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Foundrybench

Foundry Energy Efficiency Benchmarking

Intelligent Energy – Europe (IEE)
SAVE – Industrial Excellence in Energy

D8 Energy analysis reports, a case metal foundry in Finland

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FOREWORD

This energy auditing was carried out in a case metal foundry in Finland. This report describes current production and building service systems like process, HVAC, electricity their operating state and condition in a case metal foundry. The report presents also the potentials to reduce the site's thermal energy, electricity and water consumption. It also presents the total costs, gain savings and repayment periods of suggested measures.

1. SUMMARY OF AUDIT SITES ENERGY ECONOMY AND SUGGESTED MEASURES

1.1. AUDIT SITE

The branch of industry of the example foundry is copper alloy casting and machining to final products. The foundry has expert knowledge in manufacturing slide bearings.

1.2. ENERGY ECONOMY AND SAVING POTENTIAL

- **Thermal energy**

Natural Gas consumption can be decreased radically if thermal energy of foundry exhaust air is recovered. Air flows in and out of foundry are considerable and there is no heat recovery in use. This makes saving potential high.

Liquid gas can be saved if propellant burners of pouring ladles are replaced with electric heaters. This naturally increases consumption of electricity but with high energy efficiency.

Fuel-oil consumption has decreased because electricity has gradually replaced oil in melting process. The company is considering to utilize induction furnaces to replace oil driven furnaces.

- **Electricity**

Efficiency of electric furnaces is much higher than oil or liquid gas furnaces. Because of goof efficiency saving potential is pretty low. Specific consumption in melting is higher than on average in foundries. Thus energy can be saved when using furnaces more efficiently. For example by shortening time periods between melting stages achieves savings in heating of the furnaces.

Remarkable savings can also be reached when fixing the leaks in compressed air network and improving the control of the ventilation systems.

- **Water**

Water conservation measures are not presented in this audit.

Summary of sites energy consumption is presented in chart 1 (taxes are not included in expenses).

CHART 1.

Current consumption 2007		Saving potential				Investments
Thermal energy						
8 331	MWh/a	2 645	MWh/a	32	%	134 000 €
357 039	€/a	109 855	€/a	31	%	
		567	t CO_2			
Electricity						
2 412	MWh/a	136	MWh/a	6	%	16 000 €
140 572	€/a	6 664	€/a	5	%	
		95	t CO_2			
Tap Water						
12 190	m³/a	0	m³/a	0	%	0 €
43 533	€/a	0	€/a	0	%	
Total consumption		**Total savings**				**Total investments**
541 144	€/a	116 519	€/a	22	%	150 000 €/a
		662	t CO_2			

Summary on energy conservation measures are presented in chart 2.

Chart 2

SUMMARY OF ENERGY CONSERVATION MEASURES

Case metal foundry Finland																28.8.2008	
	DESCRIPTION OF MEASURE	TOTALS SAVINGS	REPAYMENT PERIOD	INVESTMENT	CO_2 EMISSION REDUCTION	SAVING HEAT				SAVING ELECTRICITY				SAVING TAP WATER		CHAPTER OF REPORT	AGREED CONTINUATION MEASURE
						ENERGY	CO_2	COSTS ENERGY	COSTS OTHERS	ENERGY	CO_2	COSTS ENEGY	COSTS OTHERS	TAP WATER	COSTS		
no		EUR/a	a	EUR	t	MWh/a	t	EUR/a	EUR/a	MWh/a	t	EUR/a	EUR/a	m^3/a	EUR/a		T,P,H,E
1	Heat recovery from furnaces hood canopies	14500	2,9	42000	101	500,0	101,0	14500	0							7.1.1	Under consideration
2	Heat recovery from general ventilation of refinery	22040	2,5	54000	154	760,0	153,5	22040	0							7.1.2	Under consideration
3	Heat recovery from local ventilation of furnaces	18850	2,0	38000	131	650,0	131,3	18850	0							7.1.3	Under consideration
4	Local ventilation of welding station and masonry place	1715	2,0	3500	25					35,0	24,5	1715	0			7.1.4	Carried out
5	Frequency converter to furnaces local ventilation fan	3920	2,9	11500	56					80,0	56,0	3920	0			7.1.5	Rejected
6	Local ventilation on continuous casting	1617	0,0	0	23					33,0	23,1	1617	0			7.1.6	Rejected
7	Usage of secondary compressor Tamrock	1960	0,0	0	28					40,0	28,0	1960	0			7.2.1	Decided
8	Leakages in compressed air network	2940	0,3	1000	42					60,0	42,0	2940	0			7.2.1	Decided
9	Combustion air blowers	1862	0,0	0	27					38,0	26,6	1862	0			7.2.2	Rejected
10	Increasing usage of electric furnaces	31100	0,0	0	37	400,0	106,8	36000		-100,0	-70,0	-4900	0			7.3.1	Decided
11	Preheating of ladles with electricity	13550	3,7	50000	22	250,0	56,8	16000		-50,0	-35,0	-2450	0			7.3.2	Rejected
12	Heating cold storage with castings	2465	0,0	0	17	85,0	17,2	2465	0							7.3.3	Carried out
	TOTAL	**116519**		**200000**	**662**	**2645**	**567**	**109855**	**0**	**136**	**95**	**6664**	**0**	**0**	**0**		

2. BASIC INFORMATION OF THE SITE

2.1. SITE

Name	A case metal foundry in Finland
Address	xxx

Lay-out of the site is presented in Appendix 1.

Gross area of construction is 4 438 m^3 and volume is 40 830 m^3. Type of the construction is industry hall class 691. 85 % of the construction volume is heated.

Basic information about sites buildings is presented in following chart.

Chart 2.1 Buildings, construction volumes and gross areas of site.

nro	Building/property	Construction year	Volume, m^3	Gross area, m^2	Operating time, h/a
1	office	1974	2450	700	2600
2	dispatch department	1974	3082	460	4200
3	Machinery 1 / roughing plant	1974	3082	460	4200
4	Machinery 2	1974	6030	900	4200
5	melting shop	1974	9246	1380	4200
6	storage	1974	7638	1140	2600
7	cold storage	2008	9380	1400	4200

2.2. LINE OF ACTIVITIES, PRODUCTION VOLUMES AND STAFF

Production takes place in two shifts and five days a week. Night and weekend shifts are carried out occasionally. In office and management work 16 employees. Maintenance has two employees, melting shop 5 employees and machinery 50 employees. Line of business is manufacturing of metal products (non iron) of which manufacturing demands machining of castings. Production volumes are presented in chart 2.2.

Chart 2.2 Production volumes, ton/a

	2003	**2004**	**2005**	**2006**	**2007**
melted		1610	1678	1910	2153
casted (total amount)	1298	1335	1403	1658	1945
casted (flat and vertical casting)		731	768	1066	1208
casted (continuous casting)		604	635	592	737
ration ship between casted and melted,		83	84	87	90

%

2.3. ACCESS TO MUNICIPAL NETWORKS

2.3.1. Heat Supply

Premises are heated by two natural gas boilers. Bigger boilers output is 1000 kW (Laka) and smaller boiler output is 730 kW (Lokomo). The boiler burners have been changed for new in 2002.

2.3.2. Electricity

Foundry's power supply to electrical network is behind the storage building in switching station. The site is connected to distribution network by 20 kV line. The electric energy consumption is registered hourly with combination meters which measure active power and also reactive power. Meters are equipped with automatic remote reading option. Distribution network operator is Vattenfall Verkko Ltd.

2.3.3. Tap Water

Tap water is bought from municipal company. The sewage is treated in municipal waste water treatment plant.

2.4. CONSUMPTION MONITORING

Consumption monitoring is carried out well enough in the site. Electricity, propane, fuel oil and natural gas consumption and costs are monitored on monthly basis. At the same time consumption development is compared to previous year consumption.

3. COSTS OF ENERGY JA TAP WATER CONSUMPTION

All costs presented do not include value added tax.

3.1. ENERGY AND TAP WATER SUPPLY

Supply methods are presented in chapter 2.3.

3.2. TOTAL CONSUMPTION, COSTS AND SPECIFIC CONSUMPTION

3.2.1. Thermal energy

Natural Gas

The sites premises are heated with natural gas. Natural gas is bought from municipal company.

The calculative price applied in pay-back-costs of energy saving options for natural gas energy is 28,52 €/MWh.

