Life Cycle Assessment of a Solid-Liquid Separating Unit

- Estimation of the CO_2 emission for an Inclined Solid-Liquid Separating Unit -

Yuki Sakamoto

Department of Environmental Education, Nara Bunka Women's College, 127, Higashinaka, Yamatotakada, Nara, 635-8530, Japan

SUMMARY

The emission factor of CO_2 ($EFCO_2$) of an inclined Solid-Liquid separating unit is estimated by a process analysis as one of life cycle assessment (LCA). The total $EFCO_2$ accounts for 248.1 kg-CO_2/product. The $EFCO_2$ from of stainless steel as raw materials is the largest, follows by those from electricity as energy and non-stainless steel as raw materials. In percentage, these are 76.8, 21.2 and 2.0 % of the total $EFCO_2$, respectively.

KEY WORDS: solid-liquid separating unit; emission factor of CO_2; life cycle assessment

1. INTRODUCTION

Recently, the wastes and/or environmental loads from various industries has been recognized as a worldwide problem. The Solid-Liquid Separating (SLS) unit is necessary on various industries as one of environmental protection systems, and utilize for not only wastewater treatments but also production processes (e.g. concentration, recovery, cleaning, etc.). However, to date, reports on the wastes and environmental loads with regard to environmental protection systems have few.

In this report, in order to measure the environmental loads (e.g. CO_2; well known as one of the representative greenhouse gases (GHGs)) for an inclined SLS unit as one of environmental protection systems, the CO_2 emissions and the emission factors of CO_2 (EF CO_2s) of an inclined SLS unit as SS (Suspended Solid) removal unit for wastewater treatment systems were estimated by a process analysis as one of LCA.

2. UNIT DESCRIPTION

2.1 Functional Principle and Operational Illustration

Figure 1 and Figure 2 show the functional principle, and the operational illustration of the inclined SLS unit.

Regarding functional principle and unit operation, “Half - Cutting Principle” works in the operation of the screen. Particles (foreign elements) whose size is larger than a half of the slit width are collected on the screen, and particles whose size is smaller than the half size fall through below the screen together with water. The reduced possibility of clogging because of wedge–profile slots, and the flat screen surface insure that the collected particles slide down the screen smoothly.

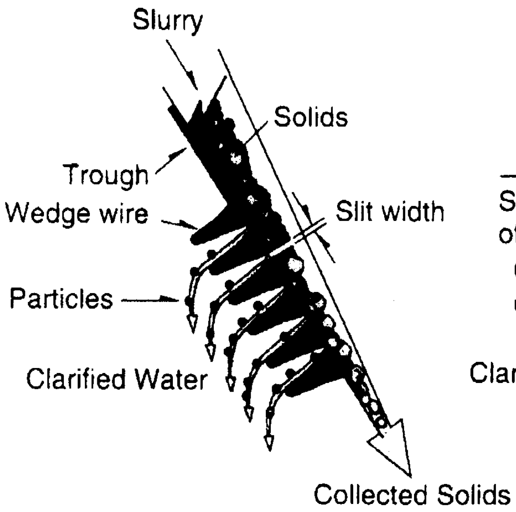

Figure 1. Functional principle

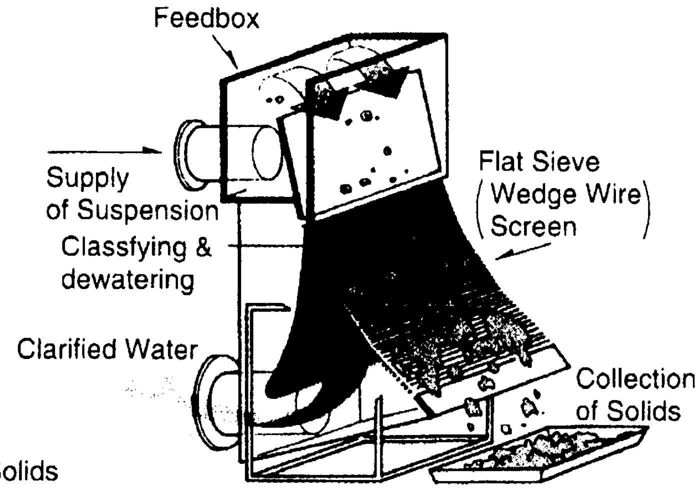

Figure 2. Operational illustration

2.2 Dimensional Drawing and Processing Capacity

Figure 3 shows the dimensional drawing of this inclined SLS unit as one of the representative unit (standard type) and Table 1 shows the processing capacity of this inclined SLS unit.

