STRATEGIES FOR IMPROVING PROCESS WATER RECYCLING TECHNOLOGY IN THE DAIRY INDUSTRY

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As a result of the milk and whey processing in concentration processes, using evaporative and membrane methods, contaminated wastewater is produced. They exhibit features that limit and often exclude their reuse in technology and/or technical infrastructure. Our own research and literature review show that the process water recovery technology, which allows to obtain water of significantly better quality, compared to treated water, can only be obtained as a result of the well-known and widely used, since the 80's of the last century, filtration of process water by activated carbon. In evaporation and membrane installations, process waters contaminated with both organic and mineral compounds are generated. The level of contamination with organic compounds is low from the point of view of wastewater treatment technology. On the other hand, it is too high for direct use in a dairy plant as a full-fledged and microbiologically safe water. Contaminated waters do not meet the requirements of the COD parameter, which for process water should be in the range of 10 – 15 mg O_2/dm^3, what results from the internal procedures adopted in the dairy industry for the analysis of critical points in ensuring food safety based on HACCP procedures, and does not result from national or the EU regulations.

The quality of water used for food production on the basis of the current Regulations of the Minister of Health on the quality of water for human consumption of 7 December 2017 (Journal of Laws, item 2294) must correspond to the quality of drinking water for the public. The regulations implement the recommendations from Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy. The above requirements are obligatory for waters in contact with the raw material and dairy product. However, the above-mentioned regulation in the dairy industry is limited by the so-called hygiene package contained in Regulation (EU) No 852/2004/EU of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs and No 853/2004/EU on specific hygiene rules for food of animal origin of 29 April 2004 prohibiting secondary water (recovered from various production processes) from coming into contact with the raw material and/or dairy product. Regardless of the quality, even if the water meets the current requirements of the regulation of the Minister of Health, it cannot be used in processes in which the raw material or product comes into contact with water recovered from the process.

According to Danish BAT [Korsstrom et al., 2001] as well as their own research; water recycling is practically possible if the recovered water comes from two sources: from the recovery of condensates from milk and whey evaporators during thermal concentration of these raw materials, and from the RO processes of rennet whey concentration (so-called "sweet whey") [Marjanowski et al. 1991, 1997, 2009, 2013, 2016a and 2016b] and [Ostrowski et al. 1992, 2005, 2006]. In addition, the recovered water must be safe in terms of avoid sedimentation process, corrosion and microbiology in order to be reused it in the water management of facility. Therefore,

the water must meet the requirements of sanitary standards and technical requirements related to the equipment and microbiological safety. These are special conditions for water used in the food industry, in particular in the dairy industry. Water as a medium is used at least in a several applications in the dairy industry, the most important of which are:

a) use for technological purposes of dairy production, mainly for the processes of washing production equipment, including washing of complex membrane systems in integrated CIP (cleaning in place) systems, washing the inside and outside of the tank cars. The dominant amount of water, i.e. approx. 33% of the total water, is used for all cleaning related to production hygiene [Lindgaard-Jorgensen, 2018] and [Best Available Techniques (BAT) guidelines for the dairy industry, 2005 Ministry of the Environment, 22-23],

b) use by people for social and living purposes,

(c) water entering the product, infrequently and in small quantities,

(d) heat/cold transfer medium in heat exchange systems,

e) production of steam up to 20 bar and hot water (115 – 117 °C),

(f) chilled water production,

(g) replenishment of evaporation systems of cooling towers and spray-forming condensers evaporators,

h) supplying the water ring of vacuum pumps,

i) cleaning floors in production halls or yards,

(j) fire protection targets.

On the basis of literature studies and own research, the paper presents selected methods and operational problems related to the use of process water from the dairy industry without prior treatment. In the experimental part of the thesis, advanced technologies for the recycling of water after industrial processes based on our own innovative solutions, registered with a utility model and patents of the Polish Patent Office, were proposed.

Hence, the classic technologies of process water recycling in the dairy industry have been intensified, expanded and improved in order to the introduction of a number of new technological solutions, that are the subject of this work. In addition, the equipment and devices used in selected reference water recycling installations in existing dairy facilities in Poland are discussed. On the other hand, the proposed technology also includes a sequence of process water treatment procedures consisting of flowing through an activated carbon filter, a strongly alkaline anionite exchanger regenerated with a chloride ion with the use of alkaline brine, and then through a cation exchanger operating in the sodium cycle, what results in obtaining almost pure water and assuring almost complete removal of organic compounds. The use of anionite regenerated with alkaline brine at elevated temperature allows to obtain longer iono-exchange cycles of the anionite. Increasing the pH of the feed at the beginning of the water treatment process results in a reduction of conductivity and COD in the permeate, improving the required characteristics for the feed of boiler water. A significant reduction in the content of organic compounds in permeate is influenced by perhydrol oxidation after RO installation and irradiation with UV lamp in a titanium housing with a passive TiO2 layer. The use of a high-pressure pump inverter with a permeate flow meter allows to regulate the stable RPM of the RO pump, adapted to the variable viscosity of the feed. However, there is a need to refine the recycling technology of process waters in order to be able to use them more widely in legally permitted applications, especially from low-pollution process waters. New technologies have been implemented in selected milk-whey processing for water and heat recovery in full-scale technical systems in Poland.

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