Chart 3.1 Natural gas consumption and costs

	2003	**2004**	**2005**	**2006**	**2007**
Consumption, MWh/a	3200	3108	3077	2899	2905
Cost, €/a	80.734	82.100	89.691	92.707	91.772
Standardized consumption, MWh/a	3241	3174	3282	3104	2928
Standardized specific consumption, MWh/ton	2,50	2,38	2,34	1,87	1,50

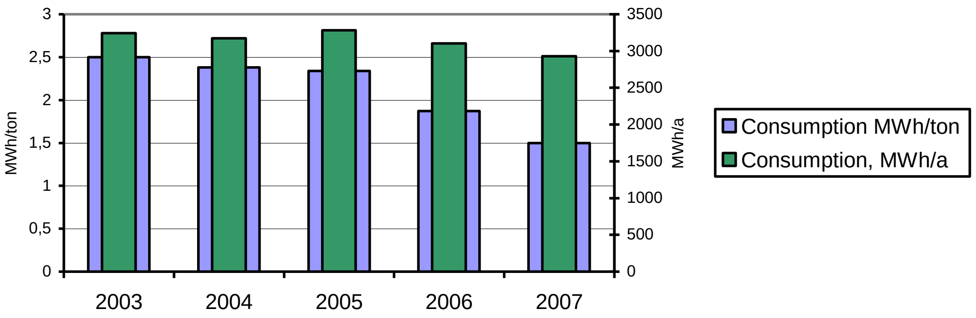

Figure 3.1 Standardized consumption and specific consumption of natural gas

Thermal energy consumption has been stable in past years. Instead specific consumption has decreased due to increased production volumes between 2006 and 2007. Natural gas consumption is not related to production volumes so it is obvious that specific consumption decreases when production volumes increases.

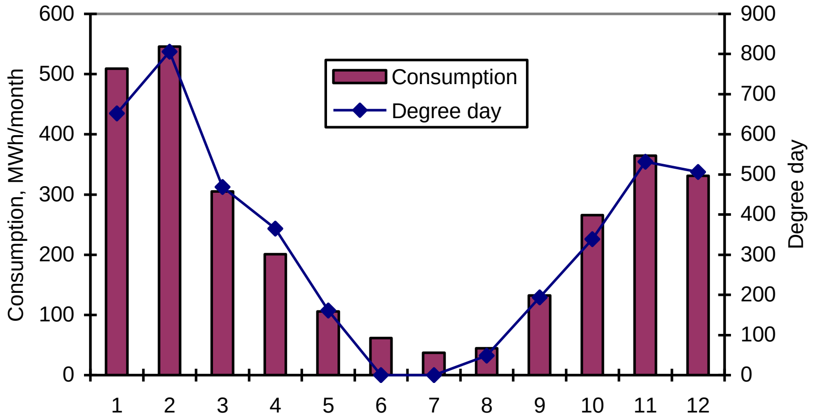

Figure 3.2 Thermal energy consumption on monthly basis and degree day in 2007.

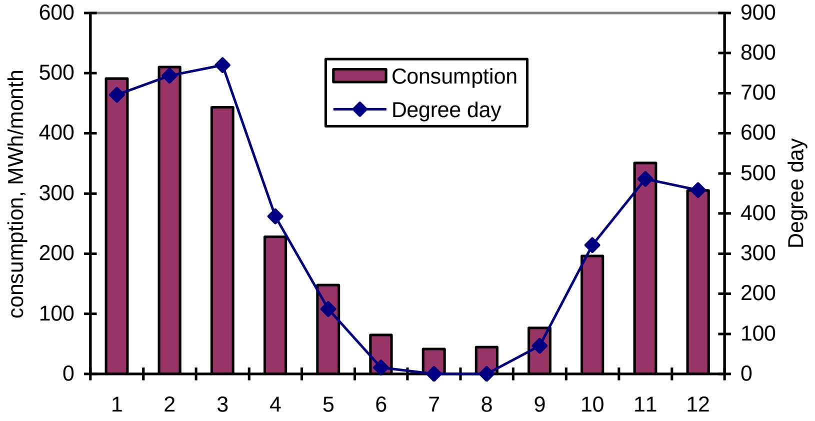

Figure 3.3 Thermal energy consumption on monthly basis and degree day in 2006.

Liquid gas

The company uses liquid gas to melting and to heating of ladles. Tehokaasu Ltd is the supplier of propane. Price of propane was 56,24 €/MWh by the end of 2007.

Chart 3.2 Liquid gas consumption and costs.

	2003	2004	2005	2006	2007
Consumption, MWh/a	1263	1835	1759	2053	1815
Cost, €/a	41.168	61.282	70.802	99.929	83.361
Cost, €/MWh	42,07	43,12	51,95	62,85	59,29
Specific consumption, MWh/ton	0,97	1,38	1,25	1,24	0,93

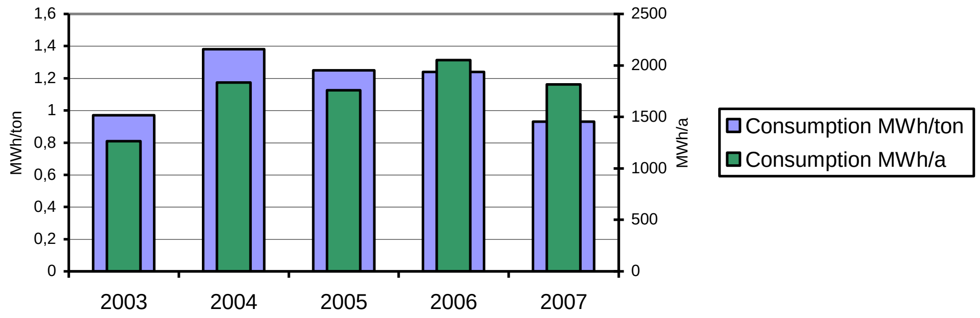

Figure 3.4 Liquid gas consumption and specific consumption.

Liquid gas consumption varies a lot in yearly basis though specific consumption MWh/ton have decreased pretty much since 2004.

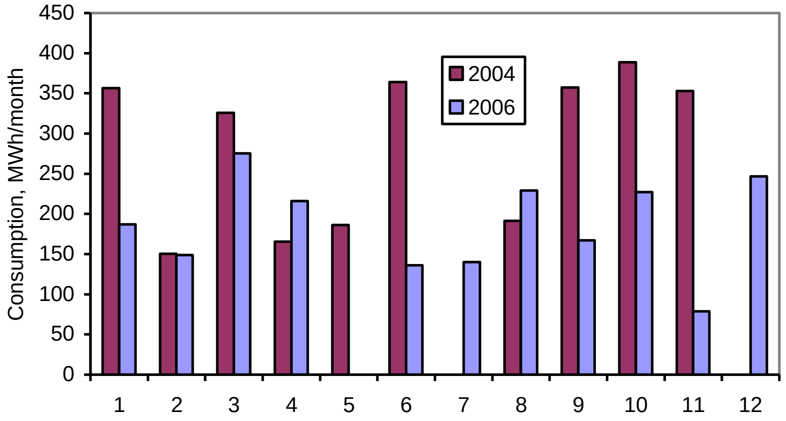

Figure 3.5 Liquid gas consumption presented on monthly basis in 2006 and 2007.

Fuel Oil

The site uses light fuel oil for example in furnaces and in continuous casting to control the temperature of molten metal. Fuel price was in summer of 2008 approximately 0,90 €/litre. Prize of light fuel oil is 90 €/MWh in energy conservation calculation.

Chart 3.3 Oil consumption and costs.

	2003	2004	2005	2006	2007
Consumption, MWh/a	7654	4220	3486	3109	3588
Cost, €/a	216.690	135.978	161.113	155.792	181.906
Cost, €/MWh	28,31	32,22	46,21	50,12	50,70
Specific consumption, MWh/ton	5,90	3,16	2,49	1,87	1,84

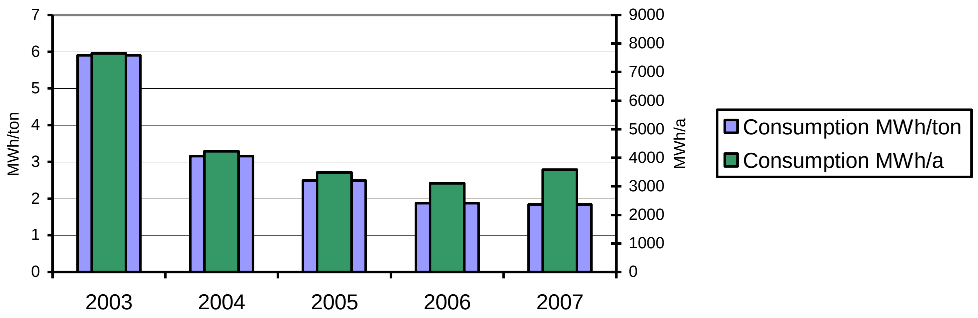

Figure 3.6 Light fuel oil consumption and specific consumption.

