

Selected industrial processes which require low temperature heat

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Low temperature processes

For economic and technical reasons, the focus for this project will be on processes requiring temperatures below 100° C, as they are considered to be the economically most interesting for climatic and technological reasons (many solar technologies for higher temperature applications are still in the R&D phase).

These processes include, for example, cleaning, drying, bleaching, colouring, blanching, cooking, painting, surface treatment, evaporation, distillation and pasteurisation. Also, when, for example, vapour at 180°C is needed, solar thermal can pre-heat water up to 100°C and then a boiler can cover the remaining temperature difference. This option will become increasingly interesting with rising gas prices. Additionally, heating of factory buildings and solar air conditioning using absorption or adsorption processes are important related application possibilities.

Market Potential

Industrial sector	Process	Temperature level [°C]
Food and beverages	drying _____	30 – 90
	washing _____	40 – 80
	pasteurising _____	80 – 110
	boiling _____	95 – 105
	sterilising _____	140 – 150
	heat treatment _____	40 – 60
Textile industry	washing _____	40 – 80
	bleaching _____	60 – 100
	dyeing _____	100 – 160
Machinery industry	cleaning _____	40 – 80
	drying _____	30 – 90
Chemical industry including pharmaceutical	boiling _____	95 – 105
	distilling _____	110 – 300
	various chemical processes _____	120 – 180
All sectors	pre-heating of boiler feed water _____	30 – 100
	heating of production halls _____	30 – 80

*based on: K4RES-H; IEA Task 33; Solare Prozesswärme in Industrie und Gewerbe, FhG-ISI, etc.,
and own research by ESV*

Bleaching in Textile industry

- Bleaching is applied to remove pigments and natural dyes that are in the fibres and give a sort of coloration. When the material has to be dyed in dark colours it can be directly dyed without need of bleaching (BAT for the Textiles Industry, July 2003).
- Bleaching can be carried out as a single treatment or in combination with other treatments (e.g. bleaching/scouring or bleaching/scouring/desizing can be carried out as single operations).

Bleaching in Textile industry-2

- Operating temperatures can vary over a wide range from ambient to high temperature. Nonetheless, a good bleaching action occurs when operating at around 60 – 90 °C.
- There is a strong correlation between water and energy use in textile bleaching, since a high proportion of the energy is used for heating wash water. Thus by reducing the water consumption of a bleach range significant savings in energy can also be realized.

Washing in Textile industry-3

- Washing is used to remove impurities from the surface of fibres, yarns and fabrics.
- Washing is a finishing process applied to fibres, yarns and fabrics. Dry cleaning is especially used for delicate fibres (BAT for the Textiles Industry, July 2003).
- Washing and rinsing are two of the most common operations in the textile industry. Optimisation of washing efficiency can conserve significant amounts of water and energy.

Washing in Textile industry -4

- Washing is normally carried out in hot water (40-100°C) in the presence of wetting agent and detergent. The detergent emulsifies the mineral oils and disperses the undissolved pigments. Mixtures of anionic and non-ionic surfactants are commonly used.
- Washing always involves a final rinsing step to remove the emulsified impurities.
- Fabric washing can be carried out in rope form or open-width, and both in discontinuous or in continuous mode. The most commonly used technique is continuous mode in open-width.

	Water consumption (l/kg)	
	TOTAL	of which HOT WATER
Pretreatment Processes		
Washing for desizing	3 - 4	3 - 4
Washing after scouring	4 - 5	4 - 5
Washing after bleaching	4 - 5	4 - 5
Washing after cold bleaching	4 - 6	4 - 6
Washing after mercerisation		
- Washing to remove NaOH	4 - 5 (hot)	4 - 5
- Neutralisation without drying	1 - 2 (cold)	n/a
- Neutralisation and drying	1 - 2 (warm)	<1
Washing after dyeing		
Reactive dyestuffs	10 - 15	4 - 8
Vat dyestuffs	8 - 12	3 - 7
Sulphur dyestuffs	18 - 20	8 - 10
Naphtol dyestuffs	12 - 16	4 - 8
Washing after printing		
Reactive dyestuffs	15 - 20	12 - 16
Vat dyestuffs	12 - 16	4 - 8
Naphtol dyestuffs	14 - 18	6 - 10
Disperse dyestuffs	12 - 16	4 - 8
Source: [179, UBA, 2001]		

Table 4.38: Achievable specific water consumption levels for continuous washing processes during finishing of open width woven fabric consisting of cotton or viscose and their blends with synthetic fibres

Cleaning-1

- Cleaning is a unit operation which includes different typical processes, such as cleaning of production halls and equipment, washing products or cleaning of bottles and cases. In all cases, the objective is to remove undesirable materials and substances from products or other surfaces involved in the production process.
- Cleaning is a process which is carried out in a wide range of industries, including chemicals, foodstuffs, minerals, paper, textiles and many others.

