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Consideration on Proper Management and Final Disposal of Residues from SRF Manufacturing Facilities in South Korea

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Abstract: Solid Refuse Fuel (SRF) manufacturing facilities process 4.72 million tons of waste annually. The residues generated after manufacturing SRF products account for 35–40% of the input waste, and most of them are finally disposed of in landfills. The process flow and management status of SRF manufacturing facilities were investigated, and the residues generated from SRF manufacturing facilities using municipaland industrial waste, respectively, were separated by particle size. The appropriate separation conditions for the residues according to the characteristics of the input raw materials were presented through the analysis of loss on ignition (LOI), organic foreign substance content, heating value, and carbon content. Based on this, the appropriate management criteria (draft) for the subsequent treatment of final residues were derived to improve recyclability. Residues generated in the SRF manufacturing process need to be additionally separated into combustibles and incombustibles through cylindrical rotary separating devices before subsequent the final disposal process.

Keywords: Solid Refuse Fuel (SRF); residues; waste management; recycle

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1. Introduction

The Republic of Korea pursues a landfill suppression policy, such as zero direct landfilling and a total landfill cap regulation in metropolitan areas, due to difficulties in securing landfills. In addition, a policy on manufacturing solid refuse fuel (SRF) was introduced in order to expand the recycling of waste and focus on the environmentally friendly treatment of combustible waste [1,2]. The European Union has set Waste Acceptance Criteria [3] regarding Mechanical–Biological Treatment (MBT) waste, which determine that the recovery of resources and stabilization of biodegradable materials must precede the landfill of waste. Germany and Austria, landfill standards of 18% TOC and heating value of 6 MJ/kg are applied to residues generated from MBT facilities to reduce greenhouse gas emissions and landfill load [4]. With the implementation of the mandatory Renewable Portfolio Standards, the use of SRF products has expanded every year, as well as their manufacturing and supply capacities. As of 2020, there are 269 manufacturing facilities for SRF products in Korea [5]. In total, 4.72 million tons of waste is processed annually at an average production yield of 60–80%, and improvement in product quality is induced through the reinforcement of environmental stability and the quality rating system [6]. However, most of the residues generated in manufacturing SRF products, accounting for 35–40% of the input waste, are eventually disposed of in landfills [7,8]. In order to improve the quality and product yield of SRF in the manufacturing process, it is necessary to find management measures according to the characteristics analysis of the residue [9–11]. In Korea, most of the residues in SRF manufacturing are incinerated and landfilled without management criteria. Therefore, in order to reduce the environmental load caused by the residues and for the efficient recycling and final disposal of residues, an institutional management plan is necessary [7,12]. Korea has enforced the Framework Act on Resource Circulation to prevent landfilling or incineration of combustible wastes and to induce their recycling and conversion into energy by imposing waste disposal charges if the recyclable wastes are incinerated or landfilled [13].

A lot of research has been conducted to increase the efficiency of SRF design and operation, such as the physicochemical characteristics of input waste and the characteristics of waste depending on factors such as the characteristics of the generation area and the seasonal effects of the waste to be treated. Park et al. [10] conducted a study on the physicochemical properties of municipal waste for an MBT facility design, and Park et al. [9] conducted a particle size analysis of waste in the non-formed SRF manufacturing process for municipal waste. Through this, the flow of waste was identified and a study on the distribution change characteristics of particle size was conducted. In addition, studies on various waste characteristics have been conducted [7–11]. However, all of these studies suggested a treatment method that can increase the quality and production yield of SRF according to the characteristics and particle size analysis of municipal waste. Studies on the characteristics and institutional management measures of the residue to seek optimal subsequent treatment options and more studies are needed in order to minimize the secondary residue generated when manufacturing SRF. Therefore, this study investigated the process flow and management status of SRF facilities and analyzed the discharge characteristics of the residues therein. In addition, appropriate separation conditions for SRF residues were suggested according to the characteristics of the input raw materials by analyzing the loss on ignition (LOI), organic foreign substance content, heating value, and carbon content of the residues generated from SRF facilities (of municipal and industrial wastes) that were sorted by particle size. Based on these, management criteria for the optimal management of the SRF residues through linked treatment were derived in view of improving recyclability and facility operation.

