Guideline: Energy Efficiency in the Confectionery Industry

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1. Introduction

The confectionery industry, with a sales volume of 13.9bn Euros and 53,600 employees (2008) is one of the most important food industries in Germany.

In recent years, the topics such as energy efficiency and sustainability have been increasingly the subjects of public discussions and therefore they are of growing interest to the confectionery industry and the manufacturers of confectionery machines. This guideline considers the processes within this industry and provides orientation for a possible approach towards more sustainable production.

One focus of attention within the confectionery industry is to increase energy efficiency. This means that all processes and working steps in production and logistics should be managed with as little energy as is possible.

Higher energy efficiency reduces the consumption of resources, lowers the cost and improves the compatibility of companies on national and international markets. This leads to immediate relief on the environment and a better image of the individual company and the industry as a whole.

The term "sustainable production" leads to an extended consideration of the subject matter. It is not only limited to the use of energy but also includes the sensible handling of all resources needed for production. Today's approach is to ensure a permanent and with that sustainable management for the next generations.

These subjects offer the manufacturers of machines and equipment for the confectionery industry the chance to prove their capabilities and innovative power. In cooperation between confectionery producers and machine suppliers, energy efficiency and sustainability are topics that are increasingly gaining importance.

[1] German Federal Statistical Office; 3. July 2009

2. Purpose and scope

The purpose of this guideline is to provide recommendations and information for the confectionery producers and the manufacturers of machines and equipment on how to improve the energy efficiency of existing production equipment and/or machines that are still at the planning stage or will be implemented in the future.

The guideline shall - in a compact and comprehensible manner -

1. <u>create awareness</u> that each manufacturer can contribute to energy efficient and sustainable production,
2. <u>communicate</u> that there are many good solutions and ideas for increasing the energy efficiency in the field of confectionery production and
3. <u>encourage</u> the utilization of these opportunities and to optimize their own processes on a sustainable basis.

The examples and information provided are based on practical experience and aimed at simple and quick implementation. They do not release confectionery producers or their machine suppliers from their duty to comply with relevant laws and legal regulations. In individual cases, reasonable measures might be required that exceed the scope of these recommendations. The guideline was compiled based on current state-of-the-art.

3. Energy demand in confectionery production and generally recommended procedures

3.1. Energy demand in the production of confectionery

The production of confectionery includes the suitable application of process engineering and technical processing operations within a complex production system. The combination of individual

Group of processes	Process	Estimation of specific energy demand	Frequency of application		
			Chocolate production	confectionery production	Pastry production
Mechanical processes	Size reduction (ball mill, roller mill)	+++	+++	+	+
	Conching	++	+++		
	Mixing	+	+	++	+++
	Conveying of bulk goods	+	++	++	++
	Pneumatic conveying	++	+	++	++
	Conveying of liquids (pumping)	+	++	+++	+
	Separating	+	+	+	
Thermal processes	Evaporation	+++		+++	+
	Cooking	++			+
	Drying	+++		++	++
	Baking	++			+++
	Roasting	++	+		
	Melting	+	+	+	+
	Tempering	++	+++	+	
	Crystallizing	++	+++	++	
	Cooling	++	+++	++	++

Overview 1: Evaluation of the specific energy demand and application frequency of selected mechanical and thermal processes in confectionery production (+++ high/++ medium/+ low)

Energy source	Group 1582 Production of dry baked goods		Group 1584 Production of confectionery	
	Consumption GJ/a	Percent	Consumption GJ/a	Percent
Fuel oil, light	115,125	2.7 %	421,365	4.3 %
Liquid gas	73,143	1.7 %	14,849	0.2 %
Natural gas, associated gas	2,486,900	57.3 %	5,565,480	57.0 %
Biogenic substances	-		-	
District heating	7,519	0.2 %	193,355	2.0 %
Electricity	1,655,751	38.1 %	3,562,682	36.5 %
Total	**4,338,438**	**100.0 %**	**9,757,731**	**100.0 %**

Overview 2: Energy consumption of selected sectors within the food industry 2007[1]

processing steps is, in many ways, dependent on the product. When considering the individual processing steps separately, the specific energy demand can be depicted qualitatively according to overview 1. Besides considering the extent of the specific energy demand, the frequency of a processing or production step within the processing chain is also relevant.