This SLS unit has the following characteristics:

- Simple structure
- Low price is made possible by lot production

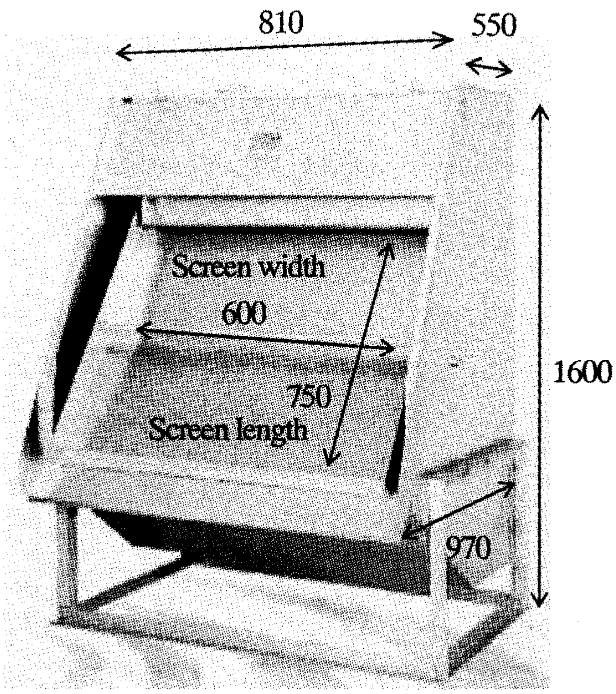

Figure 3. Dimensional drawing (standard type)

Table 1. Processing capacity (standard type)

Kinds of Waste Water	Applied Slit Width (mm)	Capacity* (m^3/H)
Paper pulp recovery out of papermaking process water	0.15 0.2 0.3	15 ~ 20
Dyeing process and laundry waste water	0.5 0.75	25 ~ 35
Fruits processing waste water	0.5 0.75 1.0	25 ~ 40
Waste water after processing leavings of school meals	0.5 0.75 1.0	25 ~ 40
Bean curd waste water	0.4 0.5 0.75	25 ~ 40
Fish processing waste water	0.75 1.0 1.5	25 ~ 40
Community plant waste water	1.0 1.5 2.0	30 ~ 40
Sewage treatment plant's raw sewage water	1.0 1.5	30 ~ 40
River water	0.75 1.0 1.5	50 ~ 65

*The capacity differs depending upon various factors such as kind of solids, concentration, existence of oily substance, etc.

· Wide capacity: 5-200 m^3/H

* Screen width: 300-3000 mm

* Screen length: 750-900 mm

*Slit width: 0.15-2.0 mm

Therefore, this can be applied for various use under various conditions.

2.3 Production Process

Figure 4 shows the outline of production processes of this inclined SLS unit.

This production processes are classified into three main processes.

(1) Screen production process

(2) Case production & assembling process

(3) Frame production process

In the screen production process (1), the wedge wire screen is composed of stainless steel wire and stainless steel rods. The stainless wire for the screen is wound on rods and welded into rods, and then the wedge wire screen is cut, expanded and cut for dimensional drawing.

In the frame production process (3), the frames of this unit is composed of stainless steel shape are produced by cut and bended for dimensional drawing as case frames.

In the case production & assembling process (2), the case of this unit is mainly composed of stainless steel plate, wedge wire screen and frames. Firstly, a plate is cut for dimensional drawing by laser cutting unit as the case, bored for bolts and pipes, and bended. Secondary, the frames produced by frame production process and the screen produced by screen production process are welded into the case and assembled as one unit. Finally, this unit is pickled in acid liquid, washed and inspected, and then packed and delivered.

