CLEANER PRODUCTION METHODOLOGY IN THE DAIRY PLANT

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Souhrn

První projekty čistší produkce v naší republice se prováděly v průmyslových podnicích převážně strojírenského charakteru a to zejména proto, že zkušenosti ze zahraničí byly z těchto odvětví nejrozsáhlejší. Vývoj ovšem pokračoval zejména v oblasti úspory v podnicích zemědělských, potravinářských a služeb.

Rozsah možností využití metodiky čistší produkce v potravinářském průmyslu můžeme doložit na příkladu případové studie mlékárny.

Posuzovaná mlékárna se svou velikostí řadí spíše mezi menší mlékárny, charakterem výroby patří do skupiny mlékáren výrobně konzumních. Zpracovává 130 až 150 tisíc litrů mléka denně. Pouze provoz sýrárny pracuje na dvě směny (ranní a odpolední), ostatní provozy mlékárny pracují na jednu směnu.

Mlékárna se specializuje na výrobu sýru Eidam. Tento sýr, typický pro našeho spotřebitele, je velmi oblíben nejen u nás, ale i v zemících středního východu. V současnosti představuje jeho výroba 62,5% celé produkce mlékárny.

Jako prioritní k řešení byla vybrána oblast syrovátkového hospodářství. Největší problémy v mlékárnách již tradičně způsobuje vyřešení otázky dalšího naložení se syrovátkou. Svým objemem představuje asi 80% z celkového objemu zpracovávaného mléka. Ačkoliv je syrovátka zdrojem velmi jakostních a nutričně ceněných bílkovin, její další zpracování je značně problematické. Neméně významný je i fakt, že právě syrovátka největší měrou zatěžuje produkované odpadní vody. V nalezení možnosti jejího dalšího zpracování se skrývá přímý ekonomický zisk, současně by se toto opatření pravděpodobně pozitivně projevilo na kvalitě odpadních vod.

Hlavním řešením projektu je využití rotačního filtru. Syrovátka se akumuluje v úschovných nádržích a odtud pomocí odstředivkového čerpadla dopravuje na rotační sítový filtr RF 1A. Pomocí tohoto zařízení dostaneme ze syrovátky zbytky vysrážených bílkovin a sýrařského prachu, tím zbavíme syrovátku kaseinu, který můžeme ve výrobě dále využít a to buď vrácením zpět do výroby nebo využitím této bílkoviny jako plnohodnotné suroviny k tavírenským účelům na výrobu tavených sýrů.

Klíčová slova: čistší produkce , odpadové hospodářství, odpadní voda potravinářský průmysl, mlékárna, syrovátka, environmentální přínos, opatření

Abstract

Project of cleaner production was elaborated for the dairy, which specialises mainly in the production of EIDAM cheese. The proposed measures are based on the filtration of whey - a by-product - on a rotary screen filter and subsequent utilisation of attained proteins in the manufacture of processed cheese. Liquid product will be utilised in the production of feed. It was estimated that annual profit of the implemented measures is almost 2.10^6 CK. The investment costs are $1{,}15.10^6$ CK and payback period is about 0,6 year. At the same time environmental benefits can be achieved by the reduction of wastewaters pollution and quantity.

Key words: cleaner production, waste management, wastewater, food industry, dairy, whey, environmental benefit, investment

1. Description of company and its production

Dairy company, located in a small town , belongs to smaller dairies. It belongs to the ”production-consumption” types of dairies as far as the character of its production is concerned. It processes 130 000 - 150 000 litres of milk a day. Only the cheese processing plant operates on two shifts (morning and afternoon shifts), other places of operation work on one shift only.

Daily production of milk is transported with the help of so called pick-up transport service usually from the nearby neighbourhood. Diaries in mutual co-operation operate pick-up transport service from longer distance. When a tank-truck arrives, samples of milk are taken and tested for acidity, fatness and temperature in a laboratory. Although the capacity of each of two inlet milk tanks is only 50 000 litres of milk, daily delivery is more than 130 000 litres. Continuous milk processing solves this problem.

The dairy specialises in the production of Eidam cheese. This cheese is very popular not only in our country, but also in the countries of Middle East. This type of production has a tradition in this dairy and at present it represents 62,5 % of the whole dairy production. The rest of the production includes especially the curd cheese, the delicate curd cheese and flavoured cream and curd cheese products.

2. Process analysis

Case study was aimed at finding shortcomings in two spheres, water management and waste management. Water management effort was aimed at the reduction of waste waters pollution load. Waste management is the second sphere, because whey, which is generated during the processing of milk, is not utilised efficiently and in the whole range.