Overview 2 shows the energy consumption by energy source for the sectors of dry baked goods and confectionery. The most important sources of energy are natural gas with about 57% and electricity with 36-38%.

This means that the predominant part of the energy consumption is used for thermal processes. Therefore, the monitoring and optimization of thermal processes is of high significance.

3.2. Energy efficiency as a sustainability parameter in the production[2]

Any kind of waste that originates during production, caused by rejects, excess production quantities, needless internal stock-keeping and long transport paths, is always associated with an additional input of material, space, personnel and energy[3]. A continuous improvement of the production under consideration of these aspects also contributes to higher resources efficiency and a more sustainable production (Figure 1).

In the years to come, controlling the production with the goal of minimizing the consumption of energy and resources by using intelligent controls for the entire system within a production facility, by optimizing the utilization of machines and equipment and by using reasonably installed storage capacities which make use of day/night effects etc, will become more and more important. One well-known example is the intelligent control of energy users in larger processing networks which is aimed at minimizing peak demands.

A precondition for such control strategies is knowledge about the energy users and their interaction. This requires the set-up of a comprehensive energy management system for the plant which includes the recording of all relevant energy and material streams within the plant's infrastructure and within the production processes. This is a clear expansion compared to all currently used energy management concepts.

3.3. Recommended procedures for improving the energy efficiency

Prior to improving the energy and resource efficiencies, it must be known how high the avoidable proportion of losses or internal waste is. This must be determined by a systematic analysis of the respective process. Besides the necessary recording and evaluation of the actual consumption values based on measurements, it has been shown that knowing the theoretical consumption of the respective process is also important. This way, the respective theoretical improvement potential becomes obvious. Parallel to that, data shall be compiled based on an active benchmarking approach which represents the current state-of-the-art. Figure 2 shows the analysis steps for the process and the identification of actions as general methodology for the optimization of thermal processes.

2 Junge, M.: Simulationsgestützte Entwicklung und Optimierung einer energieeffizienten Produktionssteuerung; 2007, kassel university press GmbH, Kassel

3 Takeda, H.: Das synchrone Produktionssystem: just in time für das ganze Unternehmen; German translation A. Meynert. 2. revised edition – Landsberg: Verlag Moderne Industrie 1999, p 154ff

4 Bretschneider, U.: Optimierung thermischer Prozesse in der Süßwarenindustrie durch strukturierte Prozessanalyse; Lecture 23.4.2008; Hannover Fair