Oil consumption has decreased noteworthy since 2003. After year 2003 oil consumption have been approximately 3500 MWh/a. Specific consumption have improved after 2003 due to electric furnaces have replaced oil furnaces.

3.2.2. Electricity

The foundry has a total supply contract with Vattenfall Ltd. Network service tariff of electricity is Tehosiirto3.

Hourly electric power and reactive power consumption of the site are measured for two week periods.

Chart 3.4 Electricity consumption and costs.

	2003	**2004**	**2005**	**2006**	**2007**
Electricity consumption, MWh/a	1764	1954	2040	2249	2412
Costs, €/a	78.163	125.057	120.889	131.207	140.572
Costs, €/MWh	44,3	64,0	59,3	58,3	58,3
Specific consumption, MWh/ton	1,36	1,46	1,45	1,36	1,24

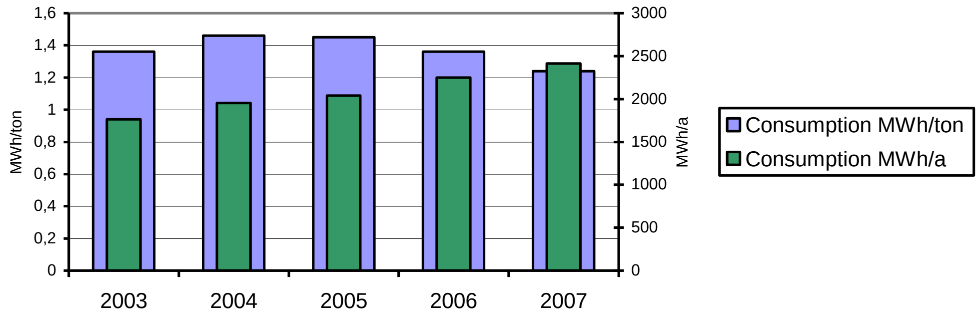

Figure 3.7 Electricity consumption and specific consumption.

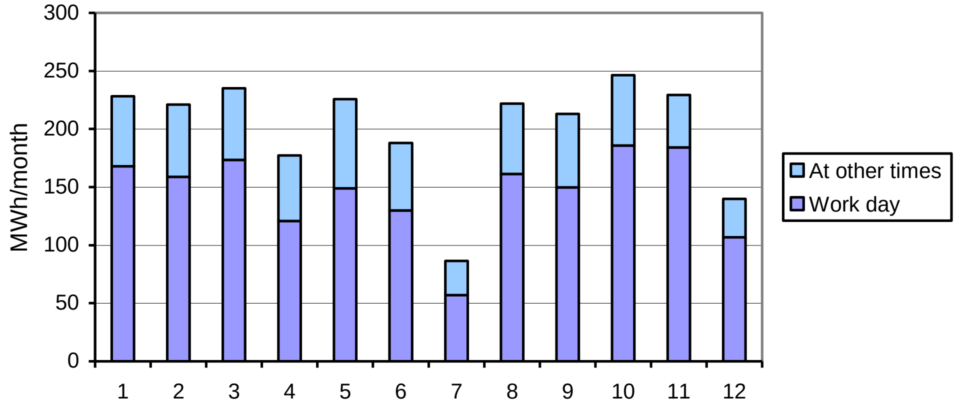

Figure 3.8 Electricity consumption on monthly basis in 2007.

Consumption of electricity has increased steadily in past years in consequence of increase in production volume. More efficient use of electric furnaces has put down specific consumption by shortening the time between pours.

3.2.3. Tap Water

Tap water cost consists of supply water charge 1,31 €/m^3 and sewage water fee 1,78 €/m^3. Total charge of tap water is 3,09 €/m^3 on the top there is a basic fee of 84,09 €/a.

Water consumption was 12.192 m^3/a in 2007 and 8828 m^3/a in 2006. Tap water cost was 43.533 € in 2007.

3.3. ENERGY BALANCES

The sites thermal energy and electricity consumptions are presented in following charts.

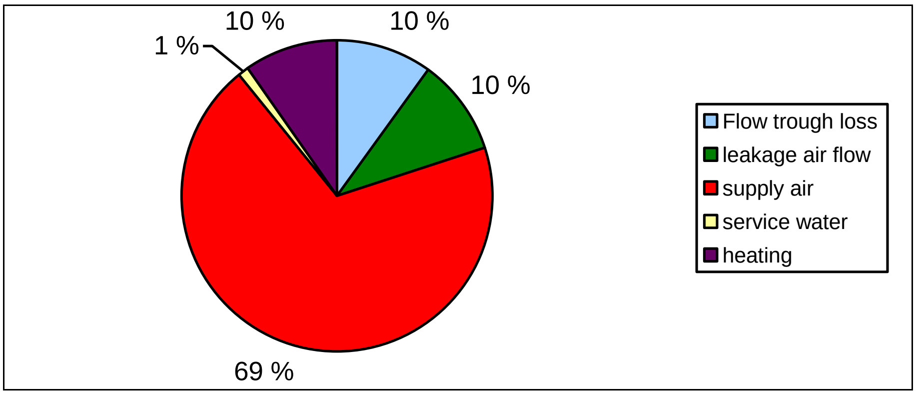

Figure 3.9 Thermal energy (Natural gas) consumption classified by usage targets.

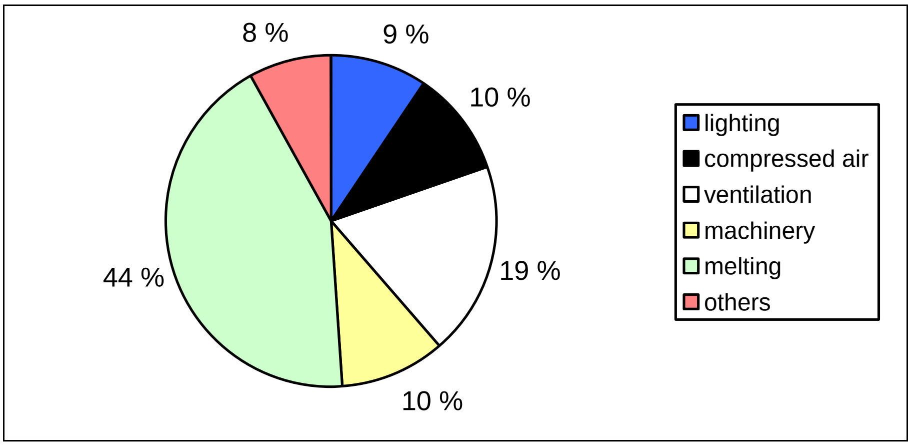

Figure 3.10 Electricity consumption classified by usage targets.

Liquid gas is mostly used for melting (84 %) and the rest is used in heating of ladles.

Light fuel oil is used for melting (74 %) and in temperature control of molten metal (26 %).

The only significant heat loss is exhaust air. Almost all spent energy is converted to heat and lost especially trough ventilation in melting shop. Heat conduction through structures and sewage water losses are insignificant.

Chart 3.5 Summary of specific energy consumption in 2007.

Energy	Natural gas	Propane	Light fuel oil	Electricity	Total
Specific consumption per tonne product produced MWh/ton	1,50	0,93	1,84	1,24	**5,51**
Specific consumption per tonne molten metal MWh/ton	1,36	0,84	1,67	1,12	**4,49**
Energy cost / volume of business, %					**3,1**

4. BASIC MAPPING OF IN-HOUSE EQUIPMENT AND ENERGY CONSUMPTION

4.1. HEATING SYSTEM

4.1.1. Description

Two natural gas boilers process the thermal energy. Main boiler is Laka Z1000 (natural gas 1000 kW) which is newer than secondary boiler Lokomo TK (natural gas 730 kW) from year 1978. Lokomo operates as reserve and peak power boiler.

Flue gas measuring results and theoretical combustion efficiency are presented in chart 4.1.

Chart 4.1 Natural gas boilers flue gas measuring results.

Boiler	Flue gas temperature, °C	CO_2, %	O_2, %	CO, ppm	Combustion efficiency, %
Laka output 2	157	9,0	5,1	0	93,6
Laka output 1	136	9,4	4,3	0	94,8
Lokomo output 2	246	8,9	5,3	12	90,0
Lokomo output 1	185	8,9	5,5	14	92,6

Theoretical air-fuel ratio is 1,0 while burning stoiciometricly. In practise this is never quit achieved. Typical air-fuel ratio on natural gas boilers is from 1,1 to 1,2. The sites main boilers air-fuel ratio is 1,28 which is still considered as a acceptable. Secondary boilers worse combustion efficiency is to be explained by sooty or worn heat exchanger surfaces.