Cleaning-2

- Water heated up to 90°C (maximally) can be used, depending on the cleaning application. The cleaning can be performed either manually or by automated systems. The cleaning process often requires detergents to achieve the removal of the unwanted substances

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Cleaning of bottles and case	Bottle cleaning system	• Dairies (60-85°C) • Breweries (max 80-85°C)	60-85	• Minimization of bottle use • Waste water recycling • Multistage bottle cleaning • Ultrasonic cleaning • Ozone cleaning • Dry cleaning • Pre-soaking • CIP for equipment • Enzyme-based cleaners
	Washing products				
	Cleaning of production halls and equipment		• Dairies (<90°C)	<90	

Heating pocesses

- This category of unit operations includes heating processes that are not complicated in terms of equipment and are based on a simple heat transfer principle. The objective in all cases is to increase the energy content of the stream so that it can be further processed.
- Other process heating is applied to several industry sectors according to the specifications of each industry.

Heating pocesses-2

- Heat transfer in these cases can be accomplished either by direct or indirect heating. Water or steam can be used as an auxiliary feed for the process.

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Pre-heating	Heat exchange network	- Ice cream production (30-40°C) - Beer production (7-76°C) - Oil production (75-95°C)	7-95	- Heat recovery from waste streams - Re-use of condensates
	Soaking	Water tanks	- Vegetable production - Decaffeinated coffee production (22-100)	22-100	Heat recovery from waste streams
	Thawing	Heat exchange network	- Fish production - Meat production	~20	- Heat recovery from cooling streams - Avoid hot air use - Use of microwave energy
Textile					

Heating pocesses-3

- Water can be used as an auxiliary feed for the process. In the case of boiler feed-water preheating, heat transfer is accomplished by using heat exchangers

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Boiler feed-water preheating	Heat exchange network	In all processes where boilers are used	-	- Heat recovery from waste streams - Re-use of condensates

Surface treatment-1

- The objective of surface treatment processes is to modify the properties of the substrate in such a way so that desirable characteristics can appear, for example resistance against corrosion.
- This unit operation is mainly applied in the surface treatment of metals and plastics

Surface treatment-2

Industrial Sector	UD per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Surface Treatment	Plating copper and copper alloy		• all <u>substrates</u>	20-70	• Heat integration
	Electroplating nickel			20-70	
	Plating chromium			20-45	
	Plating zinc and zinc alloy				
	Plating cadmium			18-35	
	Plating tin and alloy				
	Plating precious metal				
	Autocatalytic plating				
	Immersion coatings				
	Oiling				
	Anodizing			5-42	
	Sealing following			25-96	

Painting-1

- By the term painting processes used for the application of colour to a substrate are included, such as dyeing and printing in the textile industry and electropainting, lacquering, colour anodizing and metal colouring in the surface treatment of metals and plastics.
- Painting is mainly applied in the textile industry and in the surface treatment of metals and plastics.

Painting-2

Industrial Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Textile	Dyeing		- Natural fibres - Fibre blends - Synthetic fibres	60-120	- One-step continuous vat dyeing in pastel to pale shade - Enzymatic after-soaping in reactive dyeing - pH-controlled dyeing techniques - Energy and water saving in dyeing machines - Avoiding batch softening - Water re-use/recycling in batch dyeing processes
	Printing				Reduction in water consumption
Surface Treatment	Electropainting		Aluminium	60-90	Heat integration
	Lacquering				
	Colour anodizing on aluminium				
	Metal colouring				

Bleaching -1

- The objective of bleaching is to remove pigments, metals, e.g. nickel or iron from other oil refinery processes; residual soaps and phospholipids from the oil or fat.
- Bleaching is a process which is carried out in different industries, such as foodstuffs and textiles.