As far as waste waters are concerned it can be stated the following: if water is used efficiently its consumption is about 3 litres per 1 litre of milk; waste waters from dairy industry can be divided into cooling waters and rinsing waters. Cooling waters are not usually polluted and after cooling they can be recirculated without any problem. Rinse and wash waters include residues of milk and disinfectants. They are heavily polluted especially with organic substances due to the fact that over 1 % of processed milk gets into them. Their biological oxygen demand, BOD_5, fluctuates from 900 - 3000 $mg.l^{-1}$, which is caused by extremely high BOD_5 values of milk and by-products during their processing. BOD_5 is $1{,}02.10^5$ $mg.l^{-1}$ in case of milk and $3{,}20.10^4$ $mg.l^{-1}$ in case of whey. The main amount of wastewater is generated during the rinsing of milk cans and the washing of technological equipment. Decayed products and raw materials should not get into wastewater.

Wastes and by-products being generated during the processing of milk include mainly the following:

a) **separator sludge** originated during the purification of raw milk. It is grey, slimy matter and it includes up to 18 % of proteins, 2-3 % of fat, small amount of mineral substances and organic compounds. Besides that mechanical impurities get into the sludge, e.g. dust, parts of feed and litter, animal hair, as well as part of milk micro-flora, somatic cells, epithelial cells, etc. Sludge can contain a large amount of pathogenic germs and that is why it must not be used as feed. It is either processed in rendering plants or burned;

b) **buttermilk** contains residual amount of fat (0,5 %), considerable portion of phospholipids and lactose, lactic acid (0,5 %) and ashes (0,7 %). Due to its composition it can be used as dietetics or it can be processed for casein and salts of casein, which can be utilised as additives in bakery;

c) **washing** water from butter grain contains significant amount of proteins. Rinsing water can be used directly as fodder. Proteins can be coagulated, e.g. by heating to 40-50 °C;

d) **whey** is the most typical example of a by-product in dairy industry. Under normal conditions it contains 4,7 % of lactose, 1,3 % of lactic acid**,** 0,9 % of proteins, 0,6 % of mineral substances and about 0,3 % of other organic substances, mainly citric acid, non-protein nitrogenous substances, residues of fat, etc. More than two thirds of all the vitamins present in the processed milk (thiamine, riboflavin, pyridoxine, cobalamin, pantothenic acid, biotin, and vitamin A) go into whey. Whey in its original state is used for drinking, as well as in the production of drinks and as feed. It has only limited durability due to high content of water and that is why it is mainly processed into condensed whey concentrate and dried whey. The above mentioned products are used, besides the production of fodder, in food and pharmaceutical industries.

3. Supplies

Whey management was chosen as a priority objective of the project with regard to the number and significance of its environmental impacts. Issues of further whey management traditionally cause the biggest problems in dairies. Whey represents over 90 % of total amount of processed milk. Although it is the source of high-quality proteins with high nutrition value, its processing is very problematic. Equally important is the fact, that whey has the biggest negative impact on waste waters load. Finding possibilities for further processing of whey has the potential of direct economic profit together with the reduction of waste waters pollution.

Shortcoming of the present state is both relatively low economic profits for the company (on average 12 545 $CK.day^{-1}$, and also imperfect co-operation between farmers and the dairy. In present conditions of market economy, when supply of whey exceeds demand, the dairy is forced to offer whey to farmers for 0,10 $CK.l^{-1}$ despite its high nutrition value. Taking whey delivery is agreed in contracts between a firm and customers. Only the price of whey is contracted, not the amount being taken. That is why taking delivery is not the same during the year and fluctuates according to the customer's demand. It is necessary

to solve penalties for the case the whey is not taken by agreed deadline.

4. Methods - Measures of Cleaner Production

It was suggested to accumulate whey in storage tanks and from there to transport it to the RF 1A rotary screen filter with the help of centrifugal pump. It is possible to eliminate residues of coagulated proteins and cheese powder with the help of the above mentioned equipment. Casein can be removed from whey in this way. Casein can be then returned into manufacturing process or utilised as a full-scope raw material in melting processes during the processed cheese production.

Solution of the project was complex and included cleaning the entire whey conduit lines as well as cleaning the filter with the accumulation tank. It will be necessary to join all conduit lines with the cleaning system to ensure the circulation of rinsing waters and then cleaning solution. It is assumed to use the solution of sodium hydroxide through which a microbiologically clean, closed system will be attained. Proteins obtained from rinsing waters can be used for further food processing, alcalic cleaning waters can be used for washing the cans and then diverted to wastewater cleaning plant. Whey, cleared of proteins and cheese powder, will be pumped into storage tanks, where it will be ready either for sale as feed or for further processing, e.g. drying.