2. Materials and Methods

2.1. Status Survey

SRF manufacturing requires the meeting of standards for quality and grade following related regulations by summing the evaluation scores according to the criteria for each item for low heating value, chlorine content, sulfur content, and mercury content. Manufacturing and using high-quality SRFs is encouraged through an incentive scheme wherein facilities using high-grade SRF products are exempt from quarterly quality examinations. Due to quality control on SRF products, most unsuitable raw materials are separated out in the form of residues and disposed of by incineration and landfill, which amount to about 1.5 million tons per year. In Japan, only formed SRF products are recognized as solid fuel, and like in Korea, quality level standards (high heating value, moisture, ash content, chlorine) are regulated. The standards for quality and grade are largely divided into coke level and coal level according to the high heating value. In Europe, non-hazardous waste produced in production facilities above a certain standard is used as a raw material among combustible wastes that are primarily selected from MBT facilities, and the emissions generated when used in incinerators other than SRF composition are regulated [14]. SRF quality standards are defined by country, and EU-integrated standards [15] are prepared and managed. As of 2020, there are 269 SRF manufacturing facilities, including 26 public and 243 private facilities, handling 4,729,133 tons of waste annually [16]. There are 186 non-formed SRF facilities, which account for more than 70% of the total. Their production volume is 81.2% of the loads, which is continuously increasing. By using the statistical data of test analyses for the quality examination of SRFs by the Korea environment corporation 2020, parameters such as moisture content, heating value, chlorine content, sulfur content, and mercury content were analyzed. The average moisture content of Bio-SRF was 14.2%, which was three times higher than that of SRF (4.6%). The lower heating value of SRF was 7203 kcal/kg, which was twice as high as that of Bio-SRF. The chlorine, sulfur, and mercury contents of Bio-SRF were lower than those of SRF.

2.2. Selection of SRF Facilities

The number of SRF manufacturing facilities and the amount brought in by the type of waste were investigated using the records of manufacturing, use, and importation of

SRF products in Korea [16]. Moreover, the quality status of the SRF products, such as moisture content, heating value, chlorine content, sulfur content, and mercury content, was identified through statistical data test analysis for the quality examination of the SRFs. According to the raw material for SRF production, 24 facilities with a high production volume of municipal and industrial waste SRF products were first selected by classification. Seven facilities were finally selected as targets for this study in consideration of the type of SRF products (SRF, Bio-SRF), input raw materials (municipal waste, industrial waste, waste woods, etc.), and process composition, as shown in Table 1. These object facilities were classified into municipal wastes/SRF (three locations), industrial wastes/SRF (two locations), and waste woods/Bio-SRF (two locations). The sampling of the SRF residues was carried out according to the on-site investigation, manufactured SRF, and screening process.

Table 1. Selection of SRF facilities for the study (2020).

Facility	Classification	Raw Materials	Input (Tons/Year)	Output (Tons/Year)	Residues (Tons/Year)	Production Yield (%)
A	SRF/non-formed	Waste synthetic resins	28,189	27,816	373	98.68
B	SRF/non-formed	Municipal wastes	105,977	62,731	43,246	59.19
C	SRF/formed	Waste synthetic resins	22,202	18,128	3026	81.65
D	SRF/formed	Municipal wastes	10,317	3996	1767	38.73
E	SRF/formed	Municipal wastes	27,872	25,435	2417	91.28
F	Bio-SRF/non-formed	Waste woods	97,618	96,608	1010	98.96
G	Bio-SRF/non-formed	Waste woods	150,584	143,850	4150	97.60

2.3. Sampling

Residue sampling was carried out in accordance with the Korea Standard Test Method for Wastes [17]. In order to secure the representativeness of the samples, final samples were prepared by mixing those collected from three to five points, depending on the size of the waste storage. A total of 31 samples from each facility were collected two to five times quarterly for one year in accordance with the Korea Standard Test Method, and in some facilities, the collection was carried out separately, according to the final disposal methods of the residues (i.e., incineration and landfill). The basic status of the facility, as well as any problems in manufacturing and managing SRF products, were identified through on-site investigation, then physical composition analysis was performed on sample residues. These residues were processed (drying, fracturing, and crushing) into analysis samples for proximate (three components), heating value, LOI, element, and organic foreign substance content analyses. The details are shown in Table 2.

