The 10th International Conference of the Greeting of Industry Network
in Göteborg, Sweden on June 23-26, 2002.

# Pollution Prevention of the Agro-Industry in the Northeast of Thailand

Wanpen Wirojanagud *
*Environmental Engineering Department, Faculty of Engineering,Khon Kaen University,*

**Abstract**

Pollution prevention was studied under cleaner technology on eight agro-industrial mills, namely seeds production, rice, bottled drink, animal feedstock, tomato paste, tapioca and two dairy mills in the Northeast of Thailand, with an aim of gaining maximum productivity and minimum wastes. This research covers a study of inputs, production process, and outputs, including storage and handling. Moreover, measures with economic evaluation are proposed to minimize losses and environmental problems. Environmental aspects of energy loss are over-consumption of electricity in the seeds production process, and inefficient heat exchange of pipe in the tomato juice production process. Water loss occurs in the homogenize units of the dairy mills, and the cassava-washing process. Loss of raw material, inappropriate use of equipment, and dust problem are found in the storage of the tomato juice mill, tapioca-separation unit of the tapioca mill, feedstock-handling of the dairy mills. And, finally, the problem of noise occurs from a normal equipment operation in the tapioca and rice mills. The proposed measures include reuse of the cooling after from the packaging unit at the homogenize unit with a capital investment of only US$ 5 for a return of US$ 42 per month in the dairy mills, reuse of water from the tapioca-separation unit at the cassava-washing unit with a capital investment of US$ 4,000 for a return of US$ 11,730 US$ per month. As an example of low-hanging fruit measures, a reduction of equipments in the tapioca production process can save an energy expense by US$ 3,490 per month with no investment cost.

## 1. Introduction

Industrial development is one of the major factors of economic growth. Currently, there are a total of 125,000 factories in Thailand. Of this figure, about 44,500 factories are located in the northeast region. Approximately, 80 % of the total factories are small and medium enterprises (SMEs). SMEs play an important role to the economic status of the country as they generate about 50% of the Gross Domestic Product and stand for about 35% of Thailand's export. While SMEs are important to economic growth, they also generate environmental pollution. When compared to large industries, small and medium industries might not generate a high quantity of wastes, but a higher rate of waste quantity per unit of product. This is due to the limits of environmental management and technology and capital and operation cost of treatment as well as information updating and network. The Ninth National Socio-Economic Development Plan (2002–2006) underscores the need to upgrade Thailand's international competitiveness, and one of the strategies to achieve this is to increase productivity through more effective use of natural resources and through better environmental management and application of appropriate technologies.

Cleaner Technology (CT) or Green Productivity (GP) is the paradigm of sustainable concept by developing a manufacturing production coupled with environmental protection as well as socio-economic consideration. CT uses both technology and management to maximize product while minimize waste generation, leading to lower cost of production.

Currently, the Government sector and the Non-Government Organizations put their efforts to intensively promote CT or GP to industries to make them shift from the end of pipe treatment towards pollution prevention and waste minimization.

The project on pollution prevention of agro-industry in the northeast of Thailand was conducted by Khon Kaen University under the support of Thailand Research Fund in 1998–2000.

## 2. Objectives

The main objective is to assess the use of CT implemented in industry, of which the specific objectives are:

a) To minimize wastes generation and/or prevent pollution
b) To compare the outcome before and after using CT
c) To comply with the ISO 14000

## 3. Study Methodology

* Associate Dean for Research. Tel./fax: +66-43-239163.
*E-mail address: wanpen@kku.ac.th*

This research is an industry-university collaboration project, which consists of 4 main steps: preparation, problem analysis with recommendation of improvement measures, implementation and evaluation, and finally information-dissemination.

