CLEANER PRODUCTION IN THE POULTRY PROCESSING PLANT

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Souhrn:

V závodě na zpracování jatečné drůbeže byl realizován projekt čistší produkce. Podstata projektu spočívala v náhradě zastaralého systému chlazení vykuchané drůbeže ve vodě. Nová technologie využívá jako chladící médium vzduch. Potřebná teplota vzduchu je dosahována ve čpavkových výměnících. Opatření bylo sice investičně velmi náročné, a představovalo investici $2{,}5.10^7$ Kč, ale umožnilo firmě, aby se udržela na trhu s čerstvou drůbeží. Na základě výsledků hospodaření podniku v současnosti bylo prokázáno, že návratnost investice činí asi 3,2 roku a cash flow výnosů představuje kolem 8.10^7 Kč za rok. Investice bude zisková v devátém roce existence. Realizací zmíněného opatření bylo dosaženo také výrazných environmentálních přínosů, které možno spatřovat zejména v podstatném snížení rizika onemocnění konzumentů čerstvé drůbeže Salmonellou a ve snížení zátěže vod.

Abstract: Project of cleaner production was implemented in the poultry slaughterhouse. The project is based on the substitution of an obsolete water cooling system of drawn poultry for a new technology utilising air as a cooling medium. Required air temperature is reached in ammoniacal exchangers. The measures were costly (investment amounted to $2{,}5.10^7$ CK), but they enabled the company to remain competitive on the market with fresh poultry. It was proved on the basis of present performance of the company, that payback period will be approx. 3,2 year and cash flow of profits will amount almost to 8.10^7 CK after the investment is paid. The investment will be profitable already in ninth year. Considerable environmental benefits were also gained by the implementation of the above-mentioned measure. These benefits can be seen especially in the reduction of Salmonella health risks for the consumers of fresh poultry and in the reduction of burden for waters.

Key words: cleaner production, waste management, waste water, energy, poultry, cooling, company, saving of sources, investment, economic benefit, environmental benefit

1. Description of the Company and Its Production

Ukamo, Ltd. Company, Modrice is a food company, which processes poultry. Capacity of the company is about 6 000 pieces of poultry per hour, out of which 82 % is the chicken broiler. Layers are occasionally processed, too. Besides the operation of slaughterhouse the company has also meat production represented by a portioning plant and a smoked meat production. Breast and thigh muscles are divided on fully automated machines in the portioning plant. Cutlets and other semi-manufactured products, representing a higher level of preparation, are prepared there as well. Smoked meat production includes the processing of meat, fat, offal, auxiliary materials and additives of meat production. With regard to a preliminary input-output analysis the greatest potential of cleaner production was found mainly in slaughterhouse production technology of which is described below [1].

Poultry slaughterhouse line consists of a hanging plant, two slaughtering circuits, a scalding tank, a plucking machine, a drawing line, two cooling circuits, a packing room and a technology for freezing the poultry and poultry products. Equipment for the pre-treatment of wastewaters and trapping the waste is a part of the line as well.

Poultry slaughterhouse line has a good performance and productivity of labour. It is highly mechanised and automated. The main part of the line is a mechanised transport of hanging poultry. Poultry move in cages from vehicles towards the ”infinite” conveyer, where it is hung with heads down. After that it is stunned with electric current in a water stunning room, which is a flume filled with water, where electric current of 80 - 150V is installed. Stunned poultry are slaughtered by the outside cut on the ventral part of throat, where throat arteries and veins are cut. Time of bleeding is about 2 minutes and the length of flume is adjusted to it. Flume traps 50 - 70 % of all blood, which represents 7 - 10 % of live mass in case of poultry. The blood is pumped into the tanks of processing plant and is used for the production of feed.