Table 2. Analysis methods for SRF residues.

<table>
<tr><th>Division</th><th>Analysis Item</th><th>Analysis Method</th></tr>
<tr><td>On-site investigation</td><td>Sampling</td><td>Korea Standard Test Method for Waste (ES 06130.c)</td></tr>
<tr><td rowspan="5">Laboratory analysis</td><td>Moisture content</td><td>Korea Standard Test Method for Waste (ES 06303.1a)</td></tr>
<tr><td>Loss on ignition</td><td>Korea Standard Test Method for Waste (ES 06301.1c)</td></tr>
<tr><td>Heating value</td><td rowspan="2">Test analysis for the quality control of solid refuse fuel (Ministry of Environment Public Notice No. 2020-219)</td></tr>
<tr><td>Element analysis</td></tr>
<tr><td>Organic foreign substance content</td><td>Standard test method for impurity contents of recycled aggregate (KS F 2576)</td></tr>
</table>

3. Results and Discussion

3.1. Operating and Management Status of SRF Manufacturing

The results of the examination of the operating and management status of the object facilities were as follows: Facility A is an SRF manufacturing facility that uses waste synthetic resins as raw materials, of which the production yield is 98.68% and the amount of residues generated by inputting materials through the selection processes by particle size, specific gravity, and magnetism is 373 tons/year. Facility B uses municipal wastes as raw materials to manufacture SRFs. After screening ferrous and non-ferrous metals by trommel particle size separation and then magnetic screening, 43,246 tons/year of residues are generated. Facility C uses waste synthetic resins as raw materials and alternate specific gravity and magnetic separation processes to produce > 80% SRF products. The raw materials for Facility D include municipal wastes, in which a large amount of soil is contained depending on the regional characteristics. The SRF products are produced by first removing soil through a soil sorter, then separating waste through specific gravity screening. Considering that the characteristics of the residues generated in each screening process are different, residues from each process were sampled in the case of Facility D. Facility E also manufactures SRFs using municipal wastes as raw materials, and residues generated through the screening process are classified according to incineration and landfill treatment methods. Facilities F and G manufacture Bio-SRF from waste woods, from which the residues generated through magnetic screening and scrap metal screening are classified as non-combustible materials, such as hinges, screws, and nails. They exhibit high production yields of over 97%.

3.2. Characteristics Analysis of Residues

3.2.1. Physical Composition Analysis

Figure 1 shows the physical composition of the residues generated at the SRF facilities. The composition ratio of residues for each facility differed depending on the type of wastes (manufacturing raw materials) as well as the characteristics of the wastes by season and region. For the physical composition of the residues generated at the SRF facilities (A to E), combustibles were in the range of 13~95%. For Facility D, and as a result of the physical composition of each residue from the specific gravity screening (D1) and soil screening (D2) processes, D1 classified more than 70% as combustibles, while D2 classified 72% of residues as others (mixed) through manual screening because most of the residues generated from the D2 process consisted of soil and fine combustibles. In the case of Facility E, the physical composition of residues by incineration (E1) classified 95% as inflammable, while landfill treatment (E2) showed a high ratio of incombustible (49%) and a large amount of other (mixed) substances that were no longer sorted. Among the residues generated at the Bio-SRF manufacturing facilities (F and G), 77~98% were non-combustible materials, such as nails and hinges.

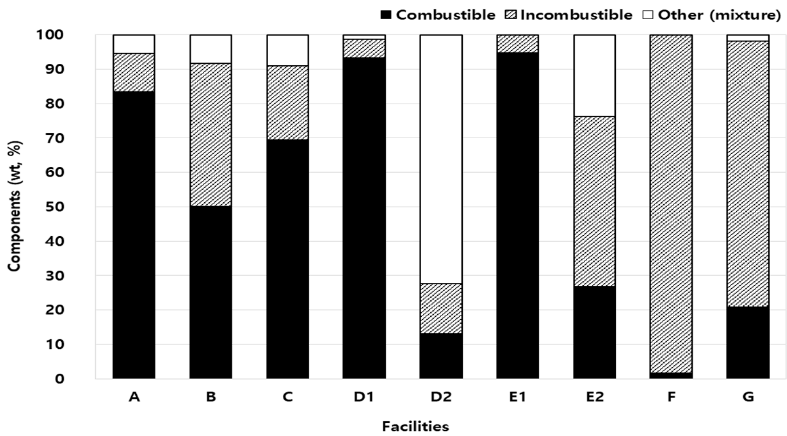

Figure 1. Physical composition of residues from SRF facilities.

