SHIP Egypt

Session 12

Process Optimisation and Best Available Techniques

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High variability in the specific energy consumption rate

Sector	Power	Heat	Total	*Unit*
Slaughterhouse			**55-193**	***kWh/t carcass***
Poultry slaughterhouse			**125-220**	***kWh /t carcass***
Dairy	**39-448**	**25-884**		***kWh /t de received milk***
Brewing	**8.4-14.4**	**20.0-52.3**		***kWh /hl de beer***
Sea products	**223-2,557**	**7.5-70.3**		***kWh /t de final product***
Canned vegetables			**50-275**	***kWh /t raw material***
Frozen vegetables			**200-600**	***kWh /t raw material***

Source: Best Available Tecniques .Spanish guidelines

Energy efficiency in process:

- **“use less energy resources to meet the same energy needs”**

Driving forces for energy efficient production techniques?

- **Environmental**
  - Fuel resource depletion
  - Climate change (CO_2 emissions)
  - Local pollution (Exhaust gases, refrigeration water,…)
- **Economic**
  - Life cycle costs
- **Environmental legislation**
  - E.g. In Europe Industrial Emissions Directive (2010/75/EC) (IPPC Directive)
- **Other**
  - Less energy dependency
  - High competitiveness
  - Environmental footprint
  - Image

Efficient techniques

- Investment costs
- O&M cost (energy costs)
- CO_2 credits / compensation

- **Energy efficient techniques are cost effective on a life cycle basis!!**

Driving forces for improve energy efficiency at industrial installations?

- **Energy Cost & Environmental Legislation**

- **BEST AVAILABLE TECHNIQUES !!!**

Best Available Techniques (BAT)

- **BAT’s are “the most effective and advanced stage in the development of activities and their methods of operation……… to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole”:**
- **Technique = Technology + operation & control**
- **BAT’s for each industrial sector are collected in the BREF (Reference Documents for Best Available Techniques)**
- **Many BAT’s are related with reduction of energy consumption in food processing.**
- **Each sub-sector has some specific BAT’s**

BREF DOCUMENTS

➢ **http://eippcb.jrc.ec.europa.eu/reference/**

Best Available Techniques Reference Document (BREFs)	Code	Adopted Document	Formal draft (*)	Meeting report	Estimated review start
Ceramic Manufacturing Industry	CER	BREF (08.2007)			
Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector	CWW	BREF (02.2003)	D2 (07.2011)	MR (06.2008)	
Emissions from Storage	EFS	BREF (07.2006)			
Energy Efficiency	ENE	BREF (02.2009)			
Ferrous Metals Processing Industry	FMP	BREF (12.2001)			Review on hold
Food, Drink and Milk Industries	FDM	BREF (08.2006)			Review started
Industrial Cooling Systems	ICS	BREF (12.2001)			
Intensive Rearing of Poultry and Pigs	IRPP	BREF (07.2003)	D2 (08.2013)	MR (06.2009)	
Iron and Steel Production	IS	BATC (03.2012) BREF (03.2012)			
Large Combustion Plants	LCP	BREF (07.2006)	D1 (06.2013)	MR (10.2011)	
Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers	LVIC-AAF	BREF (08.2007)			
Large Volume Inorganic Chemicals – Solids and Others Industry	LVIC-S	BREF (08.2007)			
Large Volume Organic Chemical Industry	LVOC	BREF (02.2003)		MR (12.2010)	

ENERGY in BREF

➢ **Key environmental issues for some FDM sectors.**

	Water use	Waste water	Chemicals use	Air pollution	Noise	Odour	Solid output	Energy use	
								Heating	Cooling and refrigeration
Meat and poultry	yes	yes		yes		yes	yes	yes	yes
Fish and shellfish	yes	yes			yes	yes	yes	yes	yes
Fruit and vegetables	yes	yes					yes	yes	yes
Vegetable oils and fats	yes	yes	yes	yes		yes	yes	yes	yes
Dairy products		yes	yes	yes	yes	yes	yes	yes	yes
Dry pasta	yes			yes				yes	
Starch	yes	yes		yes			yes	yes	
Sugar	yes	yes					yes	yes	
Drinks	yes	yes					yes	yes	yes
Breweries	yes	yes		yes	yes	yes	yes	yes	yes
Citric acid fermentation	yes	yes					yes	yes	
This table shows the key environmental issues for each sector and does not represent comparative quantitative data									