Feather is removed by steaming in scalding vats. Water temperature and time of steaming are important factors. Warm water causes coagulation of circular muscles in feather pouches and feather is released from the pouches in this way. Steaming water gets to the skin by moving both steamed poultry and also water in flumes. Water runs against feather. Poultry are steamed in the temperature of 60°C for 50 - 120 seconds. Steamed poultry is plucked on special disc plucking machines without being removed from the hanging device. Feather is washed off through self-cleaning racks into a container and is further processed in a decontamination institute. It is necessary to pluck

poultry within 15 minutes after steaming because feather is easy to be removed.

Poultry are drawn at the slaughterhouse. The reason is mainly hygienic. It is possible to eliminate the poultry with the symptoms of disease and to reduce the risk of microbial contamination of meat in this way. Industrial drawing makes it easier for the customer. First cutting-off machine cuts off feet and head and then cloaca is trimmed, skin of abdominal cavity cut into and entrails are taken out. Edible entrails (livers, heart, and maw) are then separated manually from non-edible ones. Non-edible entrails are splashed onto a separator and taken into a container. During drawing poultry is constantly washed by drinking water.

Edible entrails and throats are cleaned and processed individually. After that they are packed for sale or put into the body of cooled poultry. Automatic machine is used for cleaning muscled stomachs. Muscles are separated from internal contents (sand, stones), which are splashed together with bowels into a settling tank.

Drawn poultry have to be cooled to the temperature of 6 - 10 °C in order to stay conserved. Cooling was carried out in continually operating fume equipment with the help of cooled water. Poultry were moved with worm conveyer in tanks. Poultry absorb 0,5 - 3,0 % of water from outside during this type of cooling. Later this water is released, dripped or frozen. Water-cooling is risky due to possible contamination of poultry with Salmonella.

Final processing includes shaping, quality classification and packing. Large amount of processed poultry is being frozen, which enables its long-term storing without changing the quality of fresh meat. Freezing is carried out in the freezing tunnels at the temperature of -40 °C. Product is stored at the temperature of -18 °C.

2. Input - Output Analysis

Real values of material and energetic losses in the production flow were identified through detailed analyses and measurements [2]. Methodology was based on the implementation of operational-economic and methodological-technical procedures. Real data on the flows of materials, consumption and losses of raw materials were collected. Weak points as well as economic and environmental impacts were identified and priorities were determined for further procedure. Analysis of purchase, calculation of expenses and accounting provided principal information on the quantity and values of input materials, supplementary materials and energies. Data on products and disposed wastes were collected in the same way. Complete analysis of losses could not be obtained in the field of waste management. Methodology of partial measurement was used in this case and conversion into the complex assessment was implemented. Methodological-technical analysis identified consumption and losses during particular operational procedures. Applicable input-output analysis created the prerequisites for finding the solution options, or starting points for the determination of more detailed assignments.

After detailed identification of the problems the real costs of waste disposal were clarified, as well as the costs relating to the price of input raw material, power costs, overhead expenses and other economic elements of manufacturing process. Result of the analysis was surprising, economic loss exceeded professional estimate provided by technical staff.

3. Project Objectives

About 25 % of waste are originated in relation to the input raw material during poultry processing. The above mentioned waste makes 95 % of all the waste in the company [3]. High percentage of waste is caused by the anatomy of poultry. Packing material is another significant item, which makes 5 % of costs of material inputs. The amount of waste being originated during the production is estimated to be 20 - 40 % from the used amount of packing material.

Originated wastes increase production costs and have a negative impact on the environment. Most wastes are transported to a rendering plant [3, 4]. Significant level of recycling cannot be expected here. Company has extra costs for disposal, etc. Another problem came out with the waste transport to the collection tanks within the company. The wastes are transported in ”hydraulic way”, where the medium is highly contaminating water. It was decided to deal with this issue with respect to efficiency (ca 25 %), nutritious value and prospects of waste treatment especially for feeding purposes.