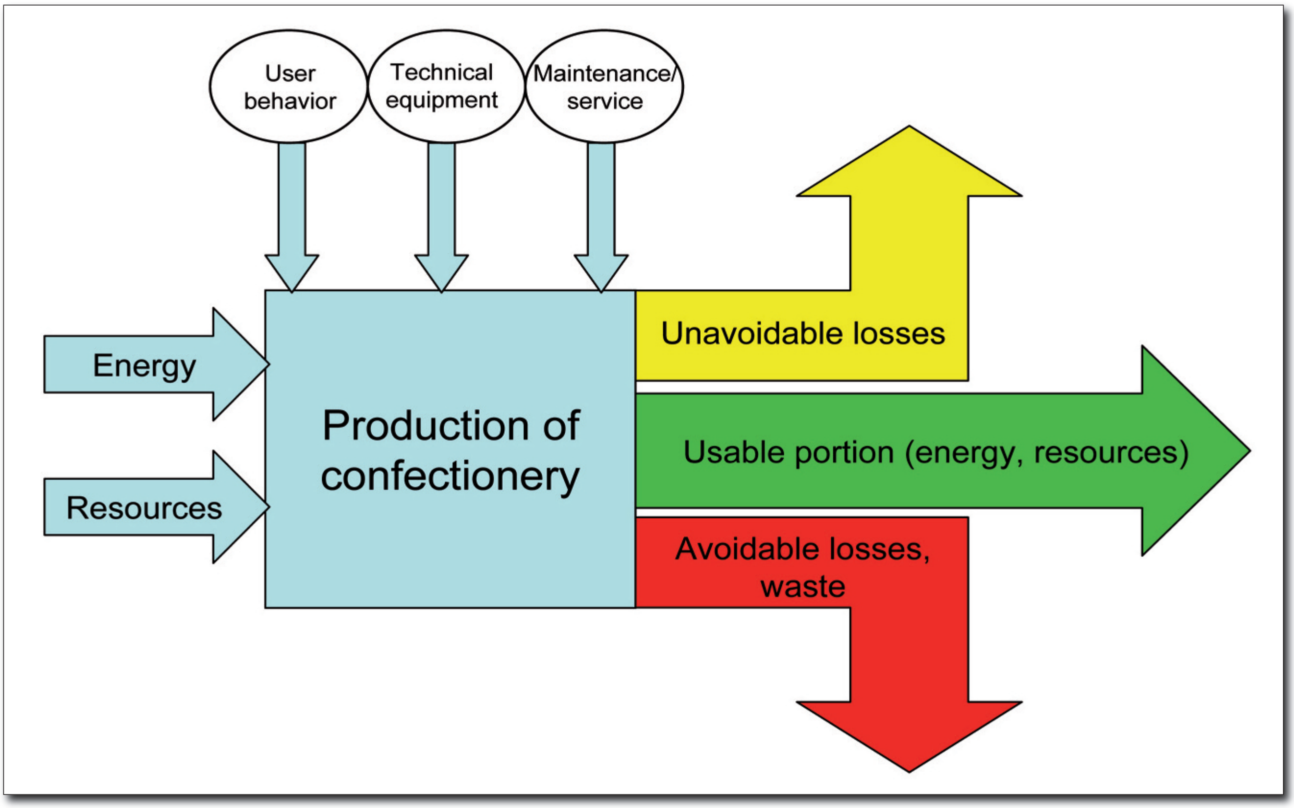

Figure 1: General considerations about processes and their influencing parameters within the inter-company performance process