Bleaching -2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Bleaching		▪ Fat-oil refining (90-130°C)	90-130	▪ Energy production from spent bleach earth ▪ Re-use of waste streams

Extraction-1

- The objective of extraction is to remove one constituent from a solid or liquid by means of a liquid solvent. These techniques fall into two categories: the first is used to dissolve soluble matter from its mixture with an insoluble solid and it's called leaching or solid extraction and the second is used to separate two miscible liquids by the use of a solvent that preferentially dissolves one of them and it's called liquid extraction.
- Extraction is widely used in food and chemical industries.

Extraction-2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies
Food	Extraction	Leaching by percolation through stationary solid beds	• Apple juice production (60-65°C) ? • Oil production ? • Instant coffee production (160-180°C) • Decaffeinated coffee production (60-110°C) • Aroma production ?	60-180	• Extraction with supercritical media • Use of evaporator condensate
		Moving-bed leaching	• Sugar production (68-72°C)		
		Dispersed-solid leaching			
		Continuous countercurrent leaching			
		Mixer settler for liquid extraction	• Decaffeinated coffee production (80-85°C)	80-85	
		Spray tower for liquid extraction			
		Packed tower for liquid extraction			
		Perforated-plate tower for liquid extraction			
		Baffle tower for liquid extraction			
		Agitated tower for liquid extractor			
		Centrifugal extractor for liquid extraction			

Melting-1

- The objective of melting is to obtain a phase change from solid to liquid, in order to prepare the material for further processing (e.g. for fats, processed cheese) or to recover the melted fraction.
- Melting is a process which is carried out in different industries, such as foodstuffs and machineries.

Melting-2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Melting	Processing kettles	▪ Cheese production(>75°C)	>75	▪ Use of microwave ovens ▪ Re-use of waste streams

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Cooking-1

- Cooking is a food-oriented unit operation. Cooking and boiling are heat processing techniques applied to foodstuffs to alter the texture, colour and moisture content of the food, or to facilitate other later processes.
- Cooking is mainly applied in the food industry.

Cooking-2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Cooking	Water bath ovens			• Use of microwave ovens • Hot air ovens • Avoid cooking prior to preservation in cans, bottles and jars if the food can be cooked during sterilization • Re-use of waste streams
		Shower ovens			
		Steam ovens			
		Air/steam circulation ovens	• Beer production (98°C)	98	
	Boiling				
	Roasting	Direct roasters			
		Indirect roasters	• Roasting of coffee beans (120-240°C)	120-240	

Pasteurization-1

- Pasteurisation is a controlled heating process used to eliminate any dangerous pathogens that may be present in milk, fruit-based drinks, some meat products, and other foods which are commonly subjected to this treatment.
- In heat treatment processes, various time/temperature combinations can be applied, depending on the product properties and shelf-life requirements. Pasteurisation temperatures commonly range from 62 to 90°C, and pasteurisation times vary from seconds to minutes.

Pasteurization-2

- Both pasteurisation and blanching are based on the use of the minimum heat requirement needed to deactivate specific micro-organisms or enzymes, thus minimising any quality changes in the foods. In pasteurisation, generally a heating temperature below 100 °C is applied.

Pasteurization-3

- Batch wise pasteurization: 62 – 65°C, up to 30min
- High temperature short time (HTST) pasteurisation: 72 – 75°C, 15 - 240sec
- High heat short time pasteurisation (HHST): 85 – 90°C, 1 - 25sec
- Batch wise pasteurisation is carried out in agitated vessels. The batch method uses a vat pasteurizer which consists of a jacketed vat surrounded by either circulating water, steam or heating coils of water or steam

Sterilization -1

- Sterilization is a food-oriented unit operation. Sterilization is a controlled heating process used to completely eliminate all living micro-organisms, including thermoresistant spores in food. UHT (Ultra-High Temperature) sterilization has a heat treatment of over 100°C during very short times; it is especially applicable to low viscous liquid food products (BAT in the Food, Drink and Milk Industries, June 2005).
- Sterilization is mainly applied in the food industry.

