detail report. This would bring in electrical **load optimization of about 66KW**. This will need change in blowers and motors and can be done by M/S XXX independently. Use of VFDs also can be avoided in this case.

3) Both above utilities work 24 hours, as such above optimization can bring in saving of almost Rs.20000 per day or more.

Furnaces

We recorded all required data, referred to logs kept by foundry, studied furnace HEAT BALANCE from basics and have recommended following energy saving majors.

1) We have studied specific energy performance of your foundry shop for last 12 months and also for one typical working day with 5 furnaces and machine shop working to its capacity.

2) The rejection recycled was found to be about 3.5% of total 77tons melted on the day of audit. It was informed to us that this is not a daily practice. We recommend all departments should put in their best to reduce this. Wastage due to extra lengths may be reduced by redesigning the dies, whereas rejection due to QC noncompliance for composition may not be totally avoidable.

3) MELT – HOLD coordination introduces almost 10 minutes extra hold in every cycle. This makes it 50 minutes per cycle for 5 furnaces and 500 minutes for 10 cycles in 24 hours. Detail calculations are given in the report, but this contributes to about Rs.13000 per day. Considering the hardships on furnace floor, it is very difficult to reduce this, but all avoidable hurdles like “Line equipment failure”, “Delay in furnace charging”, “Charging as prescribed by furnace manufacturer” may lead to reducing this by 15 to 20%. ON LINE Peer competition between operating groups may also help in reducing this. You may bring about this by displaying cycle parameters near each furnace, which will be visible to peers.

4) “Melt and Hold Furnace lids” should be kept in working condition and used whenever possible to avoid Loss due to opening.

5) We have observed higher temperatures on Furnace outside surfaces then prescribed, Furnace manufacturer should guide you for routine predictive maintenance so that this loss can be minimized. Estimated loss due to 4 and 5 is around Rs.30000 per day. Efforts should be made to reduce this by 15 to 20% at least.

Description of plant operations and infrastructure.

XXX is a plant involved in manufacturing various sizes of cast iron liners for IC engines. The process involves

1) Iron scrap melting using Induction furnaces.
2) Modifying the composition as per end product requirement.
3) Centrifugal casting
4) Machining using various CNC machines.
5) Stress reliving using tempering oven.

Plant receives 33 KV HT on an express feeder from MSEDCL. This feeder feeds only XXX plants. Contract demand is almost 5 MVA and the same is reached almost every day several times. Plant runs in all 3 shifts and has Tuesday as weekly OFF.

The HT voltage is received on a DP structure (Having GOD and DO arrangement) near compound and then brought to main VCB in Electrical distribution room through MSEDCL metering kiosk.

This HT supply is further distributed into three main circuits using VCBS. Outputs of these VCBS are further distributed to various transformers via outdoor HT structure. Detail arrangement and observed average loading is shown on next pages.

Plant has 6 induction furnaces of various sizes working on 565 volts LT AC. Various utilities like fumes extraction, water cooling circuits, compressors and illumination work on 433V AC and are fed through separate transformer. This transformer also supports furnace auxiliaries and machine shop. All LT lines have servo stabilizers between transformer LT and actual Load.

Average manufacturing for last 12 months is around 70.5 tons per day. Dec 2013 being maximum as 86 tons per day.

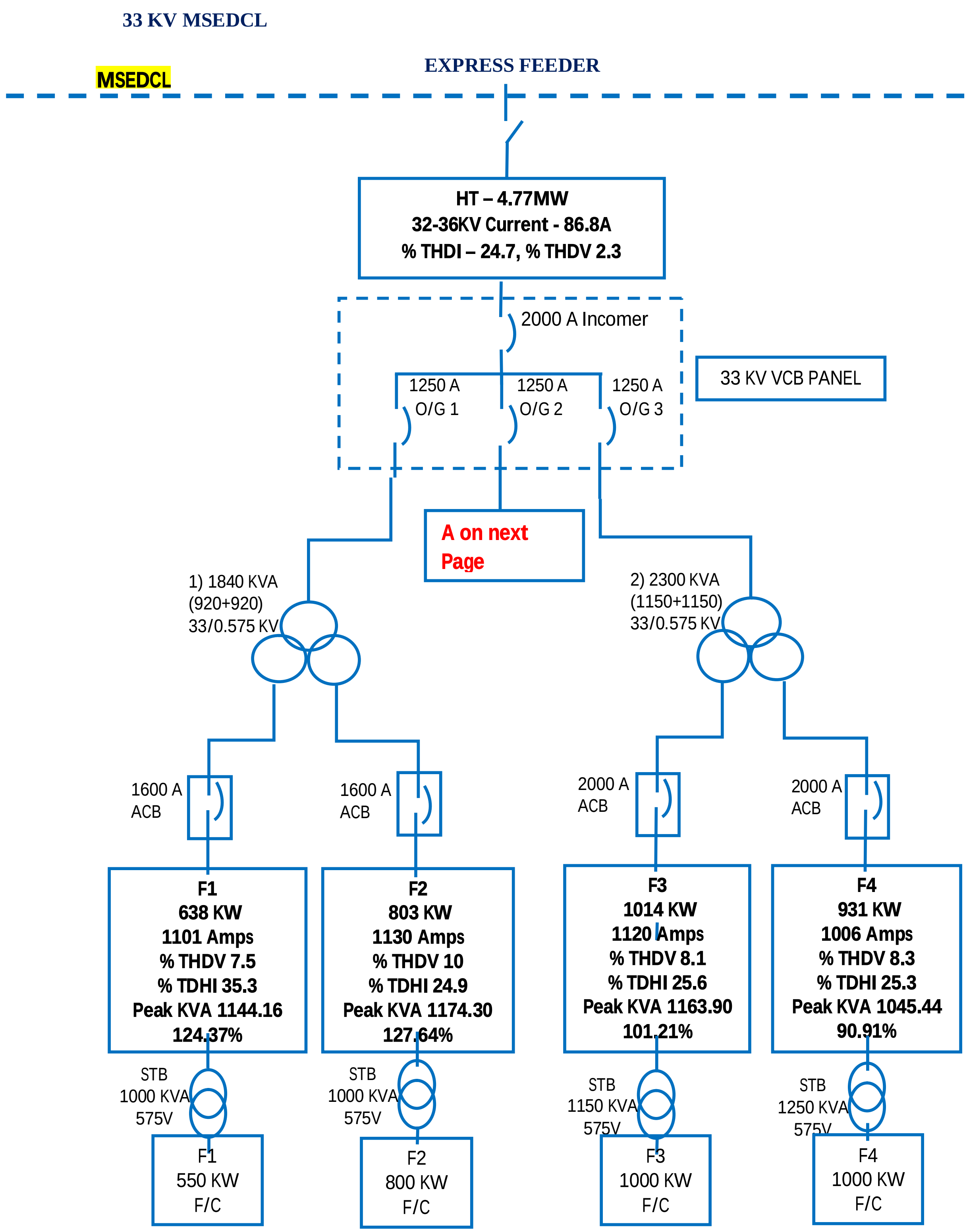
Each furnace delivers about 12 to 15 melts per day.

