Energy Audit Summary Report
CIT
Audit no. *59* – IRL03
Food Industry

Instituúid Teicneolaíochta Chorcaí
Cork Institute of Technology

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AUDIT no. 59 – IRL03

1. Data of the auditor

1.1. Contact data of the auditor

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Introduction

1.2. Objectives

The site's milk powder dryer was the focus of this assessment and the opportunities for energy optimisation.

2. Status Quo: processes, distribution, energy supply

2.1. General info on company

A large dairy site operating a number of production processes including milk concentrate, milk powder, cheese and butter. The focus of this audit was the spray dryer within the powder plant.

2.2. Flow sheet for the powder plant

The flowsheet for the powder plant can be simplified as follows.

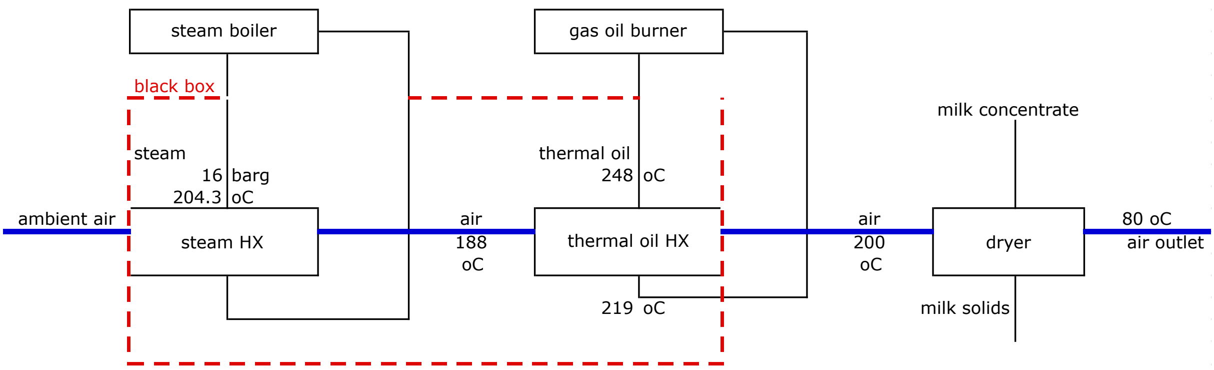

Fig: Flowsheet for the spray dryer

2.3. Description of the existing system

Energy Supply

Steam is supplied for the process by a 17 tonne/hour main steam boiler with a backup boiler. This main boiler serves all of the site including the powder plant.

Distribution system, Media and temperatures

The steam header supplies 17 bar steam to the Powder plant, which corresponds to a temperature of 204 °C, and lower pressure steam to other areas of the site. Condensate is returned to the boiler.

Main energy consuming energy processes and buildings

The main energy consuming processes at the site include the spray dryer, and two evaporators. The focus of this audit has been on the dryer.

Energy Consumption – Present State

Annual data	**Present state**	
	MWh	€
Entire site		
Primary energy consumption (PEC) – natural gas & electricity	117,000*	€4,400,000
Primary energy consumption for thermal use (PET) – natural gas & electricity	94,000*	-
Spray dryer		
Primary energy consumption for thermal use (PET) – natural gas	46,900	€1,880,000
Final energy consumption (FEC) – natural gas	42,600	€1,704,000
Final energy demand thermal (FET) - natural gas	41,900	€1,676,000
Useful supply heat (USH) – steam boiler	39,400	€1,576,000
Heat demand (UPH) – dryer	16,100	€644,000

*NB: the MWh value for electricity includes energy consumed to produce the electricity at the point of generation.

The following figure shows the cumulative annual heating demand for the dryer by temperature.