The research started with organizing of a research team composed of KKU faculty members from various fields and government representatives from Industrial Promotion Office Region 5. The collaborating industrial was selected from four groups of industries: i) seeds; ii) vegetable and fruit; iii) tapioca and animal feed; and iv) dairy. Altogether, eight factories were studied. A seminar was organized to teach the fundamentals of CT to owners of the selected factories, followed by a visit to each factory to make an initial assessment of the existing problems, production processes, the use of resources in production, and environmental pollution in order to prepare the detailed assessment for each factory.

In the problem-analysis step, information on the production process, production capacity, use of raw materials and energy in production, waste generation and others were collected. The collected and measured data were analyzed to identify problems and their causes, as well as to prepare the mass-balance calculations.

The problem analysis was followed by a detailed study of the possibilities for improvements in each factory.

This included an assessment of the economic implications of the proposed measures, and the results were presented at a meeting between the research team and the factory owners.

Based on the researchers' list and assessment of alternatives, the factory owners were able to select the measures that they found could best be implemented in practice.

During implementation, follow-up evaluation was performed to monitor the progress. The situation before and after the implementation was compared, and the success of the use of CT was evaluated.

In the final step of information dissemination, a seminar was organized for owners of factories, academics, and involved government officers to elaborate on the use of CT in terms of pollution prevention and economic benefit.

## 4. Study Result

Eight factories participated in the research. The results of the tomato paste factory will be given a more detailed presentation while the other factories will only be presented in terms of overall results. The production capacities of 8 factories are listed in Table 1.

**Table 1** List of Study Factories

| Industry | Production Capacity | Production |
|---|---|---|
| Animal Feedstock | 20,400 tons/year | Cow feedstock |
| Tomato Paste | 1,000 tons/year | Canned tomato paste |
| Tapioca | 100,000 tons/year | Tapioca starch |
| Dairy Mill 1 | 3,600 tons/year | Pasteurized milk |
| Dairy Mill 2 | 2,625 tons/year | Pasteurized milk |
| Bottled Soft Drink | 430 tons/year | Bottled vegetable jelly drink |
| Seeds Production | 6,500 tons/year | Corn seeds |
| Rice Mill | 55,000 tons/year | Packaging rice |

### 4.1 Cleaner Technology for the Tomato Paste Factory

- Tomato paste production process

The process of tomato paste production as shown in Figure 1 can be described as follows;