• Heating systems automation

Heat distribution
Outgoing water of heating network is controlled according to the outdoor temperature. Heating networks control diagrams are presented in figures 4.1 and 4.2.

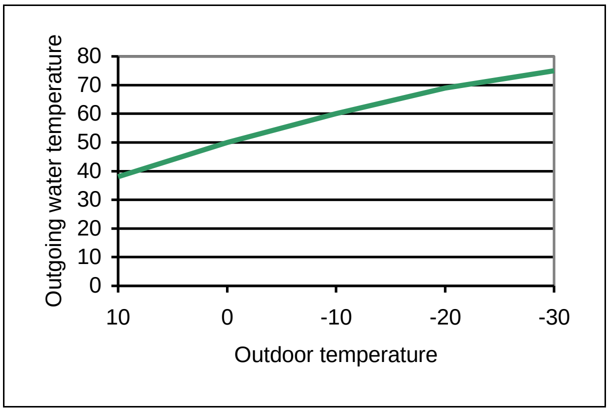

Figure 4.1 Heating network temperature diagram

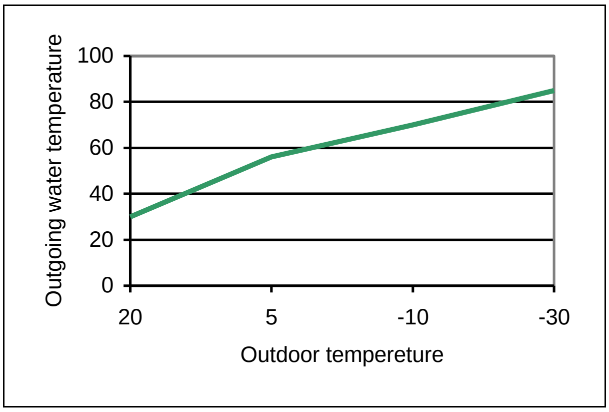

Figure 4.2 Air conditioning network temperature diagram

During the audit neither too high temperatures nor temperature fluctuations were detected. Control diagrams are correctly set.

Tap water temperature control device is recently renovated (Ouman EH-201/V). Warm tap water temperature is 50 °C which is little less than recommendation 55 °C.

4.1.2. Thermal energy consumption

Thermal energy used in HPVAC systems is processed in natural gas boilers.

4.2. HPVAC SYSTEMS

4.2.1. Basic Mapping of Ventilation

• Ventilation Installation

Ventilation installation is original from the early 70´s. Ventilation is carried out with separate supply and exhaust air devices and there is no heat recovery units.

Especially in the melting shop there is negative pressure due to very large exhaust air flows. Supply air fan was installed to melting shop in the 80´s. Heating system is probably undersized considering the thermal demand of the new supply air fan. The supply air fan can not be driven on full speed when outdoor temperature is below zero degrees because of too low supply air temperature.

• Air flow rates of ventilation devices

Chart 4.2 Supply air flow rates of major ventilation units.

Unit	working area	supply air, m^3/s
TU-1	melting shop	4,1/8,0
TU-2	machine shop	0,35
TU-3	machine shop	0,31
TU-4	machine shop	2,12
TU-5	machine shop	1,81
TU-6	melting shop	1,9
TU-7	office	1,5
TK extra	melting shop	15,5

• Operation times of ventilation devices

Operation times of ventilation units match with usage of premises thus savings trough modifying operation times are not possible.

• Heating system

Factory halls are heated with recirculation air coils connected to heating network. Offices are heated with radiators equipped with thermostat valves.

Indoor air temperature of the factory hall will be measured.

• Tap water and sewerage system

The foundry is connected to municipal water network and sewerage system. Water fixtures are in good condition and are equipped with shutter valves. Leaking faucets were not found. Single lever faucets are used in wash basins and head showers.

Flow rates of wash basins and head showers are almost according with recommendations thus flow reduction possibilities are nominal.

4.3. ELECTRICITY SYSTEM

4.3.1. System description

• Distribution boards and transformer substations

The site has two distribution substations (transformers). Both work in 20 kV/0,4kV voltage.

Distribution substation 1 is next to the distribution station. Nominal power is 1000 kVA. Main distribution boards PK1 and PK2 are connected to the distribution substation 1. All the other electric equipment but the furnaces are served via PK1 and PK2.

Distribution substation 2 is next to the furnaces. It is build for the purpose of the furnaces when old distribution substations nominal power was too small. The new distribution substations nominal power is 1 250 kVA. Main distribution board of distribution substation is M2PK.

The foundry uses separate distribution and lighting boards. The condition of the distribution boards differs according to their age. Some machine tools in the machinery are connected to distribution bus bars which are connected straight to main distribution board.

• Compensation equipment

Main distribution board PK1/PK2 is equipped with modern automatic compensation unit. Nominal power of the unit is 300 kVar.

During the audit compensating units were operating with their nominal power and additional power was needed occasionally what caused alerts.

Above and beyond M1 is equipped with fixed 20 kVar compensation unit.

M2 PK is not equipped with compensation unit. Therefore the furnaces reactive power is not compensated and causes expenses in electric bill.

• Lighting

Offices, machinery's, crushing plants and dispatching department's indoor lighting are carried out by fluorescent lamps. The melting shop is lighten by high pressure sodium and halogen lamps. Total efficiency of indoor lighting is about 55 kW and total consumption of electricity is about 240 MWh/a.

Fluorescent lamps have generally good light efficiency it is 80 lm/W (visible light from a light source per unit of energy in lumens per watt). With existing lamp types interiors are lighten efficiently and relatively modest energy consumption.

Main part of the melting shop is lighten by high pressure sodium lamps those light efficiency is (>100 lm/W) even better than fluorescent lamps.

Measured luminous intensities are mainly on recommendation level or below it and thus luminous intensity can not be decreased.

4.4. BUILDING AUTOMATION

4.4.1. Description

The site has not centralized automation system. HVAC devices are controlled with original, quite old analogue controllers. Some of these old controllers are replaced with digital control centres (Ouman EH-105).

4.5. AIR CONDITIONING

Air conditioning devices are mainly used in offices and the energy consumption of existing split units is irrelevant.

4.6. BUILDINGS AND STRUCTURES

4.6.1. Description

Office rooms and factory halls external walls are made of 200 mm thick siporex (light concrete) blocks. Above insulated roof supporters are made of hollow-core slabs (TT-slabs) of which insulation thickness is 200 mm. Structures thermal resistance is only on decent level (U-value on walls 0,60 W/m^2K and on roof 0,25 W/m^2K) whereas recommendation is 0,25 W/m^2K on external walls and 0,16 W/m^2K on roof.

Gains by extra isolation of the envelope are nominal because of the surplus heat of the production. Actual premise heating devices are useless almost around the year because of the surplus heat.

Only 15 % of the external walls surface area is covered with windows thus heat loss through windows is quite low.

4.6.2. Energy Consumption

Heat loss through external walls and roof is considerable because of low thermal insulation in structures. Yearly thermal energy loss due to heat conduction is 320 MWh. Main part of the lost thermal energy is surplus energy from the production for that reason it does not enhance primary energy consumption.

The estimation of thermal energy loss of envelope infiltration is difficult especially in melting shop where indoor and outdoor air flow to and from the hall mainly trough the open lever gear doors. Approximately 300 MWh/a of energy is lost in ex/infiltration through the building envelope.

5. BASIC MAPPING OF THE FACTORY SERVICE SYSTEMS AND ENERGY CONSUMPTION

5.1. COMPRESSED AIR SYSTEMS

5.1.1. Description

Compressed air for the foundry is processed in one compressed air central. There are two rotary screw compressors: Kaeser AS 36 and Tamrock F30. Kaeser compressor is bought recently and is the primary compressor and Tamrock powers up only during the peak loads. These compressors process all the needed compressed air. Pressure level of compressed air network is from seven to eight bars.

Compressors are air cooled and the surplus heat is used to heat the near by warehouse.

The compressors are controlled with two-step control where pressure sensor located in compressed air network regulates compressors to start, to stop and to go for unload run. Compressed air storage tanks volume is 2,0 m^3.

Chart 5.1 Technical information about compressors

	Kaeser AS 36	Tamrock F 30
Max pressure, bar	8	8
Output, m^3/min	3,0	4,5
Power, loaded, kW	22	31
Power unloaded run, kW	ca. 4,2	7,5

5.1.2. Energy Consumption

Compressors should operate only during working hours. According to measurements one compressor operated uselessly during nights. Primary compressors yearly operating hours are about 4500 h and for secondary compressor 1300 h. Electricity consumption of compressors is 1200 MWh/a.

5.2. PROCESS VENTILATION SYSTEMS

Process ventilation is presented in chapter 4.2.1.