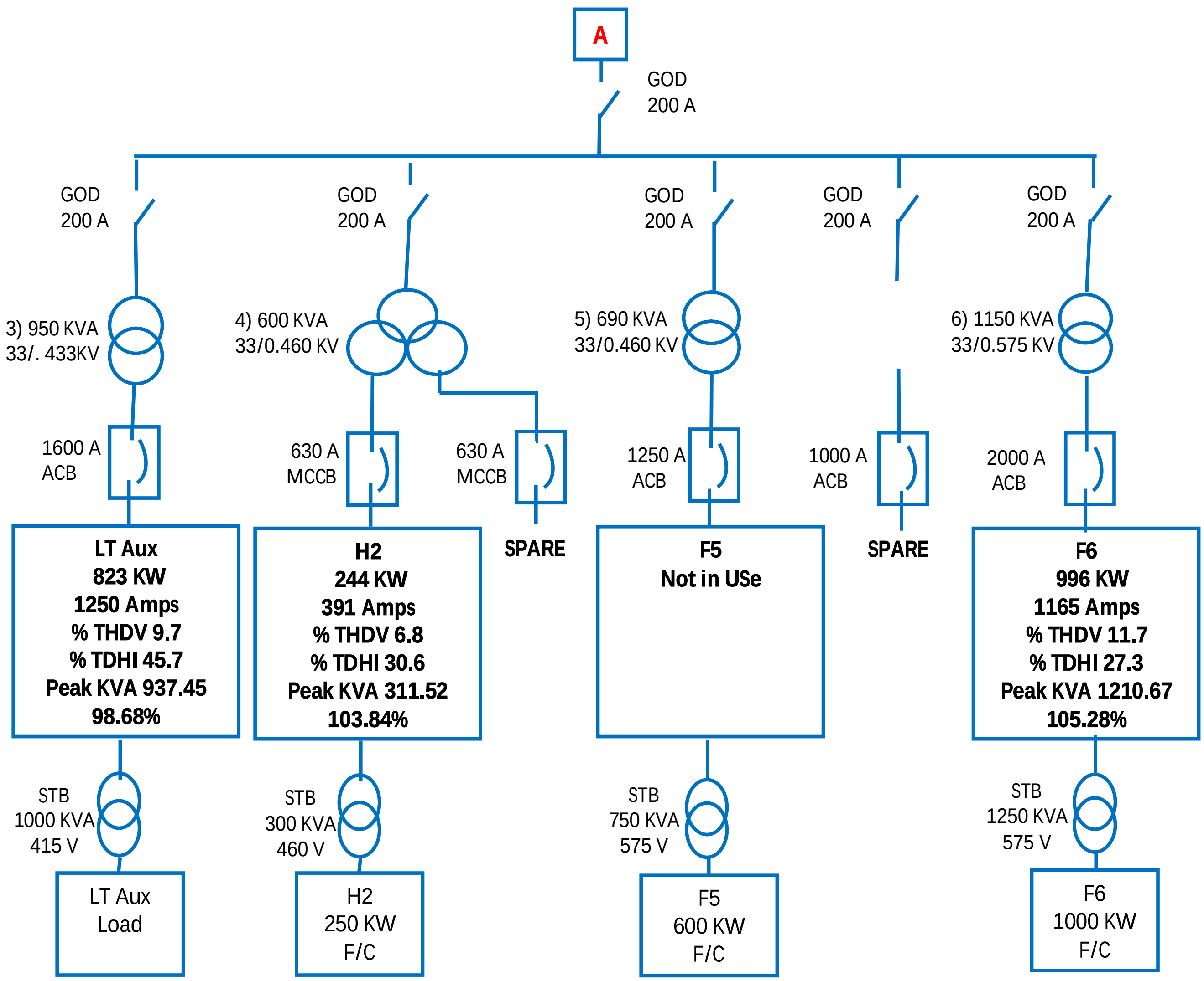
Plant has three sections

a) Utility: Electrical distribution, water pumping and compressors.
b) Foundry and heat treatment: All furnaces and shot blasting.
c) Machine shop: All CNC machining lines.

Following performance indices are calculated based on last 12 months data made available to us.

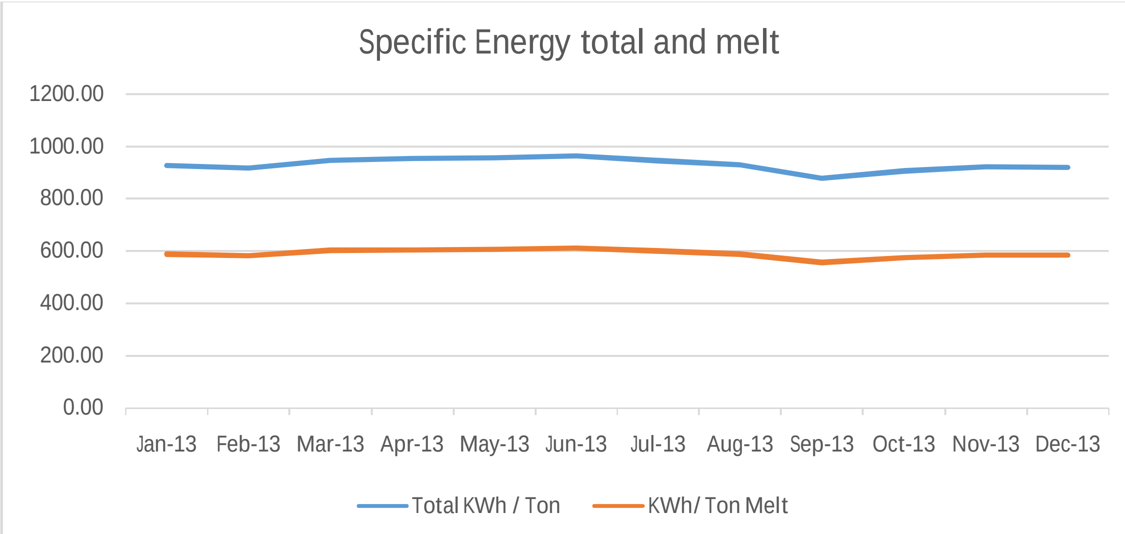
- Cost of daily electrical energy consumption is around Rs. 4.25 Lacs.
- This will mean energy cost of around Rs.6 per Kg of steel processed.
- Total processing needs about 929 Kwh for each ton of steel.