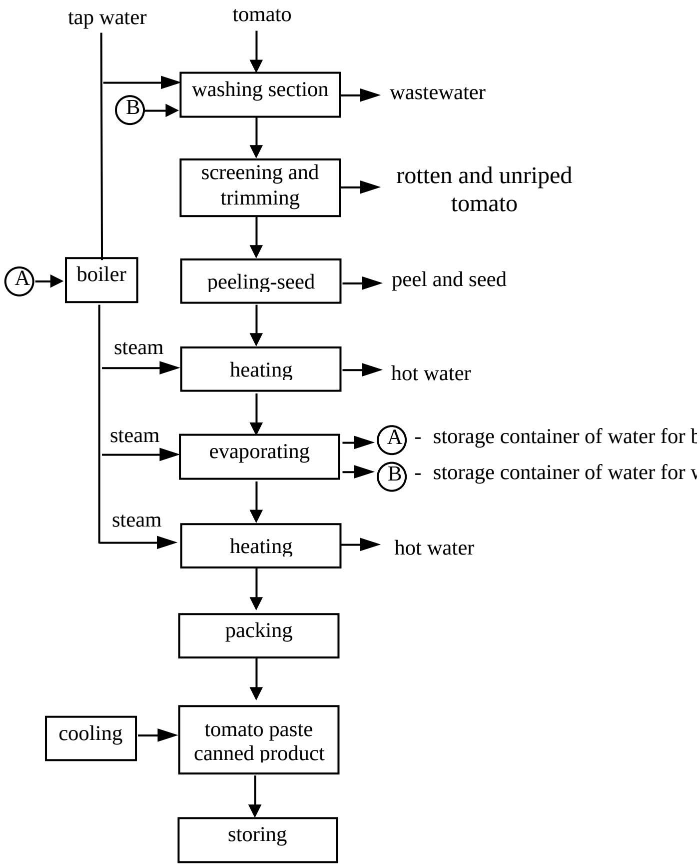

**Figure 1** Tomato Paste Production Process

Tomatoes are conveyed to a washing section to wash off soil and dirt. The tomatoes are then screened and trimmed to separate unqualified parts. The qualified material is crushed, simultaneously seed and fruit peel are separated out. The crushed tomato material is moved to a pre-heater section with a moderate heat in order to prohibit growth of microorganism. Then it goes to the evaporating unit where a great amount of heat evaporates water till the product reaches the required concentration. A certain amount of energy is supplied to sterilize packed products. A cooling system is needed to cool the canned-product before storing.

· Aspects and CT alternatives

Based on a mass balance of the whole process especially utility usage, the environmental and production process related problems were identified for each step in the production process. Energy and raw material were found to be the main concerns rather than water usage. Aspects and CT alternatives are as follows.

1) Raw material storage: Tomato, originally, was placed on a field open to the sunlight (approximately 40$^{o}$C). It was recorded that about 15% of the tomatoes were spoiled because of sun heat. In order to retard ripening of tomatoes, a lower temperature is required. One CT alternative is to install a roof (plastic net or cement tile). This will reduce tomato loss caused by over-ripening by 3% with a small investment cost.

2) Reuse of condensed water: Approximately, more than 5 $m^3$ per day of condensed water was discharged to a wastewater drain. The quality of the condensed water was checked and it was found that it was still in an acceptable quality. CT alternative comprises construction of a collection tank and pump to store water for the boiler. This option saves energy to the boiler, and also reduces wastewater.

3) Installation of insulator over doubles-effect evaporator unit is also one of the CT proposal. This would lower energy usage more than 10%.

Other aspects and CT alternatives are presented in Table 2.

It was found that energy usage could be reduced by 20-30%. In addition, the loss of raw material (tomatoes) before the processing can be reduced from 10% to 7%. In terms of occupational health and safety of workers, using a personnel noise protection equipment i.e. ear plug or earmuff can reduce noise to meet the designated standards.

## 4.2 Overall Results of Study Factories

The overall results from the research of the 8 factories are presented in terms of problems, causes, CT measures together with economic evaluation as shown in Table 3. The investigated aspects were generally found as loss of energy, material and water, respectively. Five factories encountered problems with energy loss, these were seed, tomato paste, tapioca, animal feed, and dairy factories. While only 3 factories, tomato paste, tapioca and milk factories indicated problems with water loss. Four factories tomato, bottled drink, animal feed and milk had problems with raw material loss. In terms of pollution problem, seed and animal feed factories had air pollution as dust dispersion problem. Causes of loss of any inputs (energy, raw materials, water) are different according to the type of production process and utilities. For example at the seed factory, energy loss was due to over capacity of energy supplying transformer than the required energy use. The measure is simple one by stop using one transformer and transfer the main electricity cycle to another transformer with the investment cost of 110 US$, that would make profit of 28 US$ per month with the rate of return or pay back period of 3.6 months and benefit cost ratio of 21.6. Loss of condensed water from heater was the cause of energy loss at the tomato factory. Recycling of the condensed steam to use at the boiler with the investment cost of 1,520 US$ would earn benefit 190 US$/month with the pay back period of 8 months and B/C of 1.23.

As for water loss, the obvious case was indicated at the tapioca factory as shown log using tap water for cassava washing. Recycling of the used water from the separation process for washing with the investment cost of 4,000 US$ would make a benefit of 11,730 US$/month with the pay back period of 11 days and B/C ratio of 37.4.

