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Development of Re-circulation System for Tableware -Research for LCA-

Takashi Watanabe[1], Koji Kato[1], Yoshikazu Hasegawa[1], Hideki Ishida[2]

[1]The Green Life Project (Gifu Prefectural Institute for Ceramics Research and Technology)
3-11 Hoshigadai Tajimi-shi Gifu 507-0811,Japan
[2]Human Design Research Center, INAX Corp.
3-77 Minato-cho Tokoname-shi Aichi 479-8588,Japan

To clarify the possibility for re-circulation and re-using of discharged porcelain wares as the starting materials of porcelain wares were discussed. The property such as the density and bending strength of fired body added 20 mass% discharged and disused porcelain wares and that of conventional ones had little differences. Re-circulation tableware was safe because lead and cadmium in those were not detected by atomic absorption spectrophotometer.

In the case of the CO_2 consumption for the discharged porcelain system, its total amount was 446.7 kgC/ton (product) including collection and reproduction. This is almost the same with that of the conventional system using natural raw materials. These results indicate that there are big opportunities to use the discharged materials into the conventional porcelain products.

KEY WORD: tableware, porcelain, re-circulation, LCA, CO_2 emission, environmental stress, recycle, reproduction

1.INTRODUCTION

Recently, there is a very important problem about environmental stress that has influences on ecosystem and it is necessary that consumption based society is transformed into the re-circulation based society. Ishida pointed out that CO_2 emission from ceramic production is less than that from other industry. [1,2] Most of porcelain wares discharged from household and industry are disposed. From the viewpoints of effective utilization of discharged tableware as raw materials and preservation of the environment, the re-circulation system to reuse disposed porcelain as raw materials and reproduce tableware must be constructed. In addition, it is important to caluclate the value of environmental stress in re-circulation system is based on Life Cycle Assessment (LCA).

In this study, with a view to developing re-circulation tableware added crushed powder of disused porcelain, the consumption energy of manufacturing re-circulation tableware was compared with that of conventional tableware. The safety and properties of re-circulation tableware produced on experimental basis were discussed.

2.EXPERIMENTAL

2.1Production of re-circulation tableware and properties

Raw materials used in this paper were as follows; clay(30mass%),feldspar(20mass%),quartz(30mass%)and crushed powder of disused tableware(20 mass%).
The same manufacturing processes such as forming, calcining, glazing and firing were applied to the conventional and re-circulation tablewares. Water absorption and bending strength were measured. Fired density was determined by the Archimedes method. Spalling test of 150 degC temperature difference was carried out to assess practicality of re-circulation tableware. Lead and cadmium elution analysis was carried out by using fired unglazed body added 50 mass% crushed powder of overglazed tableware. This analysis was followed by Japan Food Sanitation Law[4].

2.2The value of environmental stress by CO_2 emission

For the purpose of LCA, we examined the amount of energy used each manufacturing process for conventional and re-circulation tablewares. The energy used in each process was estimated by CO_2 emission. The consumed energy in each process for body preparation in re-circulation system was compared with conventional system. CO_2 emission coefficients used to calculate CO_2 emission in each process were shown in table 1.[3] And CO_2 emission was calculated by equation (1).

$$C_e = E \times C_f \qquad (1)$$

Where C_e is CO_2 emission, E is consumed energy and C_f is CO_2 emission coefficient for each process.

CO_2 emission was measured with the automation line which had the capacity of 3,500 pieces of 6 in. plate per day.

Table 1 CO_2 emission coefficient for each kind of energy

Kind of industrial energy	CO_2 emission coefficient	
Electric power	0.12	kgC / kw
LP gas	1.80	kgC / m^3
Light oil	0.72	kgC / l
City water	0.16	kgC / m^3

Table 2 The properties of re-circulation and conventional tableware

	Re-circulation tableware	Conventional tableware
Water absorption %	0.14-0.21	None
Density g /cm^3	2.30-2.33	ca.2.30-2.40
Bending strength MPa	84.5-95.0	ca.60.0-100.0

3.RESULT AND DISCUSSION

Table 2 shows the properties of re-circulation and conventional tablewares. Water absorption of re-circulation tableware was 0.14-0.21%, which was slightly larger than conventional ones. But there were little differences in the results of density and bending strength between conventional and re-circulation tablewares.

No cracks were observed by spalling test. As the results, there was no problem to manufacture the re-circulation tableware by conventional automation line. The re-circulation tableware made on experimental basis was shown in Fig. 1.

The values of lead and cadmium elution analysis were less than detective limits of atomic absorption spectrophotometer. Therefore, it was assured that re-circulation tableware was not harmful to daily life.

Fig. 2 shows manufacturing processes of conventional and re-circulation tablewares. The values of environmental stress for conventional and re-circulation systems were compared. CO_2 emission was calculated on the same equipment and firing temperature for conventional and re-circulation systems.