5.3. PROCESS ELECTRIC SYSTEMS

See chapter 4.3.

5.4. PROCESS COOLING SYSTEMS

Electric induction furnaces require cooling system. Circulating water is cooled down with two condensers. One of the condensers is indoors the other outdoors nearby furnaces.

On centrifugal casting melted metal is fed to a gravity die that is rotated by electric motor. Sprayed water cools down the gravity die. Part of the water vaporises immediately. Heated water flows down via drain to an underground water tank. In the tank water cools down and is pumped up to the casting machines. Same kind of cooling system is in use also in continuous casting. Vaporised water is compensated with tap water.

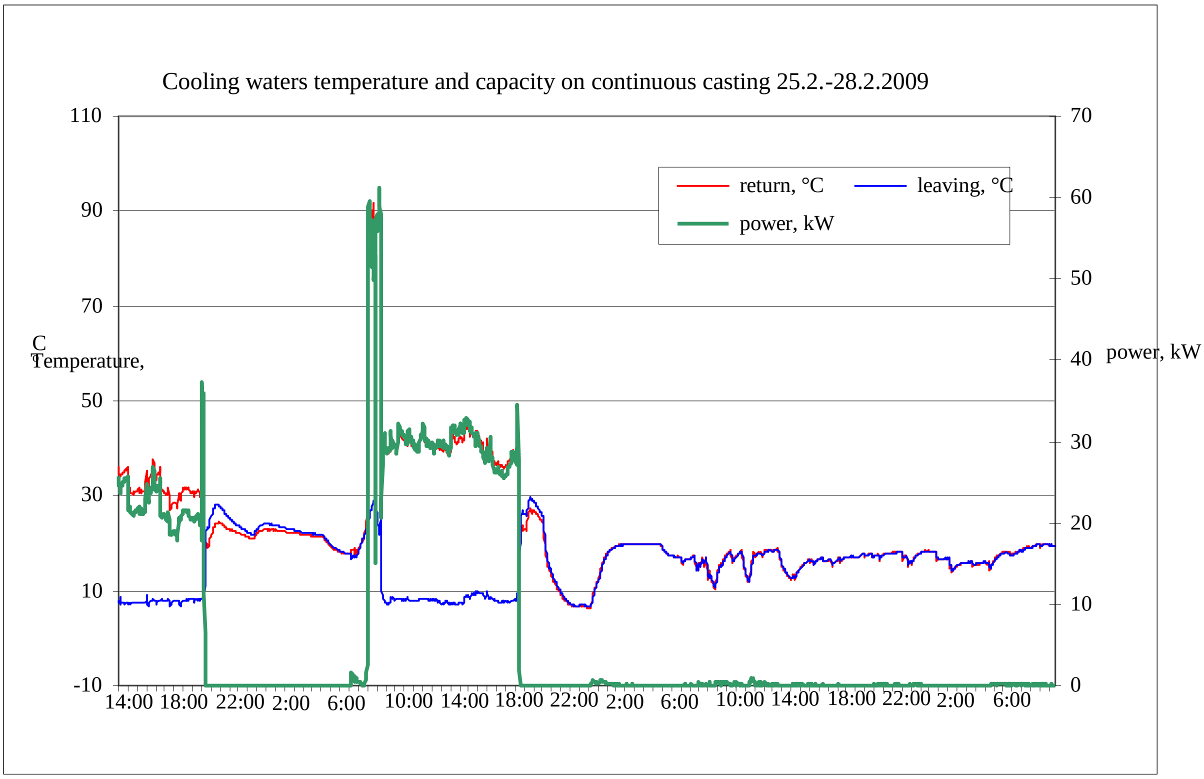

Figure 5.1 Measured cooling water temperature and calculated capacity in continuous casting 25.2. - 28.2.2009. Water flow was about 13 l/min.

6. BASIC MAPPING OF THE PROCESS EQUIPMENT AND ENERGY CONSUMPTION

6.1. MELTING FURNACES

6.1.1. Description

The foundry has nine melting furnaces that use electricity, light fuel oil or liquid gas as a fuel. Metal is heated up to 1000 °C in furnaces. Heating takes a time period of 30 minutes with electric furnaces and with liquid gas or light fuel oil furnaces it takes over two hours to melt up. Molten metal is delivered with ladles to pouring station in which metal is poured at once to dies or casting basins. In continuous casting molten metal is poured into basins of casting machines where oil burners keep the temperature high.

Five of the furnaces are electric induction furnaces of which maximum melting volumes are mentioned below:

Furnace 4: 700 kg
Furnace 5: 1000 kg
Furnace 6: 400 kg
Furnace 7: 600 kg
Furnace 8: 600 kg

(Furnace 10: 400 kg, in delivery).

The power of furnaces vary according to melting capacities. Electric power measurements will be carried out for furnaces.

Oil and liquid gas furnaces have bigger melting capacities than electric furnaces:

Furnace 1: 1000 kg
Furnace 2: 1000 kg
Furnace 3: 1000 kg
Furnace 9: 700 kg.

Each furnace got one burner where the mix of fuel and combustion air is injected. Burner power is 1000 kW in big furnaces. Flame and combustion gas heat up a crucible directly. Flue gases are released from upper part of furnace straight to factory hall from where local ventilation captures to blow the gases outdoors.

6.1.2. Energy Balance

Electric Furnaces

Energy consumption of electrical furnaces has lately been 1000 MWh/a. Overall efficiency of electric induction melting is 70 %. Losses are caused by transformers, rectifiers, conductors, induction coil and heat losses from furnace. All lost electric energy converts to thermal energy which heats up the cooling water or indoor air of the melting shop which is lost with the exhaust air.

Induction coils of electric furnaces require cooling with water. Cooling water pipeline is closed and equipped with condensers. Furnaces 5 and 6 have own their condenser which locates outdoors. The condenser of furnaces 7 and 8 locates inside the melting shop thus it heats the indoor air. In summertime warm indoor air can not cool down the cooling water and tap water is used meanwhile.

Oil and Liquid Gas Furnaces

The efficiency of these furnaces is lower than in electric induction furnaces. Efficiency is only about 20 %. Poor efficiency is caused by escaping heat in the flue gases. Energy consumption of furnaces can not be measured but calculated values are:

Oil furnaces 2600 MWh/a
Liquid gas furnaces 1500 MWh/a

Surplus heat of the furnaces escaped to the factory hall almost completely is lost in exhaust air; no heat recovery is applied.

6.2. LADLE HEAT-UP

6.2.1. Description

Ladles are preheated so that poured molten metal would not cool down during transportation and to prevent heat shocks for ladles insulation. Two liquid gas burners operate as pre-heaters. During ladle preheating there are no covers so a lot of thermal energy escapes with flue gases trough canopy hood to outdoors.

Almost all the time two ladles are in preheating when continuous casting is in progress.

6.2.2. Energy Balance

Ladle preheating burners computational energy consumption is 250 MWh/a of liquid gas. Surplus heat is escaped through air ventilation or straight trough canopy hood to outdoor.

6.3. CENTRIFUGAL CASTING AND CONTINUOUS CASTING MACHINES

6.3.1. Description

Centrifugal casting

Centrifugal casting is either vertical casting or vertical casting. Both methods operate in same way. Centrifugal casting die rotates during casting and molten metal solidificates in die under centrifugal force.

Energy consumption of casting machines is limited. Metal is molten in furnaces and rotation motor of centrifugal casting dies consumes only slightly of electricity. Rotation speed depends on diameter of casting. Typically rotation speed is between 390 and 750 1/min.

Cooling water is sprayed to the die during the casting. Part of the cooling water vaporises and the rest of heated water flows down to the cooling water tank. Same water is reused after it has cooled down.

Continuous casting

The site uses two similar continuous casting lines. Molten metal is carried with ladles to the continuous casting machines pouring basins where oil burners keep the metal in molten. From the basins molten metal is drained to a die where cast obtains the form and starts to solidificate. Energy is mainly consumed to hold the temperature of metal with oil burners. Cooling water circulates in die and returns to cooling water tank. Temperature of coming cooling water is from 8 to 10 degrees and leaving temperature is from 30 to 50 degrees. Cooling water flow in die is typically about 13 dm^3/min.

6.3.2. Energy Balance

Energy consumption of Continuous casting machines temperature upkeep burners consume computationally about 900 MWh/a of light fuel oil. Surplus heat is collected with canopy hood above the casting machines and released to outside.

Thermal power loss to cooling water is from 20 to 30 kW and thermal energy loss is 80 MWh/a (see figure 5.1). Centrifugal casting machines thermal energy loss to cooling water could not be measured but it should be on the same level as the holding energy of continuous casting machines. Cooling water tank transfers the heat to the soil and to the cold warehouse built in 2008.