33 KV MSEDCL
MSEDCL
EXPRESS FEEDER
HT – 4.77MW
32-36KV Current - 86.8A
% THDI – 24.7, % THDV 2.3
2000 A Incomer
1250 A
O/G 1
1250 A
O/G 2
1250 A
O/G 3
33 KV VCB PANEL
A on next Page
1) 1840 KVA
(920+920)
33/0.575 KV
2) 2300 KVA
(1150+1150)
33/0.575 KV
1600 A
ACB
1600 A
ACB
2000 A
ACB
2000 A
ACB
F1
638 KW
1101 Amps
% THDV 7.5
% TDHI 35.3
Peak KVA 1144.16
124.37%
F2
803 KW
1130 Amps
% THDV 10
% TDHI 24.9
Peak KVA 1174.30
127.64%
F3
1014 KW
1120 Amps
% THDV 8.1
% TDHI 25.6
Peak KVA 1163.90
101.21%
F4
931 KW
1006 Amps
% THDV 8.3
% TDHI 25.3
Peak KVA 1045.44
90.91%
STB
1000 KVA
575V
STB
1000 KVA
575V
STB
1150 KVA
575V
STB
1250 KVA
575V
F1
550 KW
F/C
F2
800 KW
F/C
F3
1000 KW
F/C
F4
1000 KW
F/C

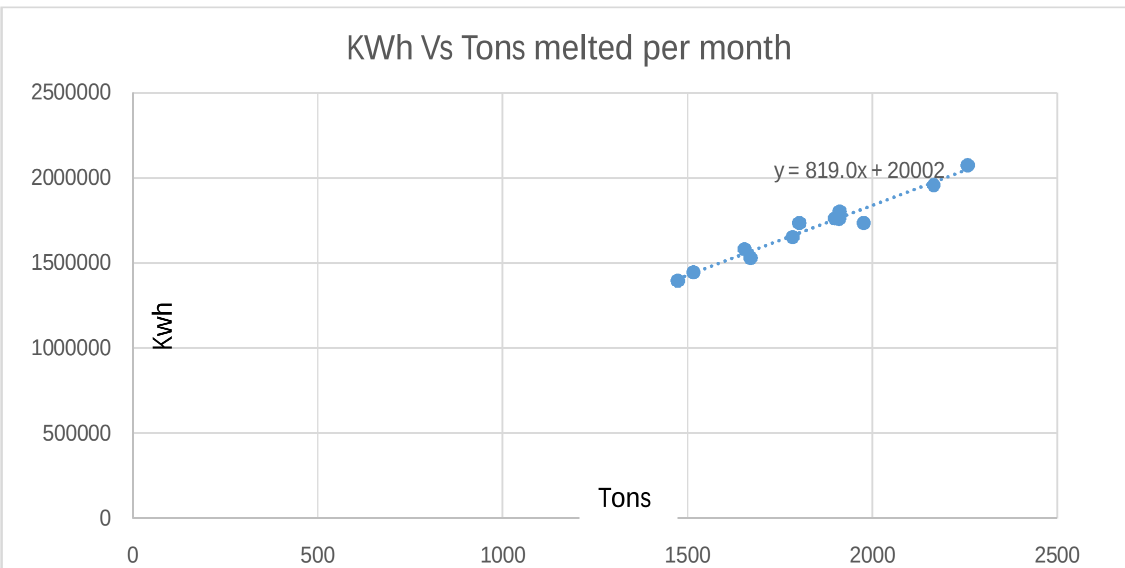

A
GOD
200 A
GOD
200 A
GOD
200 A
GOD
200 A
GOD
200 A
GOD
200 A
3) 950 KVA
33/. 433KV
4) 600 KVA
33/0.460 KV
5) 690 KVA
33/0.460 KV
6) 1150 KVA
33/0.575 KV
1600 A
ACB
630 A
MCCB
630 A
MCCB
1250 A
ACB
1000 A
ACB
2000 A
ACB
LT Aux
823 KW
1250 Amps
% THDV 9.7
% TDHI 45.7
Peak KVA 937.45
98.68%
H2
244 KW
391 Amps
% THDV 6.8
% TDHI 30.6
Peak KVA 311.52
103.84%
SPARE
F5
Not in USe
SPARE
F6
996 KW
1165 Amps
% THDV 11.7
% TDHI 27.3
Peak KVA 1210.67
105.28%
STB
1000 KVA
415 V
STB
300 KVA
460 V
STB
750 KVA
575 V
STB
1250 KVA
575 V
LT Aux
Load
H2
250 KW
F/C
F5
600 KW
F/C
F6
1000 KW
F/C

Specific energy consumption for last year and energy consumption against production figures of all the months during last year

A Graph showing Kwh / Ton for “Total Foundry” and for “Only melting”



B Graph showing Kwh consumption and Tons for last 11 months.



Graphs in A above indicate that specific energy consumption is fairly constant but slightly on higher side.

Graph B shows that total KWh consumption increases linearly with quantum of production. No hick ups are seen in this graph. This indicates that there is fair control on energy consumption. The Y intercept of this graph will be **200025 Kwh, which indicates fixed energy consumption per month** even if there is no melting. This must be related to utility consumption.

Details of the equipment used for energy audit

No.	Name of the equipment	SR. No Model	Make	Use
1	Power Analyzer	1212 5:8 ALM 35	KRYKARD	Electrical Parameter Measurement
2	Power Analyzer	ALM 35	KRYKARD	Electrical Parameter Measurement
3	Infrared Camera		TESTO	Locating electrical loose connections using thermal imaging.
4	Earth Tester		Motwani	

Audit team

MICROAIDS: Mr. Narendra Duvedi, (Certified energy auditor – Electrical Engineer)
Mr. Sunil Gogate (Certified energy auditor – Mechanical Engineer)
Mr. Vijay Sonawane, Mr. Ranjeet Deshmukh. Mr. Ajit Gowande

XXX : Mr.

Record of electricity bill payment from Jan 13 to Oct 13.