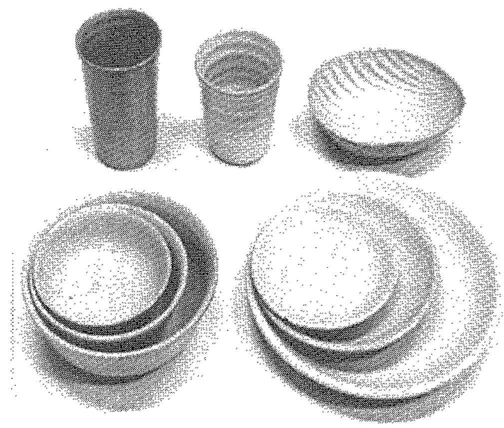

Fig. 1 Photograph of re-circulation tableware on the experimental basis

Table 3 shows CO_2 emission of conventional and re-circulation systems. The difference between two systems is body preparation process. Therefore, in re-circulation

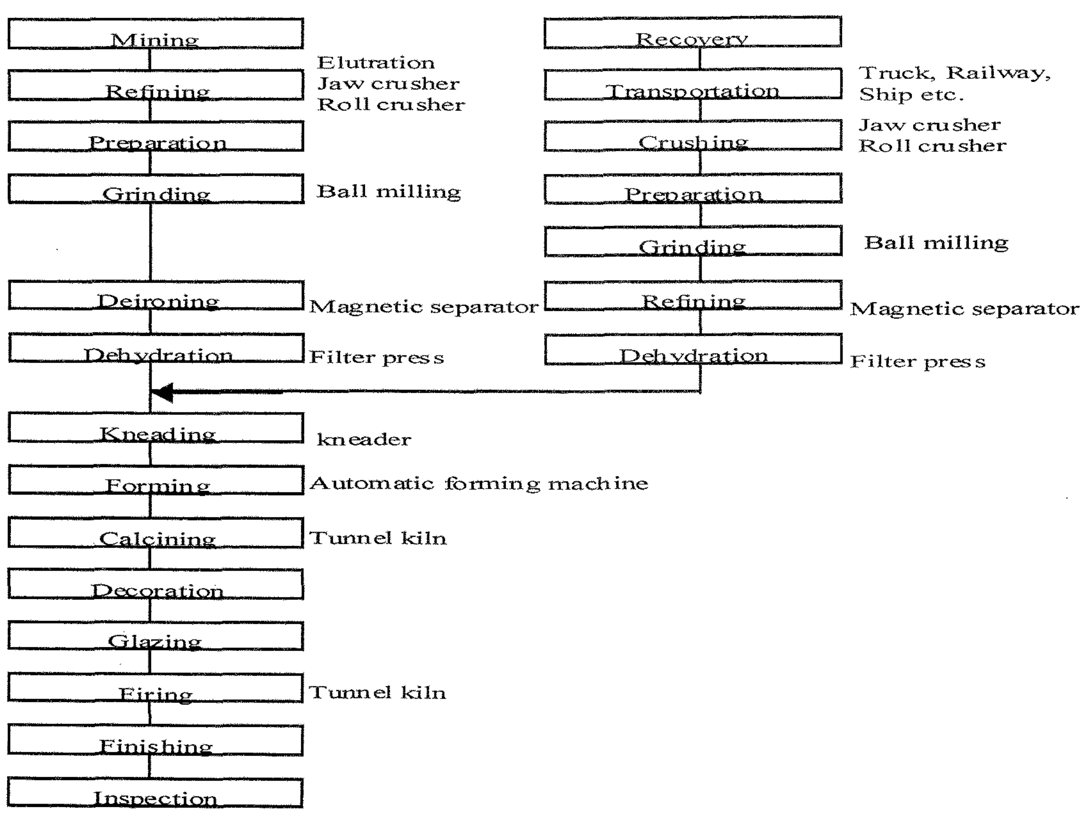

Fig. 2 Manufacturing process for conventional and re-circulation tableware

Table 3 CO_2 emission for processes in re-circulation and conventional systems [kgC/t]

	Re-circulation system		Conventional system	
Body preparation	Recovery	2.4	Mining	0.5
	Crushing	4.3	Refining & crushing	8.3
	Preparation	10.9	Preparation	10.9
		19.3*1		19.7*2
Tableware manufacturing		427.4		427.4
Total CO_2 emission		446.7		447.1

*1 (2.4+ 4.3 + 10.9) x 20 % + (0.5 + 8.3 + 10.9) x 80 % = 19.3
*2 (0.5 + 8.3 + 10.9) x 100 % = 19.7

system, the processes of mining, refining, crushing and powder preparation are changed the process of recovery of disused porcelain, recovery, crushing and powder preparation. The energy for collecting disused tableware in consumption district was ignored because it was impossible to specify transportation methods. CO_2 emission varies depending on transportation methods. According to the issue by The Eco-material Maritime Transportation Report [5], it is estimated that the marine transportation of use household electrical appliances gave less effects on the environment than the ground transportation. In this paper, however, the energy which is necessary to transport disused tableware from consumption district to production district, for example from Tokyo to Tajimi, was calculated based on railroad.

CO_2 emission varies depending on different mining and transportation methods used in different district; in this paper, we calculated CO_2 emission based on the open mining in Mino district. The total amount of CO_2 emission to produce 1 ton of tableware by re-circulation system included collection and reproduction was 446.7 kgC/ton. This value was a little lower than that of conventional tableware.

4.CONCLUSION

When re-circulation tableware added 20 mass% or 50 mass% materials crushed disused tableware was produced on experimental basis, there was little difference in its properties such as bending strength, water absorption and density between re-circulation tableware and conventional ones. Re-circulation tableware was safe because lead and cadmium were not detected by atomic absorption spectrophotometer.

In case of estimation of environmental stress by LCA, CO_2 emission of the re-circulation system for manufacturing tableware was almost the same with that of the conventional system.

These results indicate that there are big opportunities to use the discharged materials into the porcelain products.

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6.REFERENCES

[1] H.Ishida, Shigen to Sozai, 114, (1998) 491
[2] H.Ishida, Boundary, 15, (1999) 2
[3] The Energy Data and Modeling Center, Handbook of Energy and Economic Statistics, (1999) 36,37
[4] Japan Food Sanitation Law
[5] Outlook for Japan Railway by numeral, Japan Institution for Transport Policy Studies
[6] Eco-material Maritime Transportation Report, (1999) 11

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