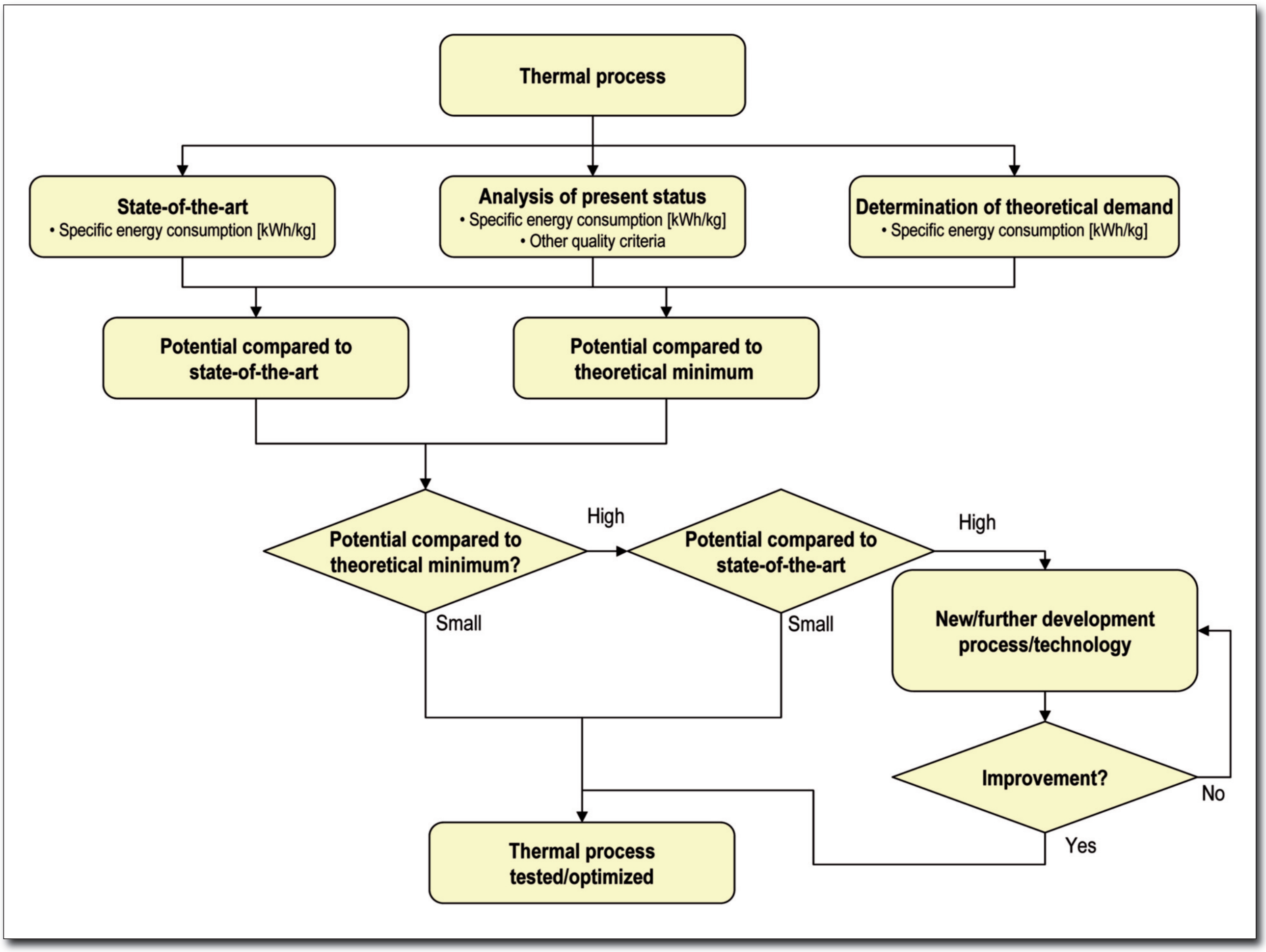

Figure 2: Structural analysis of thermal processes[4]

4. Energy efficiency - suggestions for an advantageous design of processes and processing plants

Within the scope of this guideline, the following segments of a confectionery production process are being considered:

- Plant infrastructure
- Cocoa processing
- Production and processing of chocolate mass
- Production of sugar confectionery

4.1. Plant infrastructure

The confectionery industry is characterized by the fact that heating and cooling processes are required at the same time within the processing line. Basically, this offers the chance to use co-generation units and absorption cooling units in order to achieve a higher degree of efficiency.

Position	Field	Scope of consideration	Suggestions for advantageous design
1	Building	Use of room/floor space	- The energy consumption of a factory building is dependent on the enclosed space. Therefore: • Clear separation of warm and cold zones (separating walls, locks) • Compacting of processes • Energetic separation of unused areas
2	Technical infrastructure	Media, in general	- Hot water network instead of steam main, if possible - Frequent check-up of the networks • Short supply lines/hydraulic optimization • Minimizing the size of the network • Checking the networks for short-circuits - Insulation of the installation (except compressed air)
3		Compressed air	- Minimize consumption of compressed air • Leakage monitoring/frequent check-ups of compressed air networks • Critical evaluation of the use of compressed air (avoid, if possible or at least, minimize) - Utilization of waste heat from the compressed air generation to pre-heat process water
4		Cooling (cold water/brine)	- Consider combined generation of electricity and cold temperatures - Utilization of waste heat, possibly in combination with heat pumps - Consider combined equipment for the generation of hot and cold temperatures - Comparison compression/absorption chillers
5		Hot water/steam	- Use of economizers (heat recovery) - Condensate return - Generation of processing steam locally close to the energy user
6		Air conditioning units	- Use of partial air conditioners including cross flow heat exchangers for optimum utilization of external air - Use of flat belts instead of v-belts - Use of directly driven fans
7		Pumps, fans	- For demand-oriented operation in HVAC, use of frequency-driven motors (instead of flow restrictors in water pumps for example)
8	Raw material/ product storage	Storage conditions	- Review requirements and advantageous layout of the spaces - Minimize the different temperature zones in terms of numbers and space