Contract Demand - 4990			Daily working hrs - 24								
Month	Total bill paid	KWH recorded	Billed Demand KVA	Billed Power Factor	Net TOD	Demand Charges	Energy Charges	FAC	Max PF Incentive	P.F. Incentives	Diff in PF Incentive
Dec-13	16545310	2075520	4602	0.991	-1314948	**852720**	**17442047**	**261515**	1206893	**862066**	**344827**
Nov-13	14208600	1760100	4619	0.987	-1079310	**874380**	**14791352**	**221772**	1036574	**740409**	**296165**
Oct-13	15775340	1959480	4397	0.991	-1093704	835430	16466882	232002	1150843	822030	**328813**
Sep-13	13561850	1735200	3828	0.995	-1008096	727320	14582100	132048.7	1010336	1010336	**0**
Aug-13	14404110	1762620	4246	0.993	-1025688	806740	14812529	420208.6	1050965	750690	**300276**
Jul-13	11592420	1803060	4093	0.995	-1070838	777670	12639451	-36421.8	861690	861690	**0**
Jun-13	11299370	1735740	3768	0.996	-1048152	715920	12167537	165242.5	840038	840038	**0**
May-13	10215420	1582320	3533	0.997	-925254	671270	11092063	10126.85	759374	759374	**0**
Apr-13	9807260	1445760	3579	0.995	-850146	680010	10134778	456426.4	729475	729475	**0**
Mar-13	9845570	1396620	3672	0.997	-848430	697680	9790306	826938.7	732655	732655	**0**
Feb-13	14088840	1531076	3794	0.996	-886796	720860	10732843	1074509	814899	814899	**0**
Jan-13	8661310	1184220	3653	0.994	-686700	694070	8301382	708637.3	631217	450869	**180348**
									10824960	**9374531**	**1450429**

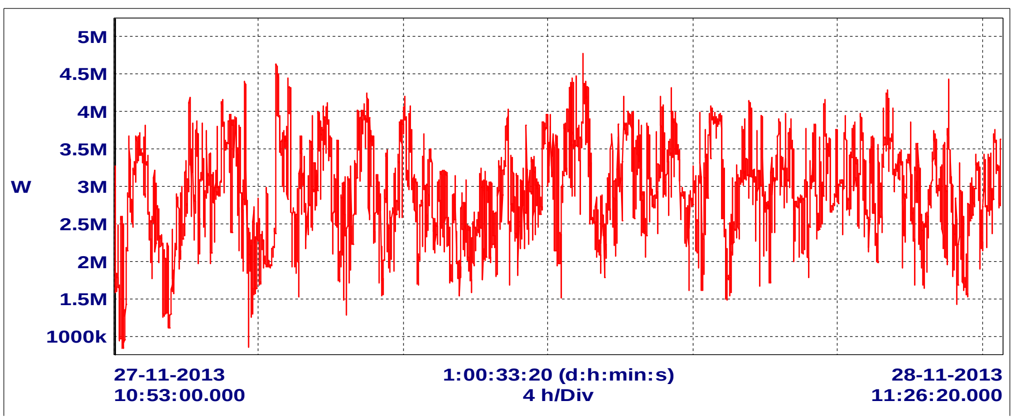
Comments:

1) It is clear from above that the load is increasing for last 4 / 5 months and billed demand is approaching contract demand.
2) At present, power factor is corrected only on LT side of auxiliary transformer. Furnace PF is not corrected at HT / LT PCC. This requires over correction at Aux transformer PCC to maintain billing P.F. at unity. This along with overloading of auxiliary transformer is resulting into 45% current harmonic distortion and also associated LT side voltage harmonic distortion. With all this it will be increasingly difficult to maintain the power factor at unity and keeping harmonic distortion controlled. This is visible in above table as during last year, full PF incentive was not available for 5 months. One can see that deficit is increasing with increase in consumption.
3) It is advised that the AUX + MACHINE SHOP load (which is 25% of total load and almost 1 MW) should be divided into two transformers each being loaded up to 70% max. Further nonlinear load on this transformer should be optimized as discussed elsewhere in this report and then Power factor should be corrected using detuned thyristor switched filters.
4) Once this is done, HT side harmonics should be measured again to decide corrective actions.
5) As per MSEDCL supply code 2005 and IEEE 519 1992, you have compliance requirement of **total current harmonic distortion on HT side as 10% and I_{SC} / I_L ratio is on border line,** so you should aim at 8% and arrange mitigation.
6) We would like to highlight that during audit, one furnace was not operational and yet your “Electrical Demand” is almost touching your “contract demand”. So plant running with 6th furnace or any further expansion is not possible within this contract demand.
7) VCBs have enough capacity to accommodate future expansion but main cable and MSEDCL incoming structure also would need up gradation for additional load. Upstream MSEDCL infrastructure also should be checked as this is express feeder dedicated to your load.
8) As per prevailing MSEDCL standard regulations, you would not get sanction for contract demand exceeding 6MVA on 33KV as HT voltage.

9) Following table shows plant load factor for M 60 during last 12 months.

Contract Demand - 4990			
Month	Total bill paid	KWH recorded	Load Factor
Dec-13	16545310	2075520	0.58
Nov-13	14208600	1760100	0.49
Oct-13	15775340	1959480	0.55
Sep-13	13561850	1735200	0.48
Aug-13	14404110	1762620	0.49
Jul-13	11592420	1803060	0.50
Jun-13	11299370	1735740	0.48
May-13	10215420	1582320	0.44
Apr-13	9807260	1445760	0.40
Mar-13	9845570	1396620	0.39
Feb-13	14088840	1531076	0.43
Jan-13	8661310	1184220	0.33

This suggests that due to batch processing limitations and manual operations it will be very difficult to push this load factor beyond 75%. Possibility of automation and achieving this will have to be discussed with process and furnace experts. Present 24 x 7 HT side load pattern is as shown below.



10) Alternatively XXX may also think about “Open access Power Purchase” from Indian Energy Exchange to save on cost of energy. Copper fulfills all basic qualifying criteria for availing open access tariff. One has to keep track of open access exchange tariff rates and then buy this power. Further if MSEDCL reduces tariff, then this would become uneconomical. If MSEDCL brings in reduction in wheeling and other charges, then this would become beneficial. At present MSEDCL charges are highest in India.

Harmonic analysis.

Regulations:

MSEDCL / MSETCL infrastructure before our plant suffers due over heating in case our load draws more harmonic current from their equipment like cables, transformers, switchgears etc. TO safeguard MSEDCL interests against this, there is a legal provision which empowers MSEDCL to ask consumers to control their harmonic currents within specified compliance limit. The document which specifies this is "Supply Code 2005" available on MSEDCL website. Under the clause 12.1 and 12.2 this document declares that MSEDCL has adopted an international harmonic mitigation standard IEEE 519 1992 which recommends compliance limits and mitigation requirements under various capacity utilization between Discom and Consumer.

IEEE 519 1992 requires calculating a ratio I_{SC} / $I_{L,}$ where

I_{SC} is short circuit current of MSEDCL transformer supplying the consumer
I_L is consumer's average load current for last 12 months.

It is clear from above that this ratio decides "How Big is the consumer as compared to local grid". Higher the ratio smaller is the consumer and smaller the ratio bigger is the consumer. Obviously smaller consumers are allowed to draw more harmonic currents and vise a versa.

Following table gives compliance limits for various ratios as per IEEE 519 1992.