There are three types of wastewaters - slaughterhouse waste waters, meat production waste waters and sink waters. Their chemical compositions vary considerably. Slaughterhouse waters, which are also used as medium for the transport of waste, include mainly slaughterhouse water, e.g. water for steaming, plucking, refinement, and drawing of poultry, cooling water and water for the market finish of poultry. The water is polluted by considerable amount of sedimenting substances, floating substances and mainly by blood. Meat production wastewaters contain only a small amount of sedimenting substances, but they have a high volume of emulsified fat and proteins, both dissolved and dispersed. Sink waters are polluted the least in comparison with the above-mentioned wastewaters. Handling harmful substances has a significant impact on the level of pollution. The harmful substances include animal wastes, contents of entrails and maws, salt and oil products.

Energy and water costs represent 4 % of material inputs. Wastewater treatment costs represent over 80 % of resources determined for the waste treatment. Parts of slaughterhouse line, where it is necessary to reduce the inputs, were chosen on the

basis of material and energetic balance. Scalding tank seemed to have the biggest losses. The older type of technological equipment is in operation, where steam at the temperature of ca 110 °C is pressurised by 1 MPa and forced in the preheated water bath. The steam bubbles through the water bath and keep the required temperature, which is 60 °C. The whole equipment is open, the steam escapes and evaporates in the surrounding and it causes energy losses and air pollution.

4. Measurements of Cleaner Production

It was suggested to implement four measures on the basis of input-output analysis. The measures are stated below and prioritised from a) to d):

a) **reduction of losses during the poultry entrails processing** by exchanging the obsolete machine cleaning the maws for a new equipment with the aim to increase efficiency;
b) **reduction of energy demand and water consumption during scalding the poultry** by exchanging the scalding tank for a more modern type with a close circuit and a compressor;
c) **reduction of harmful substances in waste waters** by reconstructing rough pre-treatment of waste waters and implementing vacuum transport of soft wastes, heads and feet;
d) **improvement of the technological flow of production** by introducing the air-cooling of poultry. The measure is based on the purchase of new technology, which will substitute the obsolete water cooling of poultry. The aim of the measure was to reduce Salmonella[a)] health risks for the consumers of fresh poultry and to remain competitive on the market with fresh poultry.

The change of cooling technology is the most costly out of all the suggested measures. That is why it was originally assumed, that this measure will be solved as the last one and that the company will gain necessary financial resources for the purchase of technology by implementing the previous, less costly measures. However, legal amendments made the implementation of this measure number one priority, if the company wanted to remain on the market with fresh poultry.

5. Benefits Achieved

At present a cooling tunnel is installed in the company and the cooling of drawn poultry is carried out in a counter flow by the air cooled in exchangers with ammonia. High investment costs amounting to $2{,}5.10^7$ CK were caused by necessary technological changes in other parts of line. Results of preliminary analyses showed, that annual production income should be about 8.10^6 CK. Director of the company stated without providing more detailed information that annual income amounts even to $1{,}06.10^7$ CK.

Chart No 1 demonstrates company's profit and its distribution after the implementation of the investment. The assumption is that machinery depreciation from the investment costs are 6,2 % in the first year and 13,4 % in the following years. Profit tax is calculated to be 39 % and interest on the Phare funds is 7 %. Construction depreciations are calculated to be 1 % of the investment costs.

It results from Chart No 1 that cash flow after the payment of investment $CF_{(t)} = 7{,}87.10^6$ CK per year (t = 6).

year of instalment	1	2	3	4	5	6
revenues	10 600	10 600	10 600	10 600	10 600	10 600
machinery depreciation	1 550	3 350	3 350	3 350	3 350	3 350
construction depreciation	250	250	250	250	250	250
interest	1 750	1 400	1 050	700	350	-
gross profit	7 050	5 600	5 950	6 300	6 650	7 000
profit tax	2 749,5	2 184	2 320	2 457	2 593	2 730
tax after taxation	4300,5	3 416	3 629,5	3 843	4 056,5	4 270
machinery depreciation	1 550	3 350	3 350	3 350	3 350	3 350
construction depreciation	250	250	250	250	250	250
payment of credit	5 000	5 000	5 000	5 000	5 000	-
cash flow	1 100,5	2 016	2 229,5	2 443	2 656,5	7 870