4.2. Chocolate production

Position	Processing stage	Scope of consideration	Suggestions for advantageous design
1	Storage of raw cocoa	Silos	- Utilization of waste heat for the conditioning of the storage area - Insulation of the storage area
		Unloading	- Choose large bulk containers in order to minimize the specific energy input
2	Roasting, debacterization	Roasting, debacterization	- Equip nib roaster or roasting equipment with heat recovery units or ask for an optional quote - Determination of process flow based on energetic aspects - Utilization of waste heat from the thermal post-combustion of the exhaust air from the processing stages roasting/debacterization and grinding
		Roaster	- Optimize burning and roasting chamber - Design burning chamber in cooperation with the supplier based on the product to be handled - Aim for process control at the lowest possible temperature level
		Steam supply for debacterization	- If saturated steam is needed for debacterization, it should be supplied on site by a flash evaporator in order to ensure optimum ratio of consumption and capacity installed - The aim should be to eliminate the generation of steam from the process (if technically possible)
		Bean/nibs conveying	- Consider energy consumption when selecting the conveying system - Short conveying paths
3	Nibs grinding	Nibs grinding	- Grinding at a low temperature level reduces the cooling load
			- Grinders: Review drive technology for use of energy efficient motors - Cocoa nib grinding is high in energy consumption ® scrutinize process design
4	Storage of cocoa and chocolate masses	Storage of liquid cocoa and chocolate masses	- Tanks placed in a heated room are preferred over a placement in an unconditioned environment Advantages: • No double jacket required • No insulation of the tanks • Use of higher pump-out temperatures from the conches to heat the room - No active room heater needed for normal operation (must still be available for emergency) Remark: Provide for insulation of the tank storage room in order to minimize heat losses! - Stirrers with interval timer
5	Production of chocolate mass	Mixing	- Drive technology with energy efficient motors - Selection of suitable mixing tools - Process of addition of components (preferable "dry into wet") - Use of gravitational forces for filling and emptying
		Rolling, conching	- Drive technology: use energy efficient motors - Consider alternative power transmission to v-belts - Design process in terms of reduction of specific energy requirement while maintaining the desired sensory properties - Couple waste heat from different machines for processes/heating and cooling Remark: For newly designed plants, a vertical layout of the individual components is preferred for improved utilization of the gravitational force. If this is not possible, connect the individual components via belts and not via screw feeders!

4.3. Chocolate processing

Position	Processing stage	Scope of consideration	Suggestions for advantageous design
1	Chocolate melting	Melting tank	- Insulation of the tank - Provide for large surfaces (chips) - Proper design for good heat transfer including consideration of materials - Use waste heat for heating
2	Storage of liquid chocolate	Storage tank	- Tanks placed in a heated space are preferred over a placement in an unconditioned environment Advantages: • No double jacket required • No insulation of the tanks • Utilization of waste heat generated by other processes • Active room heating requirements can be minimized in normal operation, but must be provided in the event of an emergency Remark: Provide for insulation of the tank storage room in order to minimize heat losses!
3	Conveying of liquid chocolate	Pumps, pipelines, valves	- Insulate heated pipes - Minimize ways (optimize lengths, bends, nominal width)) - Use flow-optimized flaps/ball valves - Multiple use, possible through pig technology, results in a smaller pipeline installation and minimizes energy requirements - Periodically review pump application range and conveying performance
4	Storage, tempering and preparation of chocolate for further processing	Container	- Insulation of containers - Optimum design of the stirrers - Proper design of sieves/vibration motor - Couple sieve's vibration motor to pumps - Minimize storage temperature/flow temperature of the heating medium
		Tempering unit	- Select tempering systems based on energetic aspects - The amounts of chocolate supplied by the tempering system must only deviate marginally from the demand of the depositing system! - Correct design under consideration of necessary reserves and maximum required performance - Consideration of the cooling water temperature (insulation of the installation) - Minimize distance between tempering unit and processing machine (enrober with external or integrated tempering unit?)
5	Processing of chocolate - depositing/ moulding	Moulds	Dimension of moulds: - Maximum mould arrangement (occupancy) and mould design influence the specific energy requirements (ratio mould weight: product weight) Pre-heat moulds in the process: - Clarify heat transfer by radiation versus heat transfer by convection depending on the respective application
		Depositing	- Set-up in a warm area
		Formation of shells	- Compare cold stamp technology and traditional shell forming technology regarding energy requirements for the actual application
		Production of filled chocolate products	- Compare technologies - multi-step technology (shell forming, filling and closing) with one-shot technology
		Mould cooler/ cooling of filled moulds	- Design of chiller - Ensure use of flow mechanically optimized fans and air guides in the chillers - Energy efficient motors, not oversized - No air drying (if possible) but rather optimization of water traps
6	Processing of chocolate - enrobing	Enrober	- Place machine in a separated warm area (about 24-26 °C) - Minimize chocolate quantity in the return pipe (as much as is feasible in terms of process and product) - Use of frequency-controlled fans/pumps - Place de-crystallizer including storage tank, pump, etc. in the warm area of the enrober line (heating by waste heat)
		Tunnel cooler for enrobed products	- Separate set-up - not in the warm area, if possible - Sufficient insulation - Minimization of air losses - Select cold water supply (decentralized versus centralized cooling system) under specific consideration of energy efficiency, supply safety and load profile - Ensure use of flow mechanically optimized fans and air guides in the chillers.