Maximum harmonic current distortion in percentage of IL for voltages less than 66 KV						
Individual harmonic order (odd harmonics)						
Isc/IL	**<11h**	**11≤h<17**	**17≤h<23**	**23≤h<35**	**35≤h<49**	**TDD**
<20*	4.00	2.0	1.5	0.6	0.3	5.00
20<50	7.00	3.5	2.5	1.0	0.5	8.00
50<100	10.00	4.5	4.0	1.5	0.7	12.00
100<1000	12.00	5.5	5.00	2.0	1.0	15.00
>1000	15.00	7.00	6.00	3.5	1.4	20.00
Even harmonics are limited to 25% of odd harmonic limits above.						

In case of XXX M 60 plant, following data was available regarding associated MSETCL infrastructure.

MVA rating = 50 MVA

% Impedance = 10.01 %

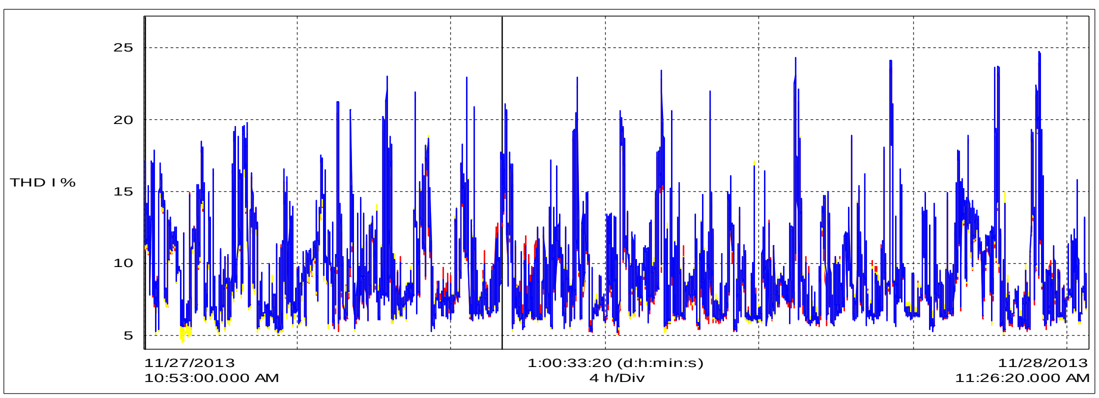
KV= 132 KV / 33 KV

Based on this following table shows calculations for compliance.

Client : XXX CORPORATION PVT. LTD M – 60	
Parameter	**Value**
MSEDCL Transformer Capacity MVA	50.00
MSEDCL Transformer % Impedense	10.01
Contract Demand KVA	4990.00
Max current as per contract demand on LT Side AMPS	6653.72
Max Load Current IL Amps on LT Side AMPS	6615.24
HT System Voltage K Volts	33.00
LT System Voltage	433.00
Full Load current of MSEDCL Transformer Amps	874.80
Short Circuit current of MSEDCL Transformer IscAmps	**8739.25**
Plant current as per contract demand on HT side	**87.30**
Plant Average load current on HT side	86.80
Isc / IL Ratio as per contract demand	**100.10**
Isc / IL Ratio as per Average Plant Current	100.68

Present situation in plant

As shown above the ratio is 100, so it is hitting upper limit of 12% compliance as per above table. As such we recommend that XXX should control these harmonics at 8%.



Above recorded data shows that these harmonics are between 12 to 20% and at times they reach even 25%. These readings are obtained on 24 hours basis and as such show all possible load cycles for a typical load pattern.

This situation needs correction. Following is recommended way ahead.

1) Optimize nonlinear load on auxiliary transformer by removing unnecessary VFDS.
2) Divide Aux transformer load on two transformers to limit % loading up to 70%.
3) Correct current harmonics by installing detuned thyristor switched filters for these auxiliary transformers.
4) Check HT side harmonics again.
5) Following table shows secondary LT side voltage and current distortion along with % utilization of each transformer associated with furnace.

Table 1

Location	% THDV	% THDI	Transformer Utilization %
T1	7.5	35.3	124
T2	10	24.9	128
T3	8.1	25.6	101
T4	8.3	25.3	91
T5	6.8	30.6	104
Spare	-	-	-
T6	-	-	-
T7	11.7	27.3	105
LT Aux	10%	45%	94%

Following table shows HT side loading, current and voltage values and distortions.

Table 2

Location	Voltage (V) V L-L	Current (A)	% THDV L-L	% THDI	Peak (KW)
HT	32 -36 KV	86.8	2.3	24.7	4770
O/G 1	34 -35 KV	31.75	2.3	14.15	1750
O/G 2	33 KV	31.78	2.9	21.22	1700
O/G 3	32 -33 KV	32.82	2.8	14.16	1780

Following table shows individual harmonic currents taken by each furnace

Table 3

Location	Harmonic Currents in Amps			
	5^{th}	7^{th}	11^{th}	13^{th}
H2	**60**	**30**		
M2	**200**	**100**	**50**	**40**
M1H1	**125**	**50**	**40**	**20**
M3H3	**150**	**75**	**40**	**35**
M4H4	**190**	**100**	**60**	**40**
M6H6	**175**	**80**	**50**	**30**

Observations:

a) Table 1 shows that all furnace transformers are loaded up to 100% or beyond.This results into voltage distortion of 7 to 12% on LT side.
b) One can see that HT line being strong enough, reflected HT side voltage distortion is below 3%, although the plant draws HT current with harmonic distortion ranging from 14 to 25%. (This includes distortion caused by LT auxiliary feeder also)
c) LT side Voltage distortion along with current distortion due to 6 pulse furnace load results into final current distortion ranging from 25 to 35%.

Way Ahead:

a) We are of the opinion that “LT – AUX” issue should be addressed first by optimizing as explained above and correcting by installing detuned filters.

b) The effect of this will be reflected into reduction in HT harmonics. This should be measured.

c) Furnace transformer secondary side current distortion is shown in table 2 and individual predominant harmonic currents are shown in table 3. Furnace transformer secondary voltages are odd and nonstandard. Active filters of these odd specifications are not available in market as standard products. Due to all this the solution from this side will not be economically viable.

d) We recommend you should plan to replace 6 pulse rectifier based panels with 12 pulse designs in future. This will offer solution for the root cause of producing harmonics. These panels will generate less harmonics. We are of the opinion that there is no point in keeping the harmonic generation alive and then adding some costly electronics to mitigate these harmonics.

OR

e) Instead of 12 pulse power sources, you may enquire with your Furnace vendor about “active front end rectifier” based furnace panels. These type of rectifiers do not generate harmonics and also maintain power factor close to unity. This retrofitting would be costly but will give complete solution for the root cause and can be undertaken in phased manner. This option will also offer benefits like life of HT side equipment and transformers will increase at least by 50%. Electronics in panels is maintained by your furnace vendor at present; so this option will not add to additional electronics.

f) While going for any new furnace and transformer, you should take following commitments from the vendor and select the equipment as per these guidelines.
    - Furnace transformer should operate at maximum efficiency at even at loads above 80%
    - Furnace transformer should not develop LT side voltage harmonic distortion > 3% while handling 35% distorted furnace current.