Parameters corresponding with the implementation of newly proposed procedure are presented below:

amount of milk processed per day: $1{,}35.10^5$ litres
amount of whey produced per day $1{,}25.\ 10^5$ litres
capacity of rotary screen filter 5.10^3 - 10^4 litres of whey per hour
operating hours of filter per day 17 hours
cleaning of the equipment including conduit line: 1 hour per week
filtration efficiency per day: 210-250 kg of proteins with the dry matter of 25 - 30 %

Milk proteins contained in whey also significantly pollute wastewater. Waste waters load will be reduced through significant elimination of organic matter. On the other hand the filtration of whey requires more labour needed for the cleaning and maintenance of filtration screen and more electric energy and fuel for transport of cheese to the processed cheese plant. It is assumed to sign on one more employees in order to manage the procedure.

5. Results and Discussion

Environmental and economic benefits of the proposed measures of cleaner production can be briefly summarised by the comparison of present and envisaged conditions as it follows below:

present state: whey
production: $1{,}255.10^5$ litres per day
sale for feeding: $1{,}255.10^5$ litres per day

If we count the cost of whey to be 0,10 $CK.l^{-1}$, then the daily sale profit is 12 545 CK, but only in case all the production is sold.

After the filtration is implemented:
whey production $1{,}255.10^5$ litres per day
sale for feeding: $1{,}255.10^5$ litres per day
sale of obtained protein: 210 kg per day
costs of one employee: 500 CK per day
increased energy costs: 1 600 CK per day
increased transport costs 400 CK per day

It is possible to obtain 12 200 CK per day higher income with regard to the above-mentioned information and to the fact that one kilogram of protein costs 70 $CK.kg^{-1}$. In case the dairy operates non-stop 250 days a year, the income is $3{,}05.10^{-6}$ CK. If whey is sent back to the production, the total income will be even higher. If the investment costs are estimated to be $1{,}15.10^6$ CK (purchase of rotary screen filter - 4.10^5 CK; purchase of necessary tanks - $7{,}5.10^5$ CK) with 12,5 % depreciation in machinery, 7 % interest and 39 % profit-tax, the economic benefit can be the following (Chart No 1):

It is clear from Chart No 1, that the cash flow $CF_{(t)} = 1{,}917.10^6$ CK per year after the investment is paid (t = 2).

The investment payback period PP can be counted according to the formula written below, where IN represents investments and $CF_{(t)}$ is cash flow of profits in the year t, when the investments have already been paid:

$$PP = \frac{IN}{CF_{(t)}} = \frac{1150000}{1916562} = 0{,}60 \text{ year}$$

Present worth of investment $PW_{(0)}$ = $1{,}075.10^6$ CK at the interest i = 0,07 and present worth of investment $PW_{(1)} = 1{,}005.10^6$ CK at the time of instalment.

$$PW_{(0)} = \frac{IN}{(1+i)} = \frac{1150000}{(1+0{,}07)} = 1074766 \text{ CK}$$

$$PW_{(1)} = \frac{PW_{(0)}}{(1+i)} = \frac{1074766}{(1+0{,}07)} = 1004455 \text{CK}$$

To the above mentioned economic benefit it is necessary to add also the environmental benefit, which is represented by the reduction of waste waters pollution and which is difficult to be

expressed in numbers. Besides that it is possible to reduce the total amount of waste waters by recycling rinsing and cleaning waters, which have gone to the wastewater treatment plant so far. It is assumed that the total amount of wastewaters would be reduced by 76,65 m^3 per year by implementing these measures.

year of instalment	1	2
revenues [CK]	3 050 000	3 050 000
depreciation in machinery [CK]	143 750	143 750
interest [CK]	80 500	-
profit before taxation [CK]	2 825 750	2 906 250
tax [CK]	1 102 043	1 133 438
profit after taxation [CK]	1 723 707	1 772 812
credit [CK]	1 150 000	-
cash flow [CK]	717 457	1 916 562

I: Profit and its distribution

6. Summary

The elaborated project of cleaner production for the dairy in the small town clearly proved considerable economic and environmental benefits, which arise from the implementation of the project. The measures of cleaner production are based on the filtration of whey through the rotary screen filter. This way casein is removed from whey. Casein is then assumed to be utilised either back in the production, or as a full-value raw material in melting processes during the processed cheese production. It was estimated, that in case of investment amounting to $1{,}15.10^6$ CK (purchase of rotary screen filter for processing the whey and tanks for storing the final liquid filtration product) it is possible to gain total annual profit amounting to almost 2.10^6 CK after the investment has been paid. Payback period is approximately 0,6 year.

At the same time positive environmental benefits will be gained by reducing organic matter in wastewaters. Another potential for the reduction of environmental load is in the implementation of recycling the rinsing and cleaning waters.

Lack of financial resources for investments is a typical problem, which imposes restraints on fast implementation of the results in practice.

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