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EPP Environmental Pollution Prevention Project

CASE STUDY

Pollution Prevention Assessment for a Starch and Glucose Manufacturer

Executive Summary

A pollution prevention assessment was conducted at a glucose production facility. The objectives of this assessment were to: 1) identify pollution prevention options that would reduce the quantity of raw materials, toxics, energy, and water used in the manufacturing process; 2) demonstrate the environmental and economic value of a focused pollution prevention assessment; 3) improve manufacturing competitiveness and product quality; and 4) provide the foundation for a sustainable pollution prevention program at the facility. The assessment team was comprised of experts from the US, the local EP3 office, and local implementing agencies.

This pollution assessment identified 11 pollution prevention options that will help reduce water consumption; reduce on-site use of heavy fuel oil; reduce contaminant loading in the waste water; and reduce energy consumption at this facility. The largest savings will come from options that focus on improving the handling and separation of the raw material feed. The total yearly savings from implementation of these measures is US$934,500 with a first year cost of US$953,600.

In addition to addressing immediate problems, the assessment also produced a recommendation that considers a long-term problem. At the present time, the facility does not need to treat the water that it discharges. However, if treatment were necessary, current water use practice would require US$151,500-US$272,700 to build a treatment facility. Furthermore, it was also calculated that the annual cost of chemicals that would be used in the treatment would equal to US$12,120.

Facility Background

The facility processes approximately 210 tons of No. 2 grade maize per day and produces corn starch, glucose, animal feed, gluten, and oil from maize. The annual starch production is 41,561 tons per year; 75% glucose concentrate, 25% white starch powder. The plant employs 570 workers and operates three, 8-hour shifts, 345 days a year.