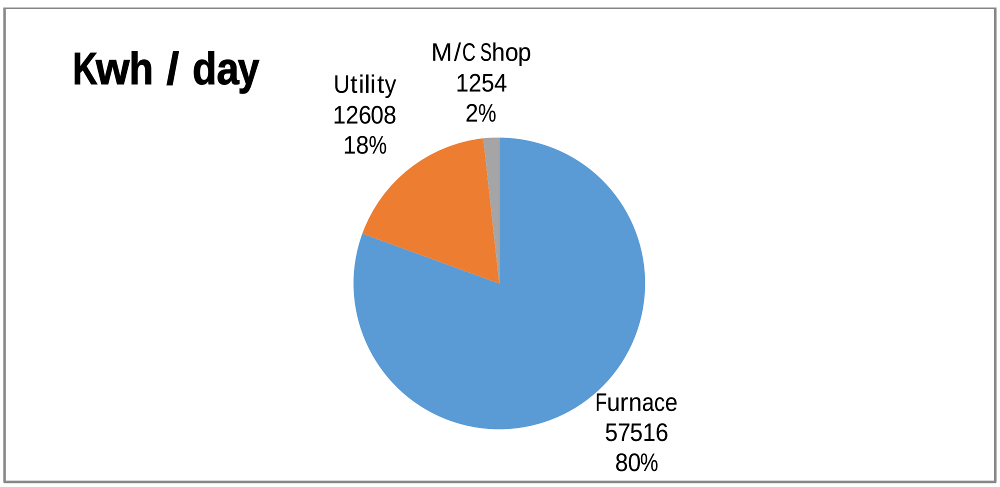
- If Active front end rectifiers are not available from furnace vendor or they are too costly, you should always opt for 12 pulse rectifier for furnaces of this size and each 12 pulse panel should be supplied by independent 3 winding transformer. This would reduce HT side current harmonics drastically.

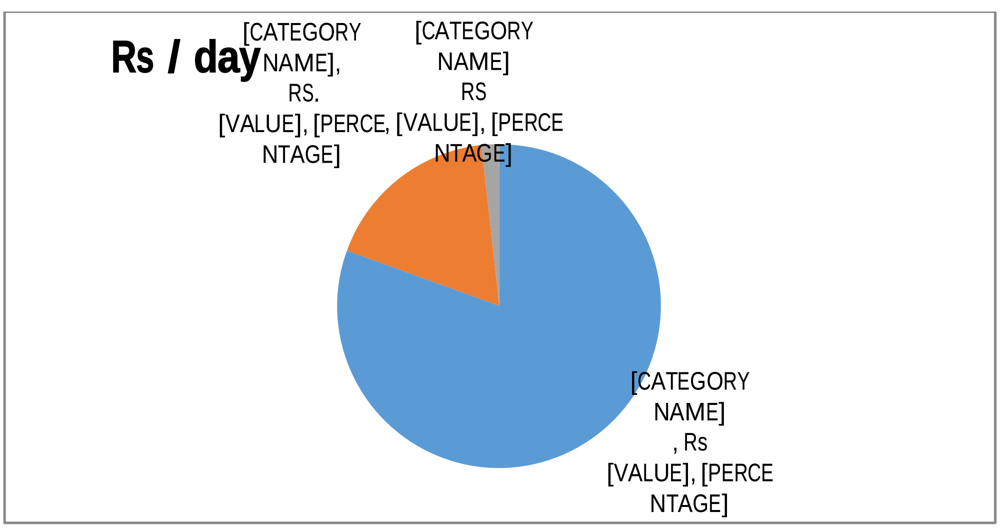
Internal Division of Electrical Energy Consumption

We have recorded following feeders for 24 hours. (Recorded on 27 and 28th Nov 2013)

1)	Main HT Incomer	A	71378 Kwh
2)	LT Auxiliary Transformer	B	13862 Kwh
3)	Machine Shop feeders	C and D	315 KWh and 939 Kwh

A will give total consumption for 24 hours.	71378Kwh
A – B will give energy consumption for Melting and Holding furnaces for 24 hours.	57516Kwh
C+D is part of Auxiliary transformer and give energy consumption on machining in 24 hours.	1254KWh
B – (C+D) will give energy consumption on all furnace utilities.	12608Kwh



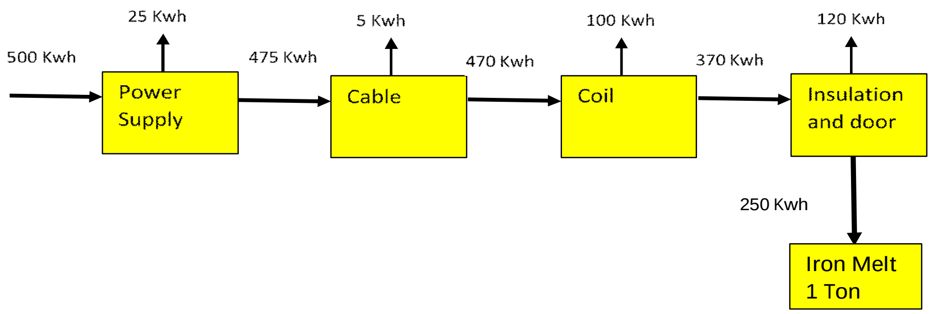


This clearly indicate that significant energy use is in FURNACES which consume 80% of total energy.

Furnace Energy Audit:

XXX uses induction furnaces for melting and holding the molten iron. In induction furnace high frequency electric current passing through a coil creates magnetic field. These magnetic field links with the charge and induce voltage / current in the charged metal, which act as short circuited transformer secondary. I^2R loss and eddy current loss in this metal heap creates heat to melt the metal.

- Typical energy balance of these furnaces is as follows



Above diagram shows energy requirements for melting 1 ton typical iron scrap in about 40 to 45 minutes. Tubular copper coil receives heat from two sources:

1) I^2R loss within the coil.
2) Radiated / Conducted heat from refractory based crucible within the coil which houses metal to be melted / molten metal.

   This coil needs cooling to protect itself from damage due to heat. This is usually arranged by circulating water. The hot water coming out needs cooling using PHEs / cooling towers etc. The heat insulation thickness between coil and crucible cannot be increased as more the thickness less is magnetic coupling between Coil as primary and metal as secondary which further reduces energy transferred for melting. Melting takes about 500 units of electricity within 40 to 45 minutes. This is around 11 units per minute. If this process takes extra time due to any irregularities, 11 units are wasted per minute. Centrifugal casting process needs holding of molten metal as a part of process as poring takes time. Optimized synchronizing between melting and pouring can save lot of energy.