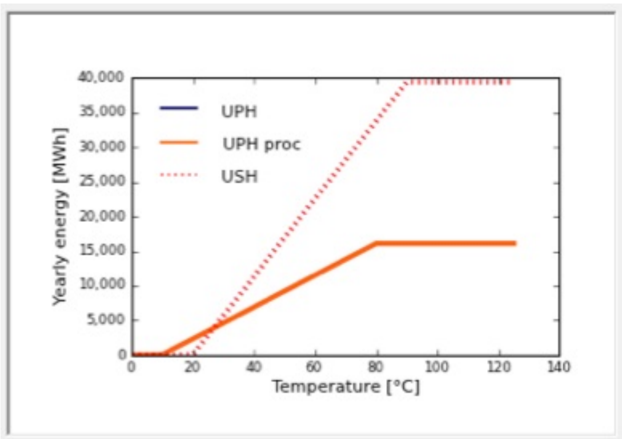

Fig: Dryer Heat demand – by temperature

The following figure shows the annual heat load demand by operating hours for the dryer during the year. The load is constant, as the dryer is in continuous operation for 20 hours a day, followed by a 4 hour cleaning cycle. The dryer is operated for approx. 350 days per year. The following figure shows the heat demand for the dryer operation only; the heating requirements related to the cleaning operation is not modelled.

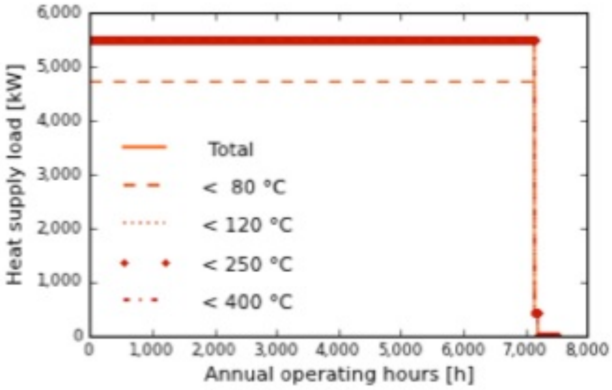

Fig: Dryer Cumulative heat demand – by time

2.4. General

3.4.1 Assumptions by introduced by the auditor

A list of assumptions made by the auditor are as follows:

- The dryer air flowrate was based on company documentation provided.
- The dryer air exit temperature was provided by site personnel.
- The dryer is usually operated with some supplementary heat provided by a circulating thermal oil, heated via a gasoil burner, which raises the temperature of the incoming air a few degrees further. The extent of the use of this thermal oil heating depends on the required air inlet temperature to the dryer, which varies by product type (whey, milk, skim milk etc.). For the purposes of this modelling, it assumed that the inlet temperature to the dryer is 200 ^{o}C (average value across the products), and that all of the heat is provided by the steam boiler.
- An average air inlet temperature of 9.8 ^{o}C was assumed, which is the yearly average ambient air temperature for the area. Air is taken in from outside.

3.4.2 Assumptions for missing data introduced by the consistency check

The only missing data at the consistency check stage were estimates for operating and maintenance costs for the present state.

3. Comparative study

3.1. Proposed alternatives

The following alternatives have been considered:

Alternative No.	Description
1	Air to air heat exchanger on the exhaust air from the dryer, where outlet air is brought from 80 to 40 °C and is used to pre-heat incoming air to the dryer.
2	Same as alternative 1) but with a larger heat exchanger to bring the outlet air down a further 10 degrees to 30 °C.

Selected alternative(s) and conclusions

3.2. Selected alternative

The selected alternative is the smaller of the two heat exchangers. This alternative was selected as it is a smaller heat exchanger size and hence reduced investment costs.

3.2.1. Heat recovery

The following are the key parameters of the proposed heat recovery system.

Proposed heat exchanger on dryer exhaust	
Source and inlet/outlet temperatures	Dryer exhaust air, cooled from 80 to 40
Sink and inlet/outlet temperatures	Dryer inlet air, heated from av. 9.8 to 50
Power recovered	1300 kW

3.3. Comparative study and conclusions

The following table outlines the existing situation (present state) and the potential savings through the proposed alternative of heat recovery on the dryer exhaust.