4.4. Production and processing of sugar confectionery

Position	Processing stage	Details	Suggestions for advantageous design
1	Storage and preparation of raw materials	Storage of liquid raw materials in tanks	- Select stirring system with low electricity consumption; stirrer design depending on the type of raw material - Optimum control of the stirring systems (rpm, duty cycle, starting) - Consider load management in tank storage - Insulation of the room - Determine the required temperature level (minimize) - Use of indirect heat for heating the storage area
		Preparation and dissolution of raw materials	- Insulation of the tank - Proper design for good heat transfer including consideration of materials - Select suitable stirring systems - Minimize use of water
2	Metering of raw materials	Metering and dosing of raw materials	- Minimize ways (optimize lengths, bends, nominal width) - Limit conveying speed - Use flow-optimized flaps/ball valves - Minimize use of water - All-in recipes - Optimize stirring systems - Optimize CIP installation
		Storage of the preparation	- Insulation of tanks - Optimum design of the stirrers - Optimum design of the sieves - Constant and proper temperature of the mixture and heater
		Conveying the raw materials mixture	- Proper design of the installation (pump, length of pipelines, flow meter, flow control, additional heater)
3	Dissolving and pre-boiling of the mixture	Dissolving of the mixture	- Apply pressure dissolution process instead of atmospheric dissolution
		Pre-boiling of the solution	- Select optimum cooking system (static/dynamic heat exchanger) - Insulate cooker, heat exchanger, steam separator - Insulate energy supply line - Optimize heat transfer - Optimize temperature profile - Utilizes waste heat (steam condensation)
		Conveying of pre-boiled solution	- Proper design of the installation (pump, length of pipelines, flow meter, flow control, additional heater) - Minimize product ways
4	Cook solution and vacuumize	Cook solution	- Select optimum cooking system (static/dynamic heat exchanger) - Insulate cooker, heat exchanger, steam separator - Insulate energy supply line - Optimize heat transfer - Optimize temperature profile - Utilizes waste heat (steam condensation)
		Vacuumize sugar mass	- Use suitable vacuum system - Reuse of waste heat? - Equip vacuum system with circulating water or pump without sealing liquid
5	Metering and blending of ingredients	Metering of ingredients	- Minimize ways (optimize lengths, bends, nominal width) - Stirrers only if needed - Optimize CIP installation - Energy-saving drives
		Blending of ingredients	- Insulate mixer - Optimize mixer in terms of mechanical introduction of energy - Energy-saving drives - Closed mixing systems - CIP possible
		Conveying of sugar mass	- Minimize paths - Optimum insulation and heating of pipelines

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Position	Processing stage	Details	Suggestions for advantageous design
6	Treatment of sugar mass	Aeration	- Optimize viscosity - Energy-saving drives - Optimize system pressure
		Pulling	- Minimize heat radiation - Energy-saving drives - Optimize pull lengths
		Crystallizing	- Optimize introduction of mechanical energy - Insulate equipment - Energy-saving drives - Optimize crystallization time (shear, heat treatment)
		Caramelization	- Insulate equipment
		Conveying of sugar mass	- Optimize paths - Optimize heating of pipelines
7	Processing of sugar mass	Starch depositing	- Consider heat emitted into the room - Improve heat transfer - Insulate pipelines - Insulate equipment - Optimize compressed air demand - Optimize cold water treatment - Recover heat from starch drying
		Starch-less depositing	- Optimize temperature of depositing equipment - Keep in-feed ways for the mass short - Secure chiller against loss of chilled air - Optimize air circulation in the chiller - Energy-saving drives
		Conditioning/drying	- Develop recipe based on minimized energy consumption (consider: raw material selection, recipe, viscosity of mass at depositing)
		Shaping, stamping	- Closed circuits for tempered water - Consider heat emitted into the room - Improve heat transfer - Insulate pipelines - Stamping tools with rolling friction instead of dynamic friction
		Extruding	- Energy-saving drives - Closed circuits for tempered water - Optimize energy introduction into the product - Insulate outside surfaces - Air cooling system with optimized fans and good heat transfer due to high air velocity - Minimize losses of chilled air
8	Cooling of sugar mass	Cooling	- Optimize air guides, air flow - Minimize air losses - Centralized or decentralized cooling system - Refrigeration unit with air or water cooling - Refrigeration performance adaptable to product throughput - Environmental conditions for the chiller
9	Start and stop of production line		- Short product ways - Minimize product quantity in the production process - Collect raw material residual amounts and reuse as rework
10	Cleaning of production line		- Circuit cleaning - Rotating spraying balls - Sufficient water velocity - Production lines capable for CIP