3. METHODOLOGY : LCA

3.1 Function and Functional Unit

In order to quantify, specify and average inputs for the production system of this SLS unit, the function was defined as the removal of SS for wastewater treatment systems. The functional unit was defined as one product (one unit).

3.2 System Boundary

Figure 5 shows the system boundary for the LCA of this inclined SLS unit. This system boundary was determined which raw materials production and products production were included within the LCA. Therefore, excluding transportation & distribution, use and recycle & disposal. The CO_2 was determined as air emission leaving this system boundary.

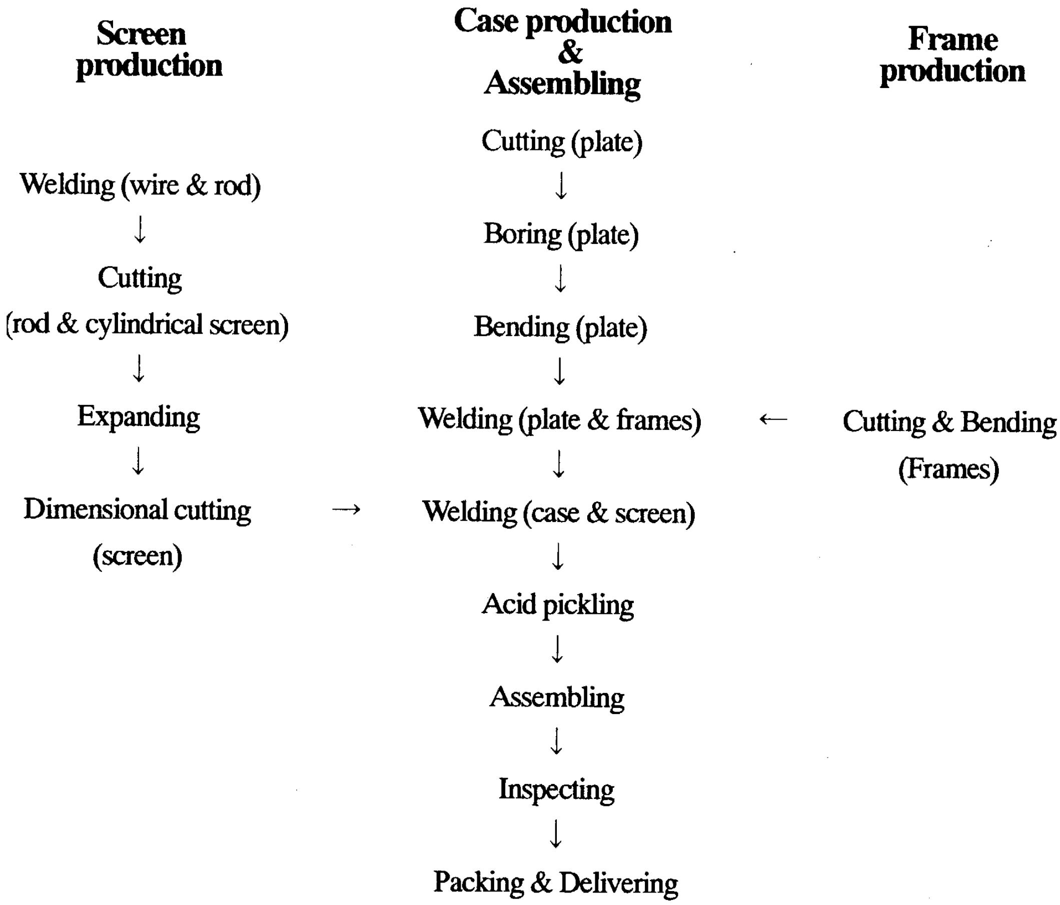

Figure 4. Outline of production processes

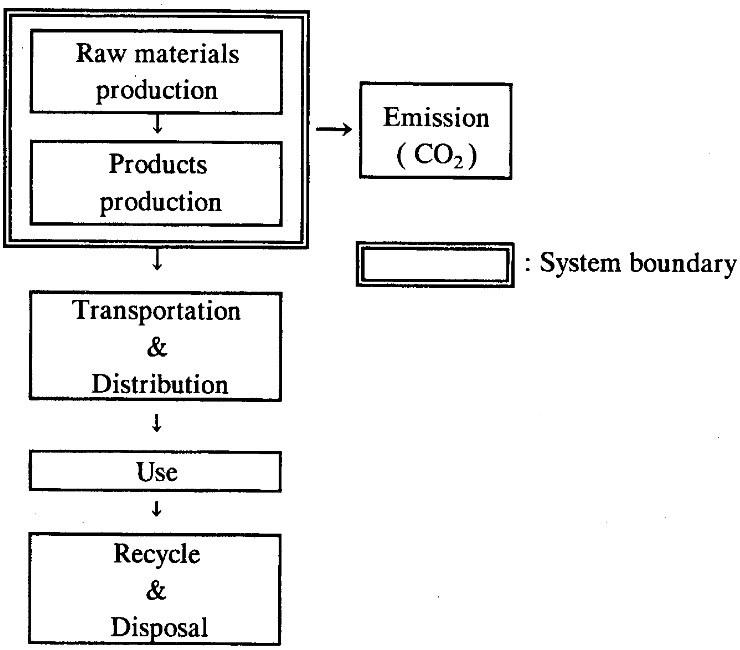

Figure 5. System boundary for LCA

3.3 Life Cycle Inventory (raw materials and energy)

3.3.1 Data of Inputs and Outputs for Production

Regarding raw materials for the production, input amounts of stainless steel system (6 kinds, e.g. wire, plate, shape, etc.) and non-stainless steel system (12 kinds, e.g. liquefied nitrogen, grinding stone, argon gas, etc.) for the production of SLS unit were collected. Regarding energy for the production, input amount of electricity for the production processes of SLS unit was collected.

3.3.2 Data Quality

Regarding input amounts raw materials and energy, these values were obtained from the annual consumptions for the production processes, and were input amounts for 10 products (10 units), and also were calculated as input amounts of per one product (one unit). Therefore, the calculated values should be accounted to the averaged values for one product (one unit).