		Present state	Alternative	Saving
Total primary energy consumption (1) – entire site				
- total	[MWh]	117,000	108,600	8,400
- natural gas	[MWh]	83,000	74,600	8,400
- electricity	[MWh]	34,000	34,000	-
Primary energy consumption – natural gas: spray dryer	[MWh]	46,900	38,500	8,400
CO_2 emissions: total site	[t/a]	37,000	35,300	1,700
CO_2 emissions: spray dryer	[t/a]	9,600	7,900	1,700

Annual energy system cost (2) – entire site	[EUR]	€4,360,000	€4,024,000	€336,000
Annual energy system cost (2) - dryer	[EUR]	€1,880,000	€1,544,000	€336,000
Total investment costs	[EUR]	-	~€1,000,000 (3)	-
Simple Payback period (4)	[years]	-	3 years	-

(1) including primary energy consumption for non-thermal uses

(2) energy cost (fuel and electricity bills). Operation and maintenance costs and annuity of total investment have not been included.

(3) Very rough, order of magnitude estimate for heat exchanger itself.

(4) Supposing 0% of funding of total investment (subsidies, grant-aid or equivalent other support mechanisms). Operation and maintenance costs and annuity of total investment have not been included.

3.3.1. Energy and environmental analysis

The proposed heat recovery on the dryer would reduce CO_2 emissions from the site by 1700 tpa.

3.3.2. Economic analysis

The table in section 5.2 outlines the economic parameters for the selected alternative. There is expected annual natural gas savings of 8,400 MWh, saving approximately €340,000 per annum. Investment is roughly estimated by the EINSTEIN programme as ~ €1 million. Thus, the simple payback period is approximately 3 years. This is based only on energy operating costs and estimated investment. No estimate has been made on the cost of annuity of investment or on operating and maintenance costs of the proposed heat exchanger or any additional electricity fan costs for pressure drop across the heat exchanger. Investment costs are also likely to be higher than that estimated by the EINSTEIN programme. Some considerations in this regard are as follows:

- The existing bag filters on the dryer do remove some milk solids particulates from the dryer exhaust. Whether this is to a sufficient level would need to be determined. As the exhaust air is cooled through the heat exchanger, the relative humidity of the air increases and the milk solids particulates will become more sticky. Reduction to as low as 40 ^{o}C may not be feasible (it is estimated the exhaust air will be at ~97% relative humidity at this temperature).
- It should be noted that there are heat exchangers that can incorporate a CIP system for cleaning the heat exchanger on the exhaust air side. This would have an impact on price.
- For the direct air-to-air heat exchanger there would need to be ducting of the air streams to the heat exchanger itself which would also impact on price.

- Use of an indirect heat recovery system could be considered since it uses an air to liquid heat exchanger on the exhaust air and a liquid to air heat exchanger on the incoming air. This would reduce the required heat exchanger sizes, since air-to-liquid are smaller than air-to-air heat exchangers.

3.3.3. Conclusions and outlook

The potential savings identified are sufficient to warrant a further investigation to establish a more definitive installation cost.

5.2.3.1 Assumptions

A list of assumptions in relation to the present state is outlined in section 3.4.1. Assumptions in relation to the proposed alternative include:

- The existing bag filters are sufficient to remove particulates to the required level.
- Operating and maintenance costs are not included.

5.2.3.2 Constraints under which the results can be considered valid

The results are considered valid for the following:

- An average air flowrate to the dryer of 80,600 m^3 per hour, and an average inlet temperature of 200 ^oC.
- An exiting air temperature of 80 ^oC.
- A feed rate of milk concentrate to the dryer of 7000 kg/hour with a solids content of 40%.

5.2.3.3 Areas where a more detailed analysis would be necessary

The following would improve the estimates:

- Measure the exact air flowrate to/from the dryer.
- Measure the relative humidity and the temperature of the air exiting from the dryer.

5.2.3.4 Next steps with the company

If the above detailed measurements could be performed the estimate could be refined. In addition, energy costs for natural gas could be updated to reflect current value. Suppliers of milk dryers can provide heat recovery systems for recovering heat from the exhaust air. Some such systems operate indirectly with an air to liquid heat exchanger on the exhaust and a liquid to air heat exchanger on the incoming air. This would reduce the required heat exchanger sizes, albeit the efficiency of recovery would be reduced somewhat. Initial estimates for investment could be explored with such companies.

Other options such as utilising waste heat contained in the evaporator condensate to pre-heat the air to the dryer, or to replace the electrical heating of a product storage room, could be considered.