Chart No 1 Creation and distribution of profit (all the values are in thousands of CK)

Payback period PP can be calculated according to the formula written below, where IN represents the amount of investments and $CF_{(t)}$ is the cash flow of profits in the year, in which the investments are paid.

$$PP = \frac{IN}{CF_{(t)}} = \frac{25000000}{7870000} = 3{,}18 \text{ year}$$

Present worth of investment $PW_{(t)}$ in the year t on the credit i = 0,07 and assumed payments by instalment of 5.10^6 CK per year is $PW_{(5)} = 1{,}67.10^7$ CK at the time the investment is paid.

$$PW_{(t)} = \frac{IN}{(1+i)^{t+1}} = \frac{25000000}{(1+0{,}07)^{5+1}} = 16658556 \text{ CK}$$

It is possible to found out that the investment is profitable in the 9th year of operation by the amount of $8{,}61.10^5$ CK. Method of present

a) In accordance with the definition of cleaner production the reduction of infectious diseases transfer risks minimises also the environmental impacts.

value of net benefits was used at the internal discount rate $K_i = 0{,}08$ for the calculation. The calculation was done according to the formula written below, where $PNVB_{(t)}$ is a cumulated present value of net benefits in the year t at the internal discount rate K_i, $PVCF_{(t)}$ is a cumulated present value of cash flow in the year t at the internal discount rate K_i, $CF_{(t)}$ represents cash flow from the investment in the year t, and IN is the amount of investment.

$$PVCF_{(t)} = \sum_{t=1}^{n} \frac{CF_{(t)}}{(1+K_i)^t} \qquad PVNB_{(t)} = PVCF_{(t)} - IN$$

The amount of cumulated present value of net benefits $PVNB_{(t)}$ for the individual years of investment, accompanied with other necessary data, is clear from the Chart No 2.

They are represented by the significant reduction of Salmonella health risks for the consumers of fresh poultry as well as the reduction of waste waters pollution by organic matter. Further potential for the reduction of the environmental load is seen in the exchange of the obsolete maws cleaning machine for new equipment with the aim to achieve higher efficiency.

year	investment costs [CK]	profits [CK]	$(1 + K_i)^t$	present value of $CF_{(t)}$ [CK]	cumulated present value of net benefits [CK]
0	25 000 000	-	1,000	- 25 000 000	- 25 000 000
1	-	1 100 500	1,080	1 018 981	- 23 981 019
2	-	2 016 000	1,166	1 728 395	- 22 252 624
3	-	2 229 500	1,260	1 769 849	- 20 482 775
4	-	2 443 000	1,360	1 795 678	- 18 687 097
5	-	2 656 500	1,469	1 807 969	- 16 879 128
6	-	7 870 000	1,587	4 959 435	- 11 919 693
7	-	7 870 000	1,714	4 592 069	- 7 327 624
8	-	7 870 000	1,851	4 251 916	- 3 075 708
9	-	7 870 000	1,999	3 936 959	861 251

Chart No 2 Cumulated present value of net benefits for the individual years of investment

It should also be mentioned that the implementation of the above mentioned technology had a positive impact on the reduction of wastewaters pollution and increase of occupational hygiene in the manufacturing process.

6. Conclusion

The applicability of cleaner production methodology in food industry was clearly proved on the example of poultry processing plant. Weak points in the production were identified on the basis of input-output analysis and the measures of cleaner production were proposed and prioritised.

As the company wanted to remain competitive on the market with fresh poultry the most costly measure was prioritised. The obsolete system of counter flow water cooling of drawn poultry was substituted for the air cooling system. The change of technology required investment costs amounting to $2{,}5.10^7$ CK. Based on the company performance the payback period of the investment was assessed to be ca 3,2 year and the company annual profit is almost 8.10^6 CK after the investment is paid. Under these conditions and at the internal discount rate of 8 % the investment will be profitable in its ninth year.

The environmental benefits were also achieved by the implementation of the measures.

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