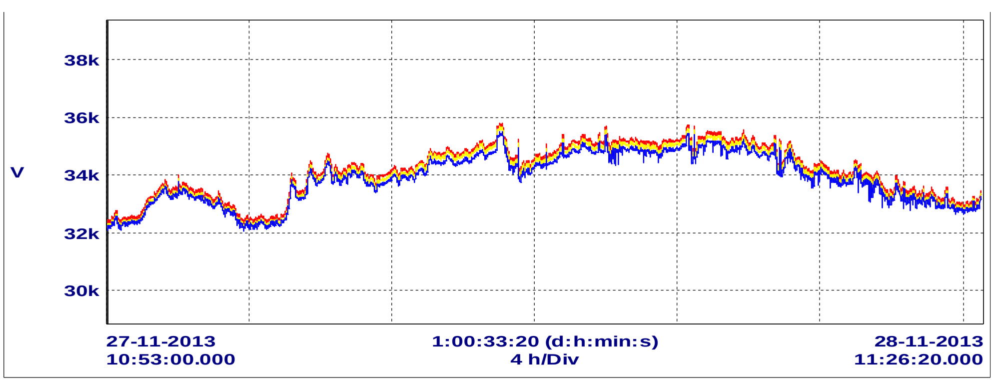
- Energy consumption for melting and holding was measured individually for furnace M2 and H2. For all other furnaces melt and hold energy was measured at single point. We measured M2 and H2 energy consumption for 24 hours and also took details on metal charging from foundry records to calculate specific energy consumption. The details are as follows:

Furnace	Temp	Time	Weight	KWh	Kg / KWh
M2	1497	01:31	991.67	459.92	2.16
Furnace	**Temp**	**Time**	**Weight**	**KWh**	**Kg / KWh**
H2	1497	01:22	991.67	93.15	10.65
Melt + Hold Kwh				553.07	
% Consumption Melt to total				83.16%	83%
% Consumption Hold to total				16.84%	17%
The division as above is done to calculate melt and hold energies separately for all other furnaces as it is not possible to measure them independently.					

1) Electrical Distribution Loss measurement

Distribution Loss measurement		Wh @ Furnace Panel	Wh @ Transformer Secondary
1/30/2014	12:30:24 PM	112.96	229.8
1/30/2014	4:36:55 PM	1538375.06	1567632.43
Wh Consumed		1538262.1	1567402.63
Wh Loss		29140.53	
KWh Loss in 4 hours		29.14053	
Kwh Loss in 24 hours		174.84318	
Kwh Loss in 24 Hrs for 5 Furnaces		874.2159	
Approximate transformer Loss 2%		1146.32	
Total Distribution Loss in Kwh / day		**2020.5359**	

This loss is mainly contributed by Transformer Loss, Servo Stabilizer loss and LT cable loss.



24 hours trace of HT voltage as above shows extreme variation of -2.3% to +7.5% in RMS voltage over rated 33KV. If this is acceptable to furnace manufacturer and also considering the fact that you have Express feeder, we are of the opinion that the servo stabilizers can be removed from the circuit. Some more savings may be achieved as a result of harmonic mitigation and reducing LT cable lengths by repositioning the distribution near foundry. About 1000 units per day from above – which is 1.5% of your total daily consumption is unavoidable.

2) Following are basic Calculation showing heat required for cast iron melting.

A.	CI Cp = 0.11 Kcal/kg			**Therefore Heat Required to Melt 1 Kg of CI from 30 deg C**				
	CI Latent 23 Kcal/kg			**182.5**	**Kcal**			
	Melt Temp : 1204 deg C			**0.212209302**	**KW**			
	Hold Temp : 1480 deg C							
B.	**Heat Lost/hr to Ambient due to Water Cooling & Insulation Losses for 2 Kg per KWh Consumption**							
	Heat For Melting 2 Kg			**0.424418605**	KW			
	Therefore Heat Loss			**0.575581395**	KW			

3) Cooling load calculations and associated savings.

Following are basic Calculation which calculate excess energy consumed and to be on safer side assumes that 65% of this excess energy is expected to be taken away by cooling water. Further these calculations also compare the parameters with those mentioned in drawings provided by furnace manufacturer and calculates annual savings.

D.	**Cooling Load for 77000 Kgs - Normal Operation of Furnace Per Day**			
	Parameter	**Value**	**Unit**	**Comment**
	Melt Energy in 24 Hrs	16340.11628	KWh	Based on basics
	Excess Energy in 24 Hrs	37955.88372	kwh	(54296 - 16340)
	Cooling Rate Kw/ Hr	1581.495155	KW	
	Assuming 65 % to Cooling Wtr	1027.971851	KW	[Over 6000KW as per drgs]
	Cooling Rate	883356.7708	Kcal / hr	
	Temp Diff as per Drgs	9	deg C	
	Water Flow Rate	98150.75231	LPH	Calculated from above
	Water Flow Rate	1635.845872	LPM	[Over 8000 LPM as per drgs]
	Water Flow Rate	27.26409786	LPS	
	Maxm Pump Head	25	m	Guessed as per site conditions.
	Maxm Pump Power	9.277366634	KW	
	Therefore Maxm CT Fan	2.2	KW	As per our Experience
	Current Pump House Power	65	kW	Measured
	Therefore Savings	**53.52263337**	kW	
	Therefore Rupee Savings	**Rs. 30,82,904**	**Rs p.a.**	

Following are actual measurements taken on water cooling system.

G	Location from LT	Water IN Deg C	Water OUT Deg C	Furnace #	Temp Diff Deg C	Operating %
	1	27	23.7	M6H6	3.3	37%
	2	Off	Off	Off	0	0%
	3	31.5	28	M3H3+M4H4	3.5	39%
	4	25	24	M2H2	1	11%
	5	27	27	M1H1	0	0%
	This indicates Cooling system Oversizing.					

Keeping in mind that above readings are taken in winter, still we are of the opinion that these systems are grossly oversized and circulate the water at much higher rate than required.

4) Fumes extracting blowers – actual measurements and associated savings.

We have measured present air quantities handled by these blowers along with present energy consumption of each blower. We assume that present air quantities are sufficient to achieve required operator comfort and fulfil pollution control requirements. We have also made reasonable assumption on scrubber pressure drop. Based on this data we have calculated required blower motor HP and accordingly the savings are calculated and given bellow.