3.2.2. Proximate Analysis

Proximate analysis (three components and LOI) was conducted on each physical composition (i.e., combustibles, incombustibles, and others) of the residues. The moisture content of the residues from the SRF manufacturing facilities was in the range of 3.2–50.4%, with an average of 16.6%. The high moisture content is associated with seasonal influence at the time of sampling (wet samples in the rainy season were stored); however, the average moisture content of the residues appeared similar. As shown in Figure 2, the LOI of residues from the SRF facilities was, on average, 81.3% (57.6–98.5%), of which inflammables and others (mixed) were 15.4% (0~74.7%) and 15.4% (0~44.8%), respectively. Among the residues of the Bio-SRF manufacturing facilities, the average LOI of the combustibles was 94.9%. The ash content of the combustibles, according to the physical composition of the residues, was an average of 18.7% (1.5~42.4%) for combustibles from SRF manufacturing facilities and 5.1% (3.9~6.1%) for those from Bio-SRF manufacturing facilities. The proportion of samples that satisfy the quality standard of ash content (20% or less) was about 66.7% in the case of the SRF manufacturing of combustibles, and in the case of Bio-SRF, the proportion of samples that satisfy the quality standard of ash content (15% or less) was 100%.

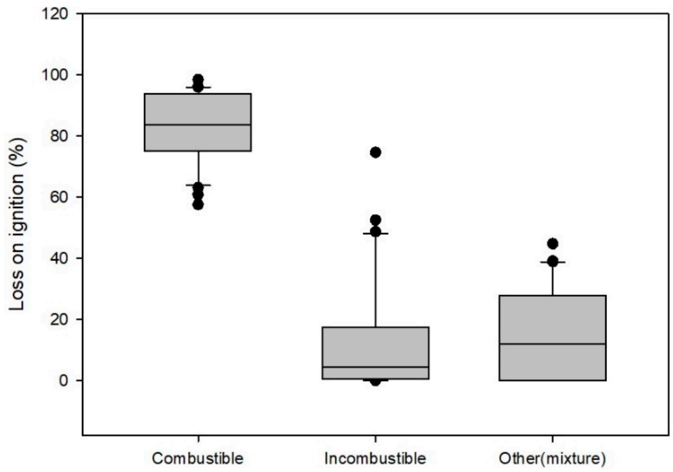

Figure 2. Loss on ignition of residues from SRF facilities.

3.2.3. Heating Value Analysis

Figure 3 shows the results of the heating value analysis for the combustibles and others (mixed) according to the physical composition of the residues from the SRF facilities. In the case of the others (mixed) samples, those not sorted by their physical composition were excluded. The dry-basis Higher Heating Value was measured using a bomb calorimeter, which showed an average value of 5555 kcal/kg (3432–8992 kcal/kg) for the combustibles and 2039 kcal/kg (615–3127 kcal/kg) for the others (mixed). In the case of manufacturing combustibles of residues with SRF, the Lower Heating Value (LHV) was calculated through moisture and hydrogen content corrections in order to compare with the quality standard for the LHV. The results showed that approximately 89% of the sorted combustibles had an average heating value of 3500 kcal/kg or higher.

3.3. Characteristics and Management Plans of Residues

Among the residues generated from the SRF manufacturing facilities, about 5 kg of the residues from facilities A (municipal wastes SRF) and B (industrial wastes SRF) were sampled. The samples collected from each facility were analyzed twice, and the average of the two values was determined as the result. Residue samples were sorted manually by particle size using the standard sieves for testing (KS A 5101-1) with mesh sizes of 25, 12.5, 5, 3, and 1 mm, and then sorted into combustibles and incombustibles within the categorized particle size. Facility A industrially screens and disposes of residues using a sieve of 50 mm, and Facility B uses one of 60 mm. Therefore, the optimal screening conditions and post-treatment management measures of the SRF manufacturing facilities were derived through analyses of LOI, organic foreign substance content, heating value, and carbon content according to particle size.