6.4. MACHINE TOOLS IN THE MACHINERY

6.4.1. Description

In the machine shop there are almost 40 types of machine tools (lathes, band saws, milling machines, drills etc.). Total power consumption of the machine tools is unknown but large CNC-lathes electric power consumption is from 30 to 60 kW.

6.4.2. Energy Balance

Electricity consumption of the machinery could not be measured during the audit because of type of the electric network on the site. Usage of machines varies a lot and couple of days measuring period can not give right figure of the energy consumption. Electric consumption of the machinery is approximately 260 MWh/a.

7. ENERGY CONSERVATION AND FEASIBILITY OF SUGGESTED MEASURES

The energy prices applied in saving and profitability calculations origin from current tariffs. Basic pays regarding energy consumption are noticed. Energy costs are presented in the following chart (all prices are without VAT).

Chart 7.0 Energy prices in profitability calculations.

- light fuel oil	90,00 €/MWh
- natural gas	29,00 €/MWh
- liquid gas	64,00 €/MWh
- electricity	49,00 €/MWh
- tap water	3,09 €/m^3

7.1. HPVAC SYSTEMS AND STRUCTURES

7.1.1. Heat Recovery from the Furnaces Canopy Hoods Exhaust Air

The option of energy conservation measure is presented in figure 7.1. Canopy hoods exhaust air is blown by a fan whose air flow rate is 5,3 m^3/s. Exhaust air fan is not equipped with heat recovery. Supply air fan is TU-1 whose air flow rate is 4 m^3/s.

Integrated supply and exhaust air machine is presented in figure 7.1. The air flow rates of machines are equal to current air flows. The ventilation unit is controlled not to use external heat source since warm exhaust air has enough thermal energy to heat up the supply air. The exhaust air is hot enough to heat up the supply air even on well below zero conditions because of efficient heat recovery. The bigger exhaust air rate compared to the supply air rate offers extra power as well.

New supply/exhaust air unit costs 28.000 € plus installation including automation, electric, HPV and construction work. Total investment cost would be around 42.000 €.
The saving potential of the investment would be the whole annual thermal energy consumption of TU-1 i.e. 500 MWh/a.

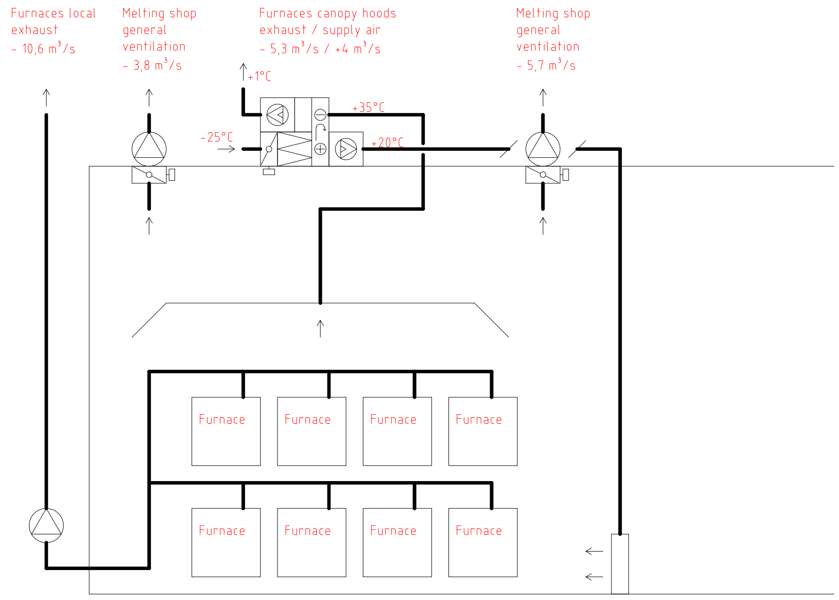

Figure 7.1 Figure of heat recovery of furnaces canopy hood exhaust air.

Chart 7.1 Profitability calculation of the option

Saving	500	MWh/a	Heat
	14.500	€/a	Heat (natural gas)
Investment cost	42.000	€	
Repayment period	2,9	years	

7.1.2. Heat Recovery of the Melting shop's General Exhaust Air

The next energy saving option is illustrated in figure 7.2 where the surplus heat of melting shop is used to heat the machinery shops. At present general exhaust air is blown out with two axial-flow fans with air flow rates of 9 m^3/s each. In machinery shop there are four supply air units TU-2, TU-3, TU-4 and TU-5 with air flow rate of 4,6 m^3/s. Supply air units are not equipped with a heat recovery system.

In the option, see figure 7.2, integrated supply and exhaust air unit will be mounted on the roof. Air flow rates of the machines are equal with current air flows. The machine can not use external heat source thus warm exhaust air is capable to heat up the supply air. Exhaust air is hot enough to heat up the supply air even in well below zero conditions because of efficient heat recovery and bigger rate of exhaust air than supply air gives more power.

A new supply/exhaust air machine costs 36.000 € plus installation including automation, electric, HPV and construction work. Total investment cost would be around 54.000 €.

Investment would save all four supply air units of the whole thermal energy consumption 760 MWh/a.

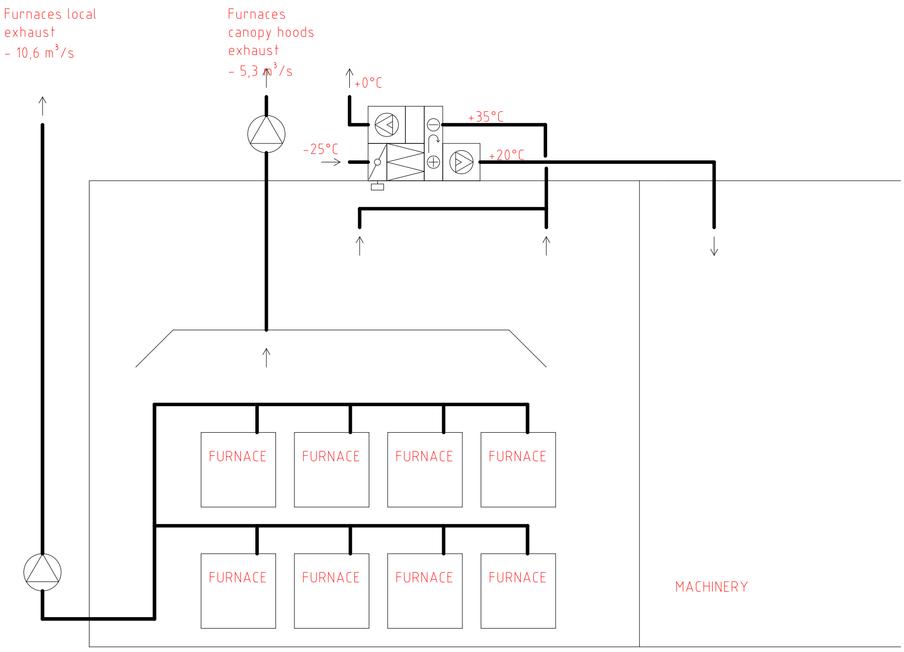

Figure 7.2 Figure of heat recovery of general ventilation in melting shop

Chart 7.2 Profitability calculation of the option

Saving	760	MWh/a	HEAT
	22.040	€/a	HEAT (nat. gas)
Investment cost	54.000	€	
Repayment period	2,4	years	

7.1.3. Heat Recovery of Furnaces Local Exhaust

Figure 7.3 presents heat recovery of local ventilation system of furnace flue gases and fumes. Currently there is no heat recovery in use. Previously heat from exhaust air was recovered to return water of heating network. Because of dust in the exhaust air heat exchangers coils were blocked (without filtering) almost immediately.

Current problem of big supply air unit (TK extra 15 m^3/s) is insufficient thermal capacity and freezing of radiator during winter time. The problem is caused by wrongly dimensioned heating network of the factory for the need of TK extra.

In the system presented in figure 7.3 supply air device is disconnected from heating network and radiator is connected to heat recovery unit from furnaces local exhaust. Piping system presented in figure 7.3 already exists. The cause of exhaust air dust heat exchanger coil must be of certain type. Traditional plate heat exchanger can not be used but pipe heat exchangers like in figure 7.4 are applied in several melting shop furnaces.