Melt & Hold Exhaust System incl Scrubber & Blowers							
Furnace #	Intake Area sqft [M+H]	Vel [fpm]	Air Qty CMH	Blower KW	Exp KW	Savings	Freq Hz
M6H6	2.71	2,160	9,935	20.5	5.0	15.5	50
M4H4	2.57	3,159	13,812	15.9	5.0	10.9	40
M3H3	2.57	2,067	9,036	6.8	5.0	1.8	30
M2H2	2.57	3,068	13,410	24.0	5.0	19.0	50
M1H1	2.57	2,100	9,179	24.7	5.0	19.7	50
						66.84	
Assumption : Scrubber Pr Drop does NOT exceed 40 mm WC						**38,49,984**	
Blower Expected Power KW @ 13900 CMH							

The savings are possible as the system design of 400 mm WC seems to be too high. Suggest that this can be verified by XXX with Almonard. Since there was no way of measuring the differential pressure across the scrubber, a realistic assumption of approximately 30 to 40 mm WC has been made.

Ideally the scrubber can be designed for operating differential pressure of 25 to 30 mm . . . definitely not exceeding 40 mm WC while being clogged. The other pressure drops do NOT account for a 400 mm WC design. If the scrubber is designed for anything more than these Pressure Drops, it may be worthwhile examining the possibility of re-designing the same, as the savings would pay back in good time. The SOP should include a scrubber clean up when differential pressure exceeds 40 mm WC.

The expected power of 5 KW is applicable @ 13900 CMH with 40 mm WC scrubber differential pressure - with both blower system & motor being designed to suit the expected pressure drops [along with a possible scrubber re-design if the actual pressure drops exceed 40 mm WC].

5) Estimation of furnace insulation loss.

Out of total excess energy consumed, we assume that 35% energy is door and insulation loss and out of this 50% is actual insulation loss. IR thermography was conducted on furnace walls and detail temperature measurements are indicated in this report. Following calculations show possible savings if Insulation is improved / replaced.

F.	F/C Insulation & Door Losses			
	Parameter	**Value**	**Unit**	**Comment**
	Door / Insulation Losses per day	13284.5593	kwh	35% of total loss
	Avg Surface Temp Recorded	125	deg C	Ref IR Report
	Possible Surface Temp	70	deg C	
	Typ Ambient Temp	40	deg C	
	Therefore Temp Ratio	35.29%		
	Assuming Insu Losses @ 50%	6642.279651	Kwh	50% of door/Insu loss
	Possible Insu Savings per day	4297.945657	KWh	
	Therefore Rupee Savings	**Rs. 103,15,070**	**Rs p.a.**	

6) Loss due to cycle mismatch

E.	Loss Due to Mismatch of Melt / Hold / Casting Times			
	For Holding Melt at Melting Furnace			
	For Holding Melt at Holding Furnace			
	Based on the site readings, there is an average mismatch of 10 mins			
	Process Parameter	**Value**	**Unit**	**Comment**
	Typical Melt Cycle	70	mins	As measured
	Excess Hold time / cycle	10	mins	As observed
	Therefore Hold Excess Energy	1684.073353	KWh	From readings
	Therefore Rupee Savings	**Rs. 40,41,776**	**Rs p.a.**	

It is observed that "Melt and Hold Cycle Mismatch" takes place frequently and is also cause of excessive energy consumption. Table above shows possible saving if this mismatch is avoided. We have observed the process carefully and we are of the opinion that it is not possible to avoid this mismatch totally as long as most of the operations are manual. However following measures could help in reducing this to some extent.

a) Close control over health of all "Line Machinery" through proper preventive maintenance.
b) Well documented and Practiced SOP for furnace operation.
c) Applying peer pressure on operators through local display of "Cycle time" and "Cycle energy".

7) Summary of all above findings

Summary of possible energy savings

Sr No	Energy Saving Opportunity Description	Annual Savings	Achieve-ability Factor	Corrected Annual Savings	Approx Investment	Approx Payback in months
A	Eliminating Rejection	58,26,072	25%	14,56,518	0	0
B	Optimizing Cooling Water Operations	30,82,904	90%	27,74,613	44,00,000	19
C	Eliminating Mismatch	40,41,776	35%	14,14,622	0	0
D	Improving Insulation	103,15,070	40%	41,26,028	55,00,000	16
E	Blower Optimization	38,49,984	75%	28,87,488	35,00,000	15
Totals		**271,15,805**		**126,59,269**	**134,00,000**	**13**

Way Ahead

1) Harmonics mitigation may start from optimizing nonlinear load on Auxiliary transformer.

2) You may check possibility of retrofitting existing 400KVAR tuned filter into a detuned filter, connect the same across LT secondary of auxiliary transformer with feedback from main HT PCC – to ensure unity P.F. as well as controlled harmonics.

3) Check voltage distortion on Auxiliary transformer LT side after this, if it is not reduced below 5%, you will have to reduce load on this transformer.

4) Check HT side harmonics after above step.

5) Eventually you are expected to bring down current harmonics on HT side below 8% as per MSEDCL supply code 2005 and IEEE 519 1992. To achieve this, you may discuss with Indctotherm about available options on furnace power supplies. If you get harmonic compensated power supplies, the source of harmonics would be curtailed so need of additional mitigation majors.

6) Follow standard furnace loading practices as prescribed by Inductotherm, make continuous efforts to reduce rejection at all levels, optimize Melt – Hold Cycling to reduce energy consumption.

7) Monitor, Log and display cycle by cycle energy consumption automatically so that peer competition can be introduced to optimize energy consumption.

8) Discuss water cooling system parameters with Inductotherm and optimize as detailed in the report to reduce energy consumption.

9) Discuss furnace insulation status and reduce energy consumption by adopting predictive maintenance strategies as advised by furnace manufacturer to control energy loss through insulation.

10) Finalize air velocities and quantities for fumes extraction. Optimize these blowers based on this data to reduce energy consumption.

11) Keep track of day to day energy consumption at all above strategic locations and control them with suitable predictive and preventive maintenance practices to get control over energy consumption.

12) You may explore possibility of buying electrical energy through open access via National Energy Exchange. A proper feasibility study may be conducted to know possible exact saving and required investments.

13) Following are some tips to optimize energy consumption in induction furnace:

a) Reduce number of COLD STARTS.
b) Use clean charge. Correct size scrap and sandwiching of borings reduce melt energy considerably. Cost reduction due to use of unclean scrap should be weighed against incremental increase in energy cost.
c) Arrange storing / batching and movement of scrap so that charging of furnace can happen quickly.
d) Close the lid for longer holds and apply full power for melting.
e) Quick deslagging should be arranged.
f) Avoid superheating.
g) Monitor and reduce delays in QC check.
h) Best possible Holding – Pouring coordination to optimize hold time.
i) Internal capacitor damage can increase specific energy consumption due to reduction in maximum energy transfer.
j) Use efficient designs of fumes extraction and water cooling.
k) Meter the energy input to each cycle and compare with benchmark.

---END OF REPORT--