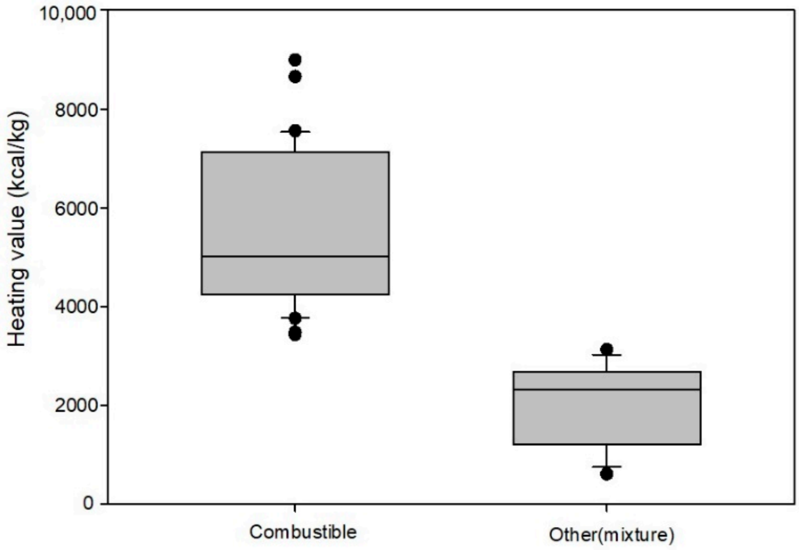

Figure 3. Heating value of residues from SRF facilities.

3.3.1. Loss on Ignition (LOI)

The residues were sorted to a particle size of 25 mm or less and then removed of moisture for analysis. The results of the LOI analysis were as follows: Facility A, using industrial wastes as raw materials, showed an LOI of 37.76% at a particle size of 12.5–25 mm or less, while Facility B, using municipal wastes as raw materials, showed a similar level of LOI in the range of 31.53–33.95% at a particle size of 25 mm or less. The proportion of incombustibles tended to increase as properties of the imported waste were not constant and as the size of the residues decreased; meanwhile, no significant change in the LOI was shown at a particle size of 12.5∼25 mm or less. Therefore, for a post-processing management plan for the residues generated in SRF manufacturing facilities, it would be appropriate to manage the municipal and industrial wastes brought in with an appropriate particle size of 25 mm or less by applying an LOI of about 30% or less.

3.3.2. Organic Foreign Substance Contents

The organic foreign substance contents by the particle size of the residues were analyzed according to the method of testing the organic foreign substance contents of the recycled aggregate (KS F 2576), as shown in Figure 4. The screening effect was assessed with an assumption that the organic foreign substance contents, except for the separated inorganic foreign substances, comprise the whole contents of the organic foreign substance contents. The results showed that the organic foreign substance contents at a particle size of 12.5~25 mm or less were 12.06% for the residues of municipal wastes and 10.26% for those of industrial wastes. As the organic foreign substance contents by particle size decreased after screening and finer incombustibles such as glass fragments were contained in the separated residues of smaller particle sizes, it was difficult to proceed through manual screening for wastes of 3 mm or less. Therefore, for a post-processing management plan for the residues generated in SRF manufacturing facilities, it would be appropriate to manage the wastes brought in with an appropriate particle size of 25 mm or less by applying organic foreign substance contents of 20% or less for the municipal wastes, and about 15% or less for industrial wastes.

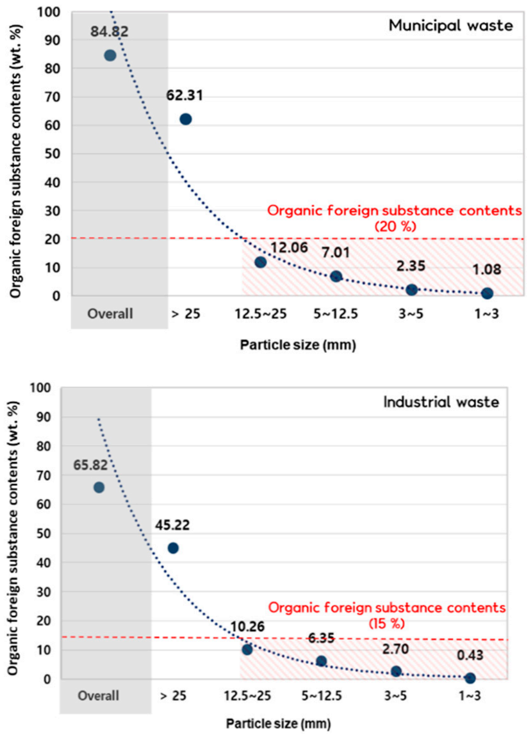

Figure 4. Organic foreign substance contents by particle size of residues.