Sterilization-2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Sterilization	Batch sterilizers	▪ Sterilized milk production (110-125°C) ▪ Condensed and powder milk production (115-130°C) ▪ Curdled milk production (>100°C) ▪ Vegetable juice production (120-125°C) ▪ Vegetable pulp production (120-125°C)	100-125	▪ Use of continuous sterilizers after filling of cans, bottles and jars ▪ Sterilization by filtration ▪ Sterilization by UV-radiation
		Continuous sterilizers			
	UHT sterilization	Batch sterilizers	▪ UHT milk production (>135°C)	>135	
		Continuous sterilizers			

Blanching-1

- Blanching is a food-oriented unit operation. Blanching operations are designed to expose the entire product to high temperatures for a short period of time, by using steam heating indirectly for fruit juices and directly for vegetables. The primary function of this operation is to inactivate or retard bacterial and enzyme action, which could otherwise cause rapid degeneration of quality.
- Blanching is mainly applied in the food industry, in the fruit and vegetable production.

Blanching-2

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Blanching	Drum blancher with countercurrent water cooling	▪ Fruit-vegetable blanching (65-95°C) ▪ Starch-potato blanching (68-75°C)	-	▪ Microwave blanching ▪ Heat recovery from the cooling system of the blanching process ▪ Re-use of cool streams of the process ▪ Belt blanching with water cooling
		Steam blanching with air cooling		65-95	
		Belt blanching with water cooling		80-95	
		Belt blanching with air cooling		80-95	

Evaporation, distillation-1

- The objective of evaporation is to concentrate a solution consisting of a non-volatile solute and a volatile solvent. In the overwhelming majority of evaporations the solvent is water. The objective of distillation is to separate a liquid mixture into fractions of different boiling points by application of heat. Compounds in the liquid mixture are separated according to their volatility. Evaporation differs from drying in that the residue is a liquid- sometimes a highly viscous one- rather than a solid; it differs from distillation in that the vapour usually is a single component and even when the vapour is a mixture, no attempt is made in the evaporation step to separate the vapour into fractions

Evaporation, distillation-2

- Industrial evaporation and distillation are energy intensive processes which are carried out in a wide range of industries, including chemicals, foodstuffs, minerals, paper, textiles and many others.

Evaporation, distillation-3

Industry Sector	UO per sector	Method	Applications	Temperature (°C)	Competitive technologies and energy saving potentials
Food	Evaporation	Open pans			• Multiple-effect evaporators • Vapour recompression • Regular cleaning • Membrane processes
		Plate evaporators			
		Horizontal-tube evaporators			
		Vertical-tube evaporators	• Condensed/sweetened milk production ? • Yogurt production ? • Fruit juice production (40-70°C) ? • Sugar production • Instant coffee production ?	40-70	
		Multiple-effect evaporator	• Sugar production (105-129°C, under pressure) • Sugar production (55-104°C, under vacuum)	55-129	
	Distillation	Pot still distillation	• Scotch whisky production		• Membrane distillation
		Column still distillation	• Scotch whisky production • Aroma essence production (40-100°C)	40-100	
	Deodorization		• Fat oil refining (180-270°C) • Decaffeinated coffee production (100-110°C)	100-270	
Textile					
Building materials					

Drying-1

- Drying is defined as the application of heat under controlled conditions, to remove the water present in foods by evaporation to yield solid products. It differs from evaporation, which yields concentrated liquid products. The main purpose of drying is to extend the shelf-life of foods by reducing their in-water activity.

Drying-2

- Typical applications for drying techniques include dairy products (milk, whey, creamers), coffee, coffee surrogates, tea, flavours, powdered drinks, processed cereal-based foods, potatoes, starch derivatives, sugar beet pulp, fruits, vegetables and spices. The water removal from the wet germinated grain is applied in the production of malt, a process which is called kilning. For the malting process, the drying step is essential and is required to create the desired colour and flavour

Drying-3

- Water heated up to 90°C (maximally) can be used, depending on the cleaning application. The cleaning can be performed either manually or by automated systems. The cleaning process often requires detergents to achieve the removal of the unwanted substances.

Drying-4

- Depending on the cleaning process, different methods can be used to achieve energy savings. Typically, the re-use of waste water streams of either the cleaning process or the entire production line is an effective way to reduce the energy consumption. Primary dry cleaning can also be used to roughly remove the unwanted materials. Additionally, automated cleaning systems (CIP) with precision in water and detergent quantities can be used for energy savings.