Loss of raw material found at the animal feed mill was due to unclosed storage room that birds can enter to eat seeds. An investment of 180 US$ to install a cover net would make a profit of 8 US$/month with a payback period of 21 months and B/C ratio of 4.45. Loss of material in terms of product found at the dairy mill and the bottled drink mill was due to using a low-grade (too thin) packaging material, causing failure of packaging leading to waste generation and loss of product. An investment cost of 270 US$ would make a profit of 450 US$/month with the pay back period of 23 months and B/C ratio of 2.84.

Pollution problems in terms of air pollution due to dust dispersion occurred as the result of ineffective performance of cyclone at the seed factory and too small of raw material dropping site at animal feed factory. The investment cost of air pollution mitigation measures are 222 US$ for increasing cyclone efficiency and 444 US$ for the modification of dropping site. This might not make a direct economic profit, but benefits in terms of environmental and health protection.

**Table 2**

**Table 3**

**Table 3 (cont.)**

## 5. Conclusion

CT alternatives proposed to industry could be divided into 3 categories, no-investment cost, low-medium, and high investment cost. Obviously, the factories would prefer to implement the no-investment cost alternatives, followed by the practical either low or medium ones. For the high investment cost, they have to be carefully considered. However, the outcomes of the implemented CT alternatives in terms of economic benefit would convince them for further investments in CT alternatives. CT would therefore be beneficial not only in terms of economy, but also in terms of environmental health.

CT is the analytical tool for determining appropriate measures to maximize productivity and minimize waste generation. It is likely a technological measure to solve the problems of environmental pollution, prevent pollution and guide for continual improvement. The CT approach can lead towards environmental performance evaluation (ISO 14030) and environmental management systems (ISO 14001).

The research also shows that relative simple but systematic analysis can lead to substantial environmental improvements and more efficient use of resources, all through application of well known low technology at low investment cost, which actually over a short period of time generates profit for the factories.

This is an important lesson not only for the industrial sector, but certainly also for the higher education system in order to prepare all relevant engineers and scientists for the challenge.

## 5. Acknowledgement

The author wishes to thank the Thailand Research Fund for financial and academic support to the research project. All successes are given to the research team of the Industry-University Collaboration Research Project on Green Productivity of Agro-Industry in Northeast, Thailand. Without our productive work, this project could not have been completed.

## 6. References

David T. Allen, Kirsten Sinclair Rosselot, "Pollution Prevention for Chemical Process", John Wiky & Sons, inc., 1997.

John C. Mycock, John D. McKenna, Louis Theodore, "Handbook of Air Pollution Control Engineering and Technology.

Louis Theodore, Young C. McGuinn, "Pollution Prevention", Van Nostrand Reinhold, 1992.

Paul L. Bishop, "Pollution Prevention: Fundamentals and Practice", McGraw-Hill, 2000.

Final Report of Waste Minimization of Agro-Industry in Northeast Thailand, submitted Thailand Research Fund, Khon Kaen University, December 2001.

**Table 2** Aspects and CT Alternatives of Tomato Paste Production

| Process unit | Aspects | CT alternatives | Potential benefits | Economic analysis |
|---|---|---|---|---|
| 1) raw material at receiving section | loss of raw material | install a plastic net roof | reduce over ripening of tomatoes from 10% to 7% | Investment cost 430.0 US$<br>Payback period 6.0 days<br>Profit 1,876.0 US$/mo.<br>B/C 61.2 |
| 2) washing unit | overflow of water from a storage container that use for washing | install a floating ball and adjust valve to control the water level | reduce water use and wastewater | Investment cost 8.0 US$<br>Payback period 1.0 days<br>Profit 22.0 US$/mo.<br>B/C 101.5 |
| 3) evaporator unit | energy utilization | install an 1-in insulator of the steam pipe | reduce consumption of fuel oil with 20-30% | Investment cost 23.0 US$<br>Payback period 16.6 months<br>Profit 1.4 US$/mo.<br>B/C 1.68 |
| 4) others | loss of condensed water from heat exchanger | construct a tank and pump for collection of condensed water to use for the boiler | - reduce water use of 800 $m^3$/production season<br>- reduce fuel oil 5,243 liters/production season or 216,700 MJ/production season | Investment cost 1,520.0 US$<br>Payback period 8.0 months<br>Profit 190.0 US$/mo.<br>B/C 1.23 |