3.3.3. Heating Value Analysis

The heating value by the particle size of the residues was analyzed according to the 'test analyses for the quality control of solid fuels', as shown in Figure 5. In general, the smaller the particle size, the lower the heating value. The residues from SRF manufacturing had a high heating value; 3819 kcal/kg at a particle size of 25 mm or more at Facility A, which uses industrial wastes as raw materials, and 2780 kcal/kg at Facility B, which uses municipal wastes as raw materials. Therefore, for a post-processing management plan for the residues generated in SRF manufacturing facilities, it would be appropriate to manage the wastes brought in with an appropriate particle size of 25 mm or less by applying a heating value of about 1500 kcal/kg or less for municipal wastes and about 3000 kcal/kg or less for industrial wastes. For the efficient use and treatment of residues, incineration treatment could be considered for those at a particle size of 25 mm or more and landfill treatment for those at a particle size of less than 25 mm.

3.3.4. Carbon Contents

The carbon content by the particle size of the residues was analyzed according to the 'test analyses for the quality control of solid refuse fuel', as shown in Figure 6. The results showed that, for those with a particle size of 25 mm or more, Facility A showed a carbon content of 41.36%, and Facility B showed a carbon content of 29.63%. The residues at Facility A were generated through a screening process for a particle size of 50 mm, showing a high proportion of combustible materials, such as vinyl and plastic. Therefore, an additional post-treatment process for appropriate particle size is required. The analysis for Facility A also showed that the range of change in carbon content was larger as the particle size decreased, while the carbon content at Facility B remained in the range of 12.56–16.79% at a particle size of 25 mm or less. Therefore, for a post-processing management plan for the residues generated in SRF manufacturing facilities, it would be appropriate to manage the wastes brought in with an appropriate particle size of 25 mm or less by applying a carbon content of less than approximately 18% for municipal wastes and approximately 27% or less for industrial wastes.

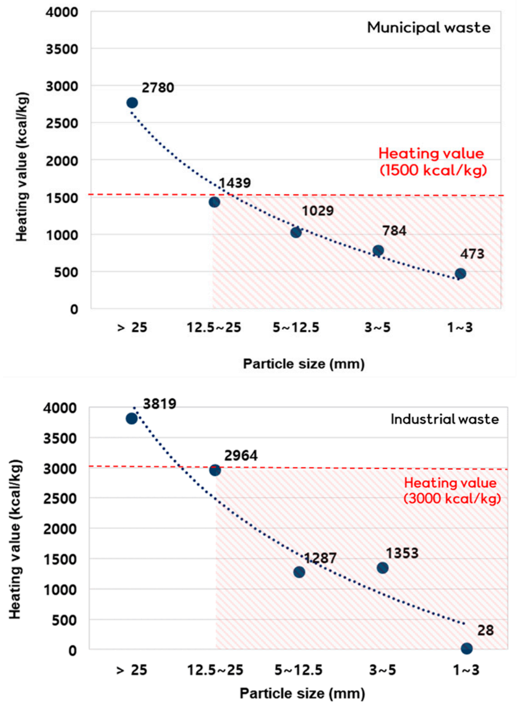

Figure 5. Heating value by particle size of residues.