Examples of energy efficiency in the food industry: BREWING SECTOR

IMPROVEMENT OF ENERGY EFFICIENCY IN WORTH BOILING

Improvement of energy efficiency in worth boiling

- **Energy demand in brewhouse with 7.5% of total evaporation**

	Energy consumption kWh/hL	% energy consumption in brewhouse
Mashing 52/78ºC	2.21	19.8
Heating 78/99ºC	3.38	30.2
Boiling	5.03	45.0
CIP	0.28	2.5
Hot service water	2.28	2.5
TOTAL	11.18	

Source: adapted from Scheller et al, (2008)

Improvement of energy efficiency in worth boiling

- **Two compatible alternatives for improving energy efficiency in worth boiling:**

- **RECOVERING HEAT FROM BOILING VAPOUR CONDENSATE**

- **REDUCING TOTAL EVAPORATION IN BOILING**

- ***Each one per cent of evaporation in wort during boiling corresponds with a specific energy loss of 0,67 kWh/hL***

Improvement of energy efficiency in worth boiling

- **RECOVERING HEAT FROM BOILING VAPOUR CONDENSATE**
  - Alternative 1: production of hot water for other processes, e.g. production, cleaning operations, flushing brew kettles or for room heating (see FDM BREF Drinks section 4.7.9.6.5 recover heat from wort boiling).
  - Alternative 2: heat recovery tank integrated in the heat supply system to preheat the wort before boiling. The wort can be heated from 72 ºC to approximately 90 ºC by means of the heat recovered from the vapour condensate

	Standard	Energy Storage system
Evaporation	4 %	4 %
Kettle full [hl]	520	520
Temperature at start of heating [°C]	75	92*
Temperature at start of boiling [°C]	99	99
Energy for heating [KJ]	5,291,520	1,543,360
Heating time [minutes]	48*	14**
Boiling time [minutes]	60	60
Brews per day	10.8	14.5

Source: Equitherm equipment from Krones

Improving energy efficiency in wort boiling

- **b) REDUCING TOTAL EVAPORATION IN BOILING**
  - The standard total evaporation for acceptable wort quality is around 8–12%
  - Quality of wort is related with maintenance of homogeneity during wort boiling, low thermal stress on wort particles and enough stripping of unpleasant flavour volatiles.
  - New techniques allow reducing evaporation to values below 4% without jeopardize the wort quality.
  - Objective to increase energy efficiency (lower evaporation rate):
    - **Increasing the heat transfer homogeneity and promoting the stripping of volatiles.**
    - **Several technical alternatives and approaches**

Improving energy efficiency in wort boiling

- **b) REDUCING TOTAL EVAPORATION IN BOILING**
  - Approach 1: increasing the heat transfer homogeneity using lower temperature differences between the heating medium and the wort and effectively increasing heating area. Two main alternatives
    - **Two phase boiling: in the first phase, thermal conversion is promoted by a effective and homogeneous wort boiling with low thermal stress. In the second phase, evaporation is promoted. This system can achieve reductions in total evaporation to values under 4%.**
    - **Dynamic/low pressure boiling**
    - **Combined systems**

Improving energy efficiency in wort boiling

- **b) REDUCING TOTAL EVAPORATION IN BOILING**
  - Approach 2: promoting the stripping of volatiles (by promoting the formation of liquid/vapour bubbles).

Examples of energy efficiency in the food industry:
COFFEE production

Improving energy efficiency in roasting coffee

Improving energy efficiency in roasting coffee

- **Roasting is the process unitary step having the higher thermal energy demand. Roasters typically operate with a hot air temperature between 300°C and 540°C.**
- **Exhaust hot air from roasting operation is typically ducted to treatment system to reduce VOC and particulate matter. The energy from these air treatment systems is frequently directly exhausted to the atmosphere.**

- ***Some techniques potentially renders significant energy savings in roasting operation and then also at process level***

Improving energy efficiency in roasting coffee

- **Alternatives**

  - 1.- Partial recirculation of the roast gases in the same roasting system either directly (roasters with recirculation) or by means of a heat exchanger to produce warm water or to heat buildings (section 4.7.8.4.1 FDM BREF 2006)