3.3.3 *Life Cycle Assessment (CO_2 emission and $EFCO_2$)*

Amount of the CO_2 emissions and the $EFCO_2$ as a LCA for one inclined SLS product (one unit) were estimated from the preceding inventory data and the $EFCO_2$ s of raw materials and energy.

Regarding amount of the CO_2 emissions, amounts of the CO_2 emissions of raw materials were calculated by multiplying the weight of each material by the $EFCO_2$s (e.g. unit: kg-CO_2/t-material and kg-CO_2/m^3-material) of each material. Amounts of the CO_2 emissions for energy consumptions were calculated by multiplying the amounts of consumed electricity of each process by the $EFCO_2$ (0.353 kg-CO_2/kWh, conversion efficiency: 38.2 %) for purchased electricity as primary energy. And then these amounts of the CO_2 emissions were summed up, and as the $EFCO_2$ for one inclined SLS product (one unit) is estimated.

The $EFCO_2$ of each material and energy were quoted from the database of "LCA Project" by the Japanese national government (Ministry of Economy, Trade and Industry: METI and Japan Environmental Management Association For Industry: JEMAI, 2002), "LCA Jitsumu Nyumon" (JEMAI, 1998) and author's studies (Sakamoto, 1998; Sakamoto *et al.*, 2000).

4. RESULTS AND DISCUSSION

Table 2 shows the $EFCO_2$ of an inclined SLS unit (product). The total $EFCO_2$ accounts for 248.1 kg-CO_2/product. The $EFCO_2$ of stainless steel system (raw materials) is the largest and accounts for 190.5 kg-CO_2/product, followed by those from energy (electricity) and non-stainless steel system (52.6 and 5.1 kg-CO_2/product). In percentage, these are 76.8, 21.2 and 2.0 % of the total $EFCO_2$, respectively.