**Table 3** Identification of Aspects and Proposed CT Measures with Economic Analysis

| Aspect/Factory | Problem | Cause | CT measures | Economic Analysis | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Investment Cost (US $)** | **Profit (US $/month)** | **ROR** | **B/C** |
| **1. Raw materials** | | | | | | | |
| Tomato paste | loss of tomato | - storing tomato in an open area cause tomatoes spoiled due to sun heat | - install a roof over the tomato storing area | 430 | 1,880 | 6 days | 61.30 |
| | | - spill of tomato from crushing unit | - using cover for crushing unit | 12 | 20 | 17 days | 42.00 |
| Bottled drink | loss of aluminum foil lid | too thin of aluminum foil | use a thicker foil | - | 16 | - | - |
| Animal feed | loss of raw material | birds enter to the storage area to eat seeds | install a net to prevent birds from entering | 180 | 8 | 21 month | 4.45 |
| Dairy | loss of packing film at packing unit | too thin of packing film | use a thicker film | 270 | 450 | 23 months | 2.84 |
| **2. Water use** | | | | | | | |
| Tomato paste | water loss | - too long hose from the tap and no nozzle use for washing | - using a nozzles hose | 5 | 4 | 33 days | 81.50 |
| | | - overflow of water from a storage tank that use for washing | - install a floating ball and adjust valve to control water level | 8 | 22 | 11 days | 101.50 |
| | | - loss of cooling water | - recycle cooling water | 10 | 15 | 22 days | 121.90 |
| Tapioca | loss of water at cassava washing unit | using tap water for washing | recycle used water for cassava washing | 4,000 | 11,730 | 11 days | 37.40 |
| Dairy | loss of cooling water at packing unit and at homogenizes | no recycle cooling water | - recycle cooling water from packing unit to use for homogenizes<br>- collect and store cooling water for washing | 5 | 42 | 4 days | 441.00 |

**Table 3 (Cont.)** Identification of Aspects and Proposed CT Measures with Economic Analysis

| Aspect/Factory | Problem | Cause | CT measures | Economic Analysis | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Investment Cost (US $)** | **Profit (US $/month)** | **ROR** | **B/C** |
| **3) Energy** | | | | | | | |
| Seed | energy loss at transformer | energy required was lower than the capacity of transformer | stop using one transformer and transfer the main electricity cycle to the transformer 500 KVA | 110 | 28 | 3.6 months | 21.60 |
| Tomato paste | loss of condensed water from heater | no recycle heat | recycle condensed steam to use at the boiler | 1520 | 190 | 8 months | 1.23 |
| Tapioca | energy loss in separator unit | over use of separators | reduce number of separators | - | 3,490 | - | - |
| Animal feed | diesel lost for transporting material | mineral store and mixing unit are located apart | moving a mineral store to the mixing unit area | 670 | 215 | 3.13 months | 2.24 |
| Dairy | Electricity energy loss at the ice conveyor | slope of ice conveyor was inappropriate | adjust the slope of the ice conveyor | 45 | 3 | 16.8 months | 3.40 |
| **4) Air pollution** | | | | | | | |
| Seed | fly ash emission from stack | ineffective cyclone | install a fan in gas collecting duct before entering to the cyclone to increase efficiency of cyclone | 222 | - | - | - |
| Animal feed | dust dispersion during raw material dumping and transferring | inappropriate design of raw material dropping | adjust the dropping size to accommodate the amount of raw material | 444 | - | - | - |

**Note:** ROR = Rate of return (or Pay back period)
B/C = Benefit–Cost ratio