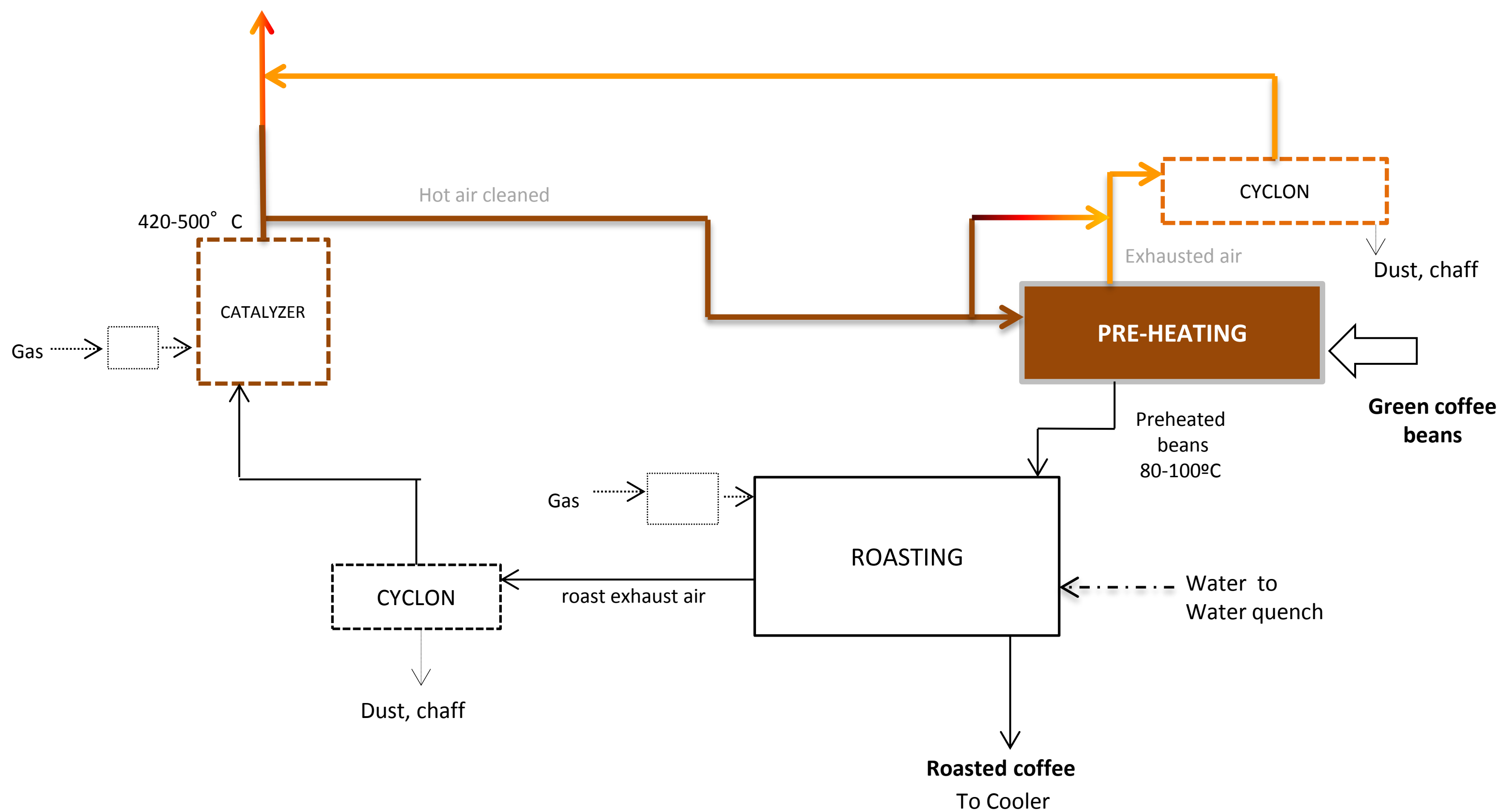
  - 2.- Pre-heating the green coffee beans immediately before the roast operation by recovering heat from cleaned exhaust gases.