5. Energy and resources efficiencies in the planning and implementation of new equipment

In the planning and implementation of new machines, equipment and lines, much more attention will have to be paid in the future to the issues of energy efficiency and preservation of resources. Confectionery manufacturers and their machine suppliers will need to exchange their experiences at the beginning of the project and also determine the respective objectives that are to be met.

An optimum process design in combination with optimal engineering and technology offers the opportunity of bringing the specific energy consumption very close to the theoretical minimum. This is, in particular, true for new plants. Both sides need to seize this opportunity.

Together with a user, the manufacturers of confectionery machines need to monitor the projects already implemented in order to be able to improve the energy efficiency of their machines even further. The data determined during such a monitoring process will assist the operator in defining improvement measures for the respective system. The machine supplier, on the other hand, can use this information to achieve a higher prediction precision regarding the expected energy and resource demands at different load profiles.

Added to that, the experience from completed projects can be transferred to new projects. The analysis of energy sinks and energy sources and their optimal coupling within the plant infrastructure offers a high savings potential for the specific energy demand in confectionery production.

Moreover, existing conditions and ways of thinking must be questioned. The structures have to be designed as clearly and be as controllable as possible.

6. Disclaimer

a) Technology and know-how, as long as not published or belonging to general technical knowledge, are subject to confidentiality.
b) Laws and legal regulations have to be complied with.
c) Recommendations and suggested solutions have in each case to be checked by experienced personnel for practicability and suitability prior to their application and implementation.
d) This guideline makes no claim to be complete.

7. Summary/outlook

The guideline presented here shall support companies from the confectionery field and manufacturers of machines and equipment in finding solutions for energy efficient and resource conserving production processes and their practical application.

Machine manufacturers and confectionery producers should

- optimize processing technology and process flow with the goal of minimizing the energy requirements;
- simplify structures to make them more manageable and controllable;
- install process control procedures (monitoring, determination of deviations, optimizing);
- harness energy sinks and energy sources in complex production systems;
- install storage capacities for the balancing of short-term peaks and for the utilization of day-night effects;
- apply intelligent energy and resource management for optimum operation of the processes.

Even though the confectionery industry does not belong to the most energy consuming sectors, addressing the deliberate use of energy and resources makes sense not only in terms of cost savings but also in terms of image.

8. Bibliography

Bretschneider, U.: Optimierung thermischer Prozesse in der Süßwarenindustrie durch strukturierte Prozessanalyse; Lecture 23.4.2008; Hanover Fair

Förster, H.: Energieeffizienzreserven von Kälteanlagen; Die Kälte+Klimatechnik, März 2008, p 24ff

Förster, H.: Die Kälteanlage der Zukunft; Die Kälte+Klimatechnik, Februar 2009, p 44ff

Junge, M.: Simulationsgestützte Entwicklung und Optimierung einer energieeffizienten Produktionssteuerung; 2007, kassel university press GmbH, Kassel

Meyer, J. u.a.: Rationelle Energienutzung in der Ernährungsindustrie 2000; Fried. Vieweg & Sohn Verlagsgesellschaft mbH, Braunschweig/Wiesbaden

Takeda, H.: Das synchrone Produktionssystem: just in time für das ganze Unternehmen; dt. Übers. A. Meynert. 2. überarbeitete Auflage – Landsberg: Verlag Moderne Industrie 1999, p 154ff

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