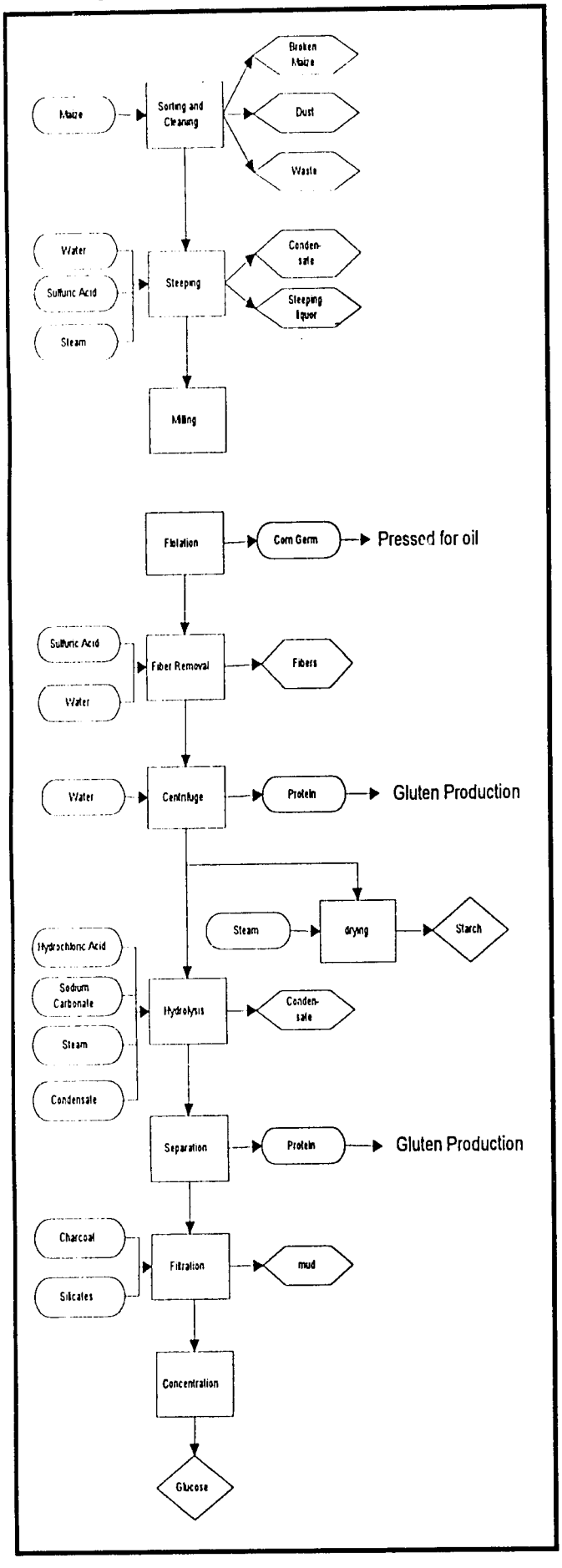
Process Description

This assessment focused on the starch and glucose production processes at this facility. There are three unit operations: 1) raw material handling; 2) starch production; and 3) glucose production. **Figure 1** gives an overview of these operations.

Raw Material Handling: Maize arrives by truck and is manually transferred to a hopper that feeds to a conveyor which moves the maize to storage silos. Small broken bits and powder residue from the maize are separated from the whole grains at this stage.

Starch Production: The maize is first cleaned and washed and then placed into vats filled with a heated sulfurous acid solution to soften the kernels; this steeping lasts for 50-70 hours. Next, the kernels are drained and passed through a coarse mill and then a fine mill. After milling, the germ is removed from the starch bearing milk using a flotation method of separation. The germ is dried and processed for oil. The milk is further processed to remove fibers, protein, and fat.

Figure I: Overview of Facility's Printing Process



Glucose Production: Starch milk is mixed with hydrochloric acid, centrifuged, and washed with condensate to remove protein. The resulting solution is further acidified, heated, and put under pressure to complete the conversion to glucose. The glucose solution is then neutralized to a pH of 7 with sodium carbonate and filtered using a two-step carbon filtration system for decolorization. Finally, it is evaporated to a concentration of 80%-84%.

Environmental Issues

Environmental problems at the plant include respiratory hazards from worker exposure to fine corn dust; high biological oxygen demand (BOD) loading in effluent water; generation of waste water; generation of solid waste; and emissions due to high fuel consumption.

Pollution Prevention Options

Eleven pollution prevention options were identified in this assessment that address the problems discussed above. **Table 1** lists the recommendations and presents the environmental benefits and first year costs for each.

Raw Material Handling

Install automated unloading system: Using the appropriate dump trucks can reduce unloading time from two hours to ten minutes, increasing worker and time efficiency. The cost of an unloading dock is US$15,150. While the financial benefit is not quantifiable, the reduction in worker exposure to corn dust improves worker safety and health.

Install a three-level, two-stage screening system: The present system allows dust, small chunks of corn and plant debris to be mixed in with the pre-process corn. The new screening system will result in better and more uniform raw material and reduce water and energy consumption. The cost of the system is US$75,800; the annual financial benefit is US$336,400.

Starch Production

Add a second-stage separation unit in the corn-germ flotation process: Using a second stage separator can increase the amount of germ extracted from 5% (current) to 6%. Reducing the amount of germ (protein) in

Table I: Summary of Recommended Pollution Prevention Opportuntities

Operation	Pollution Prevention Option	Environmental and Health Benefits	First Year Cost (US$)	Annual Financial Benefits US$	Payback Period
Material Handling	Install automated unloading system	Improved worker health and safety	US$15,150	US$0	N/A
Material Handling	Install 3-level, 2-stage screening	Reduction in water and fuel consumption; more uniform and higher quality feedstock	US$75,800	US$336,400	3 months
Starch Production	Add 3rd stage separation unit in flotation process	Reduction in fuel consumption and solid waste generation; reduction in BOD load in effluent	US$121,200	US$181,800	8 months
Starch Production	Install automated control system for centrifuge	Reduction in fuel consumption and solid waste generation; reduction in BOD load in effluent	US$41,200	US$28,200	1.5 years
Starch Production	Install temperature measurement and control devices	Reduction in fuel consumption and solid waste	US$247,300	US$90,900	2.7 years
Glucose Production	Use granular carbon for de-colorization	Reduction in solid waste generated	US$212,100	US$121,200	21 months
Glucose Production	Install protein monitor that controls pH	Reduction in energy consumption; solid waste generation, and BOD loading in effluent.	US$15,150	US$3,000	5 years
Maintenance	Repair steam leaks, install isolation valves	Reduction in fuel consumption; reduction in emissions	US$30,300	US$90,900	4 months
Maintenance	Replace steam traps, recycle condensate	Reduction in fuel consumption; reduction in emissions	US$43,900	US$62,700	9 months
Maintenance	Replace mechanical seals	Reduction in waste water generated	US$121,200	US$18,200	6.5 years
Maintenance	Install high efficiency motors	Reduction in fuel consumption	US$30,300	US$1,200	25 years
TOTAL			**US$953,600**	**US$934,500**	