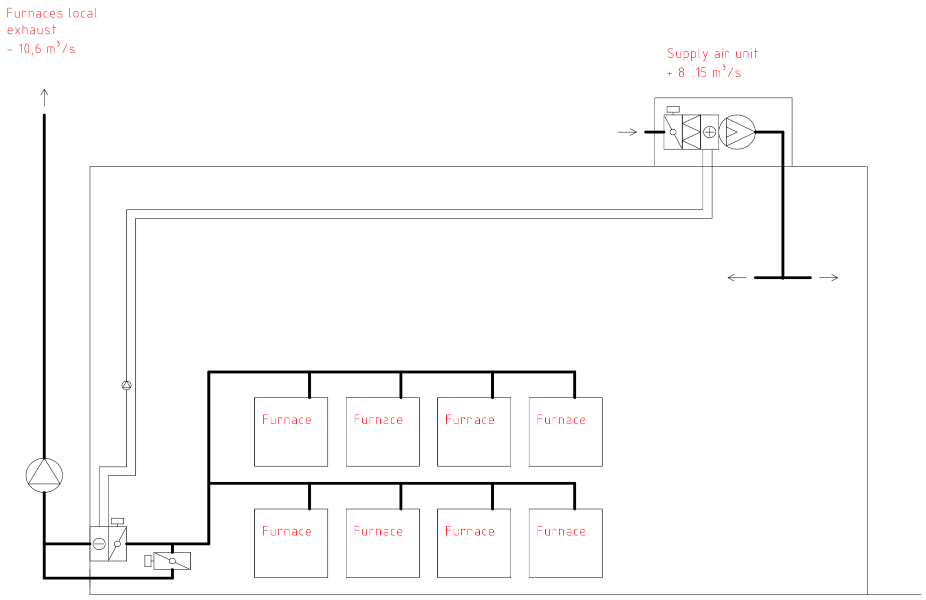

Figure 7.3 Heat recovery of furnace flue gases

Figure 7.4 Heat exchanger that can be applied in dusty exhaust air

Cost of investment is the new heat exchanger and pump for water and glycol plus installation including automation, electric, HPV and construction work. Total investment cost would be around 38.000 €.

This option would save the whole thermal energy consumption 650 MWh/a supply air machines.

In the case of later need of dust filter is ascended it should be installed in exhaust air duct before heat exchanger.

Chart 7.3 Profitability calculation of heat exchanger

Saving	650	MWh/a	HEAT
	18.850	€/a	HEAT (nat. gas)
Investment cost	38.000	€	
Repayment period	2,0	years	

7.1.4. Frequency Converter for Welding Stations and Masonry Work Places Local Ventilation Fan

The high pressure fan that extracts air from the welding station and the masonry work place all working hours. Power of the fan is 11 kW and energy consumption is 44 MWh/a. As a matter of fact both working places are is use rarely therefore fan should not operate all the time at maximum power. This can be prevented by equipping the fan with a frequency converter that retains stable under pressure in exhaust duct. Both working places should also be equipped with dampers. When one or both dampers are closed the fan will automatically reduce the speed. Estimated energy conservation is 35 MWh/a. Investment cost are about 3.500 €.

Chart 7.4 Profitability calculation of fan speed control

Savings	35	MWh/a	ELECTRICITY
	1.715	€/a	ELECTRICITY
Investment cost	3.500	€	
Repayment period	2,0	years	

7.1.5. Damper control and Frequency Converter of the Furnaces Local Ventilation

The furnaces local ventilation is presented in figure 7.3. The fan extracts exhaust air from all the furnaces. Exhaust air rates are similar in all the furnaces. Exhaust air ducts are not equipped with individual dampers (figure 7.6) or they are not in operation. Without dampers and frequency converter the fan operates at maximum power all the time and usually only half of the furnaces are in use at the same time. With the investment fan speed is automatically controlled according to demand. The fan energy consumption is nowadays 150 MWh/a and cost is around 7.400 €/a.

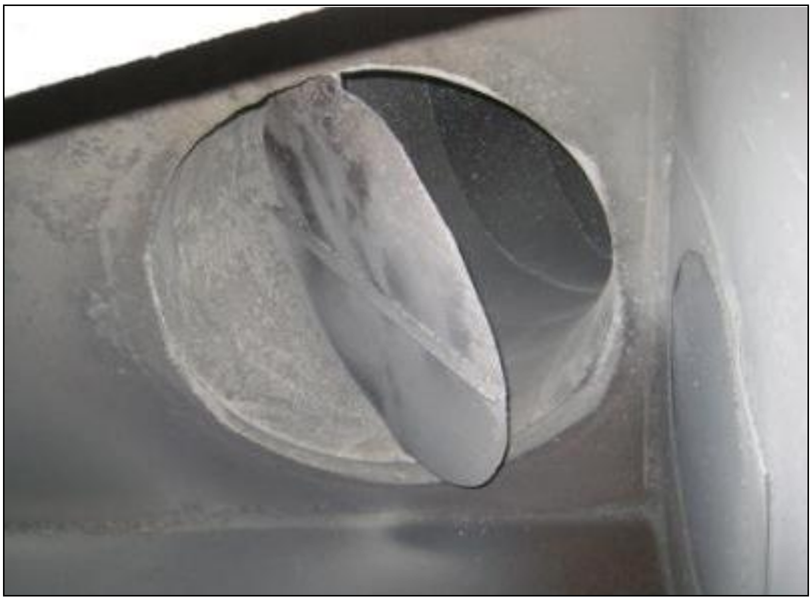

Figure 7.6 Exhaust ducts damper of furnace flue and fume gases

This investment costs 11.500 € and saves 4.000 €/a.

Chart 7.5 Profitability calculation of the saving option

Savings	80	MWh/a	ELECTRICITY
	3.920	€/a	ELECTRICITY
Cost of investment	11.500	€	
Repayment period	2,9	years	

7.1.6. Local Ventilation of the Continuous Casting

The continuous casting machines were transferred closer to the furnaces. The previous location was equipped with local ventilation which has air flow rate of 3,6 m^3/s and electric power of 11 kW.

In current location local ventilation is dealt with exhaust air fan of vertical casting and casting on horizontal machines. The exhaust air fan of previous location became useless.

33 MWh/a electricity is saved. Thermal energy of exhaust air is not concerned as saving because heating is dealt with surplus heat from the production.

Chart 7.6 Profitability calculation the option

Savings	33	MWh/a	ELECTRICITY
	1.617	€/a	ELECTRICITY
Investment costs	0	€	
Repayment period	0	years	

7.1.7. Oil Mist Filters of Machinery shops

Oil mist containing air is extracted from machine tools at the rate of approximately 4,5…5 m^3/s. Air is blown through filters to outdoors. The exhaust air is neither recycled nor there is any type of heat recovery. Four supply air fans blow make up air to machinery hall and supply air rate is equal to exhaust air rate. Powered roof extractors are hardly ever in use thus exhaust air is extracted through local ventilation system.

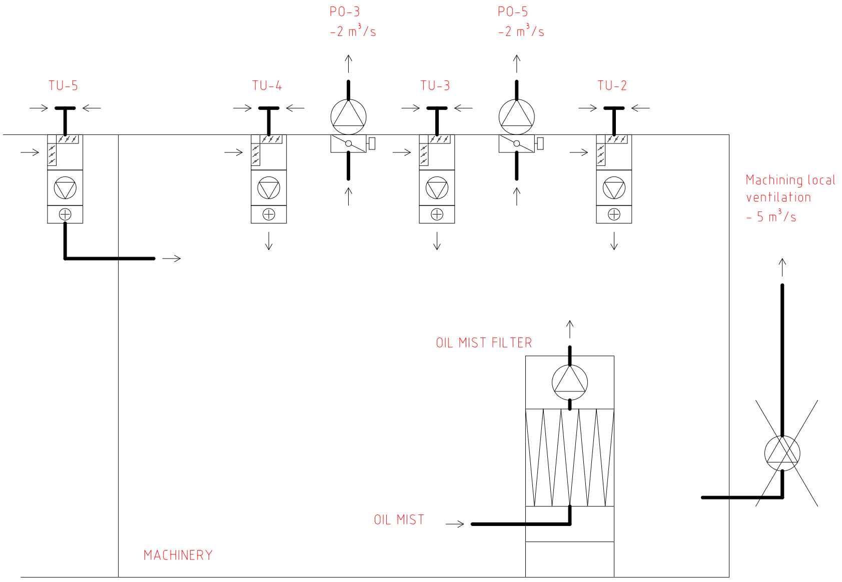

Figure 7.7 Ventilation of machine shop.

Oil mist containing exhaust air could be filtered and circulated in the halls. This option has no significant saving potential because the same supply air flow is needed in any case. There is no sense to invest for heat recovery of powered roof extractors. Oil mist filtered air could be returned to heat other premises e.g. new warehouse or lowered underpressure of melting shop.