Improving energy efficiency in roasting coffee

- **1.- Partial recirculation of the roast gases in the same roasting system**
  - Recirculating roasters consume up to 25 % less energy than non-recirculating roasters and produce a lower volume of waste gas for treatment

Improving energy efficiency in roasting coffee

- **2.- Pre-heating the green coffee beans immediately before the roast operation**
  - A reduction of the heating energy consumption by up to 20 % can be achieved



Examples of energy efficiency in the food industry:
SOFT DRINKS

Improving energy efficiency in air knives for drying of packages

Improving energy efficiency in air knives for drying of packages

- High volume of air at low pressure is usually used to dry the packages or belting in this stage. Compressed air systems provide unnecessarily high pressure dry air steam (around 7 bar) resulting in high energy consumption.
- The efficiency of air compressors (the ratio of energy input to energy output) at the point of use can be as low as 8-10 % in many air compressed systems.

Source: Refresco Iberia

Improving energy efficiency in air knives for drying of packages

- **Significant energy savings can be achieved by using well designed high velocity blowers in place of compressed air based air knife for drying bottles and cans.**
- **Small blowers installed at the point of use can replace compressed air based dryers producing the same amount of airflow and pressure with a much higher motor efficiency.**

Source: Refresco Iberia

- **Energy savings up to 87% have been referred**

Examples of energy efficiency in the food industry:
DAIRY SECTOR

Improving energy efficiency pasteurization

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Improving energy efficiency pasteurization in dairy sector

- **Use of continuous pasteurisers (section 4.7.5.5 FDM BREF 2006)**

- **Regenerative heat-exchange in a pasteurisation process (section 4.7.5.6 FDM BREF 2006)**

- **Use multi-effect evaporators (see Section 4.2.9.1 FDM BREF 2006)**

Improving energy efficiency pasteurization in dairy sector

- **Use of continuous pasteurisers**
- **To reduce energy consumption and waste water generation, continuous pasteurisers are used instead of batch pasteurisers.**

  - Batch wise pasteurisation uses a temperature of 62 to 65ºC for up to 30 minutes.
  - Continuous pasteurisers include high temperature short time pasteurisation (HTST) and high heat short time pasteurisation (HHST). HTST uses a temperature of 72 to 75 ºC for 15 to 240 seconds. HHST applies a temperature of 85 to 90 ºC for 1 to 25 seconds. In continuous pasteurisation, flow-through heat-exchangers, e.g. tubular, plate and frame, are used.

Improving energy efficiency pasteurization in dairy sector

- **Multi-effect evaporation**
  - Evaporation can take place in several stages using evaporators (effects) operating in series. With multi-effect evaporator systems, the product output from one effect in the evaporator is the feed for the next effect, and the vapour removed from one effect of the evaporator is used to heat the product in the next evaporator effect. It is an example of energy recovery/re-use. Vacuum is applied in a multi-effect chain to enable the water to boil off.
  - In this way, one unit of steam injected in the first evaporator might remove three to six units of water from the liquid. The energy savings increase with the number of evaporation stages. Up to seven stages can be operated in series, but three to five is more common.

Improving energy efficiency pasteurization in dairy sector

➢ Multi-effect evaporation

Types of evaporator	Total energy consumption (kWh/kg water evaporated)
TVR 3 stages	0.140
TVR 4 stages	0.110
TVR 5 stages	0.084
TVR 6 stages	0.073
TVR 7 stages	0.063
MVR single-stage	0.015

Source: FDM BREF 2006

Improving energy efficiency pasteurization in dairy sector

- **Regenerative heat-exchange in a pasteurisation process**

- **Pasteurisers are equipped with some regenerative countercurrent flow heating sections. The incoming milk is preheated with the hot milk leaving the pasteurisation section. Typically energy savings over 90 % can be achieved.**

Improving energy efficiency pasteurization in dairy sector

- **Example: by applying indirect heat-exchange between the after-thermal treatment product and the inlet product, the specific energy consumption of 148,000 kcal/t can be reduced by 80 %, i.e. to 29,000 kcal/t. The reported temperatures of the process are as follows:**
  - • Initial temperature of 4 ºC
  - • Regeneration heating temperature of 65 ºC
  - • Pasteurisation temperature of 78 ºC
  - • Regeneration cooling temperature of 20 ºC
  - • Pasteurised milk temperature of 4 ºC.

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