the starch improves the shelf-life of the starch, thus making it more suitable for export. In addition, decreasing the amount of protein in the starch at this stage results in a reduction of energy and chemicals required and solid wastes generated in the final filtration and separation steps. The cost of implementing this option is US$121,200; the annual financial benefit is US$181,800 per year.

Install automated control system for the centrifuge system: The current system is manually controlled. Automating the process controls will prevent product spills, that while reclaimable, adds to the production cost because it must be reprocessed. In addition, automation will minimize the need to de-colorize the glucose in a subsequent stage. Implementing this option reduces energy consumption, solid waste generation and BOD

loading in effluent. Purchasing a control system will cost US$41,200; annual savings will be US$28,200 per year.

Glucose Production

Install temperature measurement and control devices: Maintaining the temperature at an appropriate level during steeping increases crude starch production by 1%. The environmental benefit is a reduction in energy consumption and solid waste generation. The cost of a temperature monitoring and control system is US$247,300; the annual financial benefit is US$90,900.

Use only granular carbon for de-colorizing and filtration: Using and recycling granular charcoal in the filtration and de-colorizing steps can save approximately 80% of cost of powder charcoal and reduces the amount of solid waste generated. To implement this option, a vacuum pump has to be installed with a cost of US$212,100 (including energy cost); the annual savings are US$121,200.

Plant Maintenance

Install protein monitor that controls pH: The pH of every batch of raw material should be monitored to improve the separation of protein and glucose. Implementing this pollution prevention option results in a reduction in energy consumption, solid waste generation, and BOD loading in the effluent. The cost of implementation is US$15,150; the annual savings are US$3,000.

Fix steam leaks and install isolation valves: Repairing steam leaks at this plant would cost US$30,300, and yield a yearly savings of US$90,900 for fuel. Installing isolation valves would allow technicians to perform maintenance without shutting the system down completely. Implementing these options would result in a reduction of emissions from on-site fuel combustion.

Replace steam traps and recycle condensate: Re-using condensate eliminates the need to heat "fresh" de-ionized water for the boiler, and eliminates the need to burn 1,000 tons of fuel. In addition, process chemicals that would be lost with the effluent are retained, resulting in a savings of US$18,800. The cost of implementing this option is US$43,900; the yearly savings is US$62,700.

Replace mechanical seals: Water loss at the plant is 350 m^3/day. Installing seals would prevent water loss from leaking seals which is equivalent to a savings of at least US$181,800 per year. Implementing this option is a proactive measure that would reduce the cost of constructing a water treatment plant in the future. The cost of such a plant would be US$151,500-US$272,700. In addition, the annual cost of chemicals needed for water treatment is calculated at US$12,120.

Install high efficiency motors: Converting to high efficiency motors can save 7% in electricity consumption. The cost of installing 10 motors is US$30,300; the annual savings is US$1,200 per year.

Conclusion

Implementing the pollution prevention options will benefit this plant in several different ways. Resource use and therefore cost is reduced, increasing the efficiency at the plant. Furthermore, these pollution prevention measures actually improve product quality at this plant.

Over the long term, the pollution prevention options could also reduce capital and operating costs. Currently, there are no requirements to build a waste water treatment system at the plant. If installation does become necessary, implementing the recommendations could, conservatively, reduce future investment by 10%.

For Further Information

For futher information on this assessment or other activities sponsored by EP3, call the EP3 Clearinghouse at (703) 351-4004, send a fax to (703) 351-6166, or on Internet: ep3clear@habaco.com