One HEPA filter for a machinery tool costs some 2.300 €. Filters for several tools cost 4.000 - 7.000 € depending on the air flow (0,3…0,7 m^3/s). Total investment is estimated to 50.000 €.

Conclusion does not include this option because of the missing information of space applied.

7.2. FACTORY SERVICE SYSTEMS

7.2.1. Compressed Air System

Use of the Secondary compressor Tamrock

Night time run consumption of Tamrock compressor should be measured when there is neither production nor consumption. Main compressor is equipped with timer that shuts down compressor at 23:00. Secondary compressor is not equipped with timer and when pressure drops in the compressed air network compressor starts to increase the pressure.

Secondary compressor should be equipped with timer or be shut down after evening shift to prevent pointless operation. Pointless consumption during night time is 40 MWh/a.

Chart 7.7 Profitability calculation of the timer

Savings	40	MWh/a	ELECTRICITY
	1.960	€/a	ELECTRICITY
Investment costs	200	€	
Repayment period	0,1	years	

Leakages in Compressed Air Network

According to measurements compressed air consumption is significant during night time. Consumption is caused by the leakages in the compressed air network. Especially in the machinery shop numerous leaking hoses were found during the audit.

Leakages in the compressed air network cause 85… 110 MWh/a electricity consumption. Entirely tight compressed air network is impossible to build thus saving potential is around 60 MWh/a.

Chart 7.8 Profitability calculation of leakage repair in CA -system

Savings	60	MWh/a	ELECTRICITY
	2.940	€/a	ELECTRICITY
Investment costs	1.000	€	
Repayment period	0,3	years	

7.2.2. Combustion Air Blowers

The site has two combustion air blowers:

	power, kW	pressure rise, kPa	Air flow, m^3/s
blower 1	22	<15	0,1…1,0
blower 2	11	<6	0,1…2,0

The blowers are placed alongside and connected to the same combustion air ductwork. The pressure level of blower one is so high that blower two can not operate in the conditions. Air flows outwards in the inlet of blower two.

In practise the blower two is in use needlessly and should be turned on only when needed. Electricity consumption of the blower two is 38 MWh/a.

Figure 7.9 Combustion air blowers

Chart 7.9 Measurements profitability calculation

Savings	38	MWh/a	ELECTRICITY
	1.862	€/a	ELECTRICITY
Investment costs	0	€	
Repayment period	0	years	

7.3. PROCESS SYSTEMS

7.3.1. Increase in Use of Electric Furnaces

There is no exact information of melting amounts per furnaces. Nowadays roughly half of the molten metal is melted with electric furnaces. The site is purchasing one new electric furnace more. With the new furnace it is possible to decrease the use of the light fuel oil furnaces.

Electric furnaces efficiency is approximately four times better than oil furnaces. If the new electric furnace increases share of electric melting of total melting by 5 percent that leads to 300 MWh/a energy savings. Because the same amount of melting consumes with electric furnace 100 MWh/a and light fuel oil furnace of 400 MWh/a energy.

In this saving procedure costs for invest are excluded because procurement decision is made by productive criterion.

Chart 7.10 Profitability calculation of increased induction furnace use

Savings	400	MWh/a	OIL
	36.000	€/a	OIL
	-100	MWh/a	ELECTRICITY
	-4.900	€/a	ELECTRICITY
Total Savings	31.100	€/a	

Investment costs	0	€	
Repayment period	0	years	

7.3.2. Preheating of Ladles

Possibilities for increased efficiencies of ladle preheating are presented in chart 7.11. At the site ladles are preheated with liquid gas burners. Efficiency of preheating with gas burner without a cover is poor, approximately 15 percent. Preheating efficiency with electric resistors is much better almost 80 percent. The cost of preheating station for two ladles is approximately 50.000 €.

Energy saving of 250 MWh/a is achievable by replacing current liquid gas preheaters with electric preheaters. At the same time electricity consumption increases with 50 M Wh/a.

Chart 7.11 Measurements profitability calculation.

Savings	250	MWh/a	PROPAN
	16.000	€/a	PROPAN
	-50	MWh/a	ELECTRICITY
	-2.450	€/a	ELECTRICITY
Total Savings	13.550	€/a	
Investment costs	50.000	€	
Repayment period	3,7	years	

7.3.3. Heating of the Cold Storage with the Castings

The castings are moved to cold storage to cool down. Even though it is called cold storage the temperature of the storage is kept warm with two air circulators and a supply air device. By exploiting the releasing heat from the hot castings 85 MWh/a of energy can be saved in storage heating.

Chart 7.12 Profitability calculation of cold storage heating

Savings	85	MWh/a	NATURAL GAS
	2.465	€/a	NATURAL GAS
Investment costs	0	€	
Repayment period	0	years	

7.4. FOLLOW-UP SURVEYS AND INQUIRIES

Increasing electric furnace usage increases also reactive power consumption. This may cause additional costs to reactive power fee.

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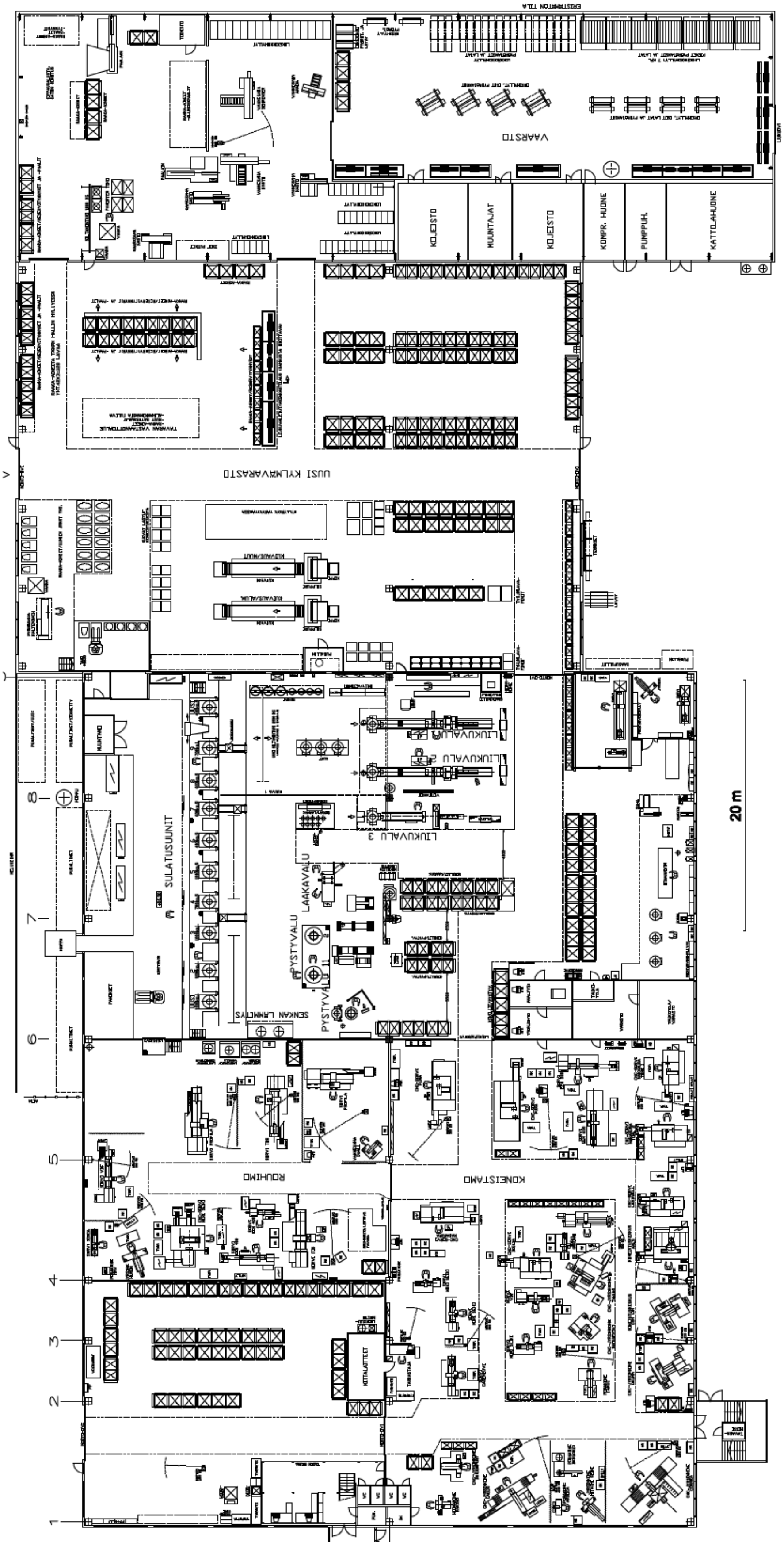
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