Regarding raw materials (stainless steel system), the $EFCO_2$ of the plate in case production & assembling process is the largest and accounts for 124.6 kg-CO_2/product, followed by these from the wire in screen production and the shape in frame production (41.8 and 11.0 kg-CO_2/product). In percentage, these are 50.2, 16.8 and 4.4 % of the total $EFCO_2$, respectively.

Therefore, as a countermeasure for the deduction of environmental loads (i.e. CO_2) in stainless steel system, thinning the width of plate and/or exchanging stainless plate for other raw materials (e.g. engineering plastics) would be significant measures.

Regarding raw materials (non-stainless steel system), the $EFCO_2$ of liquefied nitrogen in case production & assembling process is the largest and accounts for 3.0 kg-CO_2/product, followed by these from grinding stone in screen production process and argon gas in case production & assembling process (0.8 and 0.5 kg-CO_2/product). In percentage, these are 1.2, 0.3 and 0.2 % of the total $EFCO_2$, respectively.

Regarding energy (electricity), the $EFCO_2$ of case production & assembling process is the largest and accounts for 35.3 kg-CO_2/product, followed by these from screen production and frame production (16.3 and 1.0 kg-CO_2/product). In percentage, these are 14.2, 6.6 and 0.4 % of the total $EFCO_2$, respectively.

In particular, the $EFCO_2$ of electricity consumption by laser cutting unit in case production & assembling is the largest and accounts for 11.2 % of the total $EFCO_2$.

Table 2. $EFCO_2$ of inclined SLS unit

Materials and Energy		CO_2 emission (kg-CO_2/product)	CO_2 emission (%)
Stainless steel system	Wire	41.8	16.8
	Plate	124.6	50.2
	Shape	11.0	4.4
	Bolt	4.4	1.8
	Pipe	5.0	2.0
	Welding rod	3.7	1.5
Subtotal		190.5	76.8
Non-Stainless steel system	Liquefied nitrogen gas	3.0	1.2
	Grinding stone	0.8	0.3
	Argon gas	0.5	0.2
	Acid pickling reagent	0.5	0.2
	Miscellaneous (e.g. Laser gas)	0.2	0.1
Subtotal		5.1	2.0
Electricity use in production process	Screen production	16.3	6.6
	Case production & assembling	35.3	14.2
	Frame production	1.0	0.4
Subtotal		52.6	21.2
Total		248.1	100.0

5. CONCLUSION

In this report, the CO_2 emissions and the $EFCO_2$s of an inclined SLS unit as SS removal unit for wastewater treatment systems were estimated by a process analysis as one of LCA. The total $EFCO_2$ accounted for 248.1 kg-CO_2/product. The $EFCO_2$ of stainless steel system was the largest and accounted for 190.5 kg-CO_2/product, followed by those from energy (electricity) and non-stainless steel system (52.6 and 5.1 kg-CO_2/product). In percentage, these were 76.8, 21.2 and 2.0 % of the total $EFCO_2$, respectively.

Consequently, as a countermeasure for the reduction of the CO_2 emissions, decreasing input amount of stainless steel (plate) in case production & assembling process are considered significant in production processes.

ACKNOWLEDGEMENTS

This work was sponsored by "LCA Project" by METI and JEMAI. The author is grateful to METI and JEMAI, and deeply appreciated for Mrs. N. Fujimoto and Mr. M. Abe for data collection and analysis.

REFERENCES

Japan Environmental Management Association For Industry (JEMAI). 1998. *LCA Jitsumu Nyumon* (Guide book of LCA Practice) Maruzen: Tokyo (in Japanese).

Ministry of Economy, Trade and Industry (METI) and Japan Environmental Management Association For Industry (JEMAI). 2002. The database of "LCA Project", JEMAI (in Japanese).

Sakamoto Y. 1998. Assessment for CO_2 global recycling system. New Energy and Industrial Technology Development Organization (NEDO) Rep. (Development of Chemical CO_2 fixation and utilization using catalytic hydrogenation reaction): 783-804.

Sakamoto Y *et al.* 2000. Estimation of CO_2 emission fot each process in the Japanese steel industry: a process analysis. *International Journal of Energy Research* **24**:625-632.