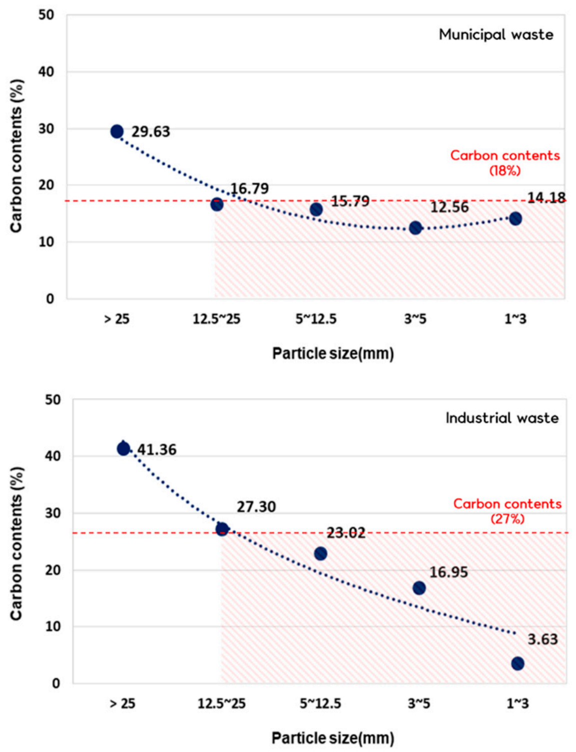

Figure 6. Carbon contents by particle size of residues.

3.3.5. Suggestions for a Management Strategy

Pre-Restraint of Bringing in Wastes Subject to Screening to SRF Facilities

It is necessary to improve the quality of wastes brought into SRF facilities and used as raw materials by screening them to the maximum extent possible. The use of inappropriate raw materials not only reduces production efficiency but also generates hazardous substances. For example, raw materials containing a large number of PVC materials, such as plastic water pipes and floor plates, cause dioxin generation, and raw materials with high foreign substances and ash content cause lower heating values, resulting in the decreased value of SRF as a fuel [18]. Bulk foreign substances, such as rubber gloves, blankets, plastic strings, hangers, and wires, cause the breakdown of crushing devices. Materials containing hazardous substances, such as heavy metals, wet raw materials, and field wastes, may contain high moisture content and are inappropriate for use (Korea Environment Corporation, 2017). Therefore, the management of wastes brought in is necessary, such as by introducing bulky wastes to the manufacturing process after screening and primary crushing, as well as mixing wastes with high moisture content with raw materials with low moisture content or putting them through a drying process after screening. In addition, heavy metals, such as chlorine cadmium, which are the main detection items for non-conformity, were found in raw materials containing batteries, rubber, electric wires, electrical appliances, coated materials, and printed materials. Thus, a pre-screening operation, such as the removal of finishing, should be conducted before putting the waste into the manufacturing process [19].

Utilization of Applicable Screening Devices for Incoming Wastes

In order to improve the quality of SRF products and increase production yield, it is possible to use additional devices that are capable of screening combustibles and incombustibles from wastes brought in within the range applicable for operation. A disc screen, such as a spiral or a disc rotator, can be mounted on a fork crane to sort incombustible materials, which is a replaceable device for each particle size from 25 to 60 mm. In the case of trommel screens, an alternative structure may be considered, such as a method that can separate combustibles and incombustibles in two ways: by rotating the cylinder, or a double structure and parallel type configuration according to the difference in particle size between the inner and outer cylinders of the trommel screen.

Institutional Support for Stakeholders of SRF Products

Issues raised by stakeholders regarding the manufacturing and management of SRFs are summarized here. Stakeholders include waste dischargers, collection and screening companies, and SRF facilities. Waste dischargers cooperate with the recycling of resources by discharging recyclable resources after separation but experience difficulties in separating and discharging composite packaging materials. Therefore, in order to facilitate the discharge and improve the quality of raw materials brought in, it is necessary to specify the separate discharge method for each product through accurate labeling. Waste collection and screening companies experience problems in which the quality and properties of waste resources deteriorate due to the introduction of contaminated recyclables and suffer from insufficient manpower and facilities for screening compared to the amount of waste brought in. Therefore, policy support for the dissemination of appropriate screening devices is necessary. The biggest problem with SRF facilities is the lack of authority to reject bringing in non-conforming raw materials, resulting in the deterioration of the quality of the SRF products as well as safety risks, such as fires, due to the non-conforming raw materials, such as lithium-ion batteries. It is necessary to prepare countermeasures for bringing in such non-conforming raw materials, of which the associated problems and responsibilities have been borne by the manufacturing facilities. SRF use facilities face complaints of bad odors and other complaints relating to the large volume of incinerated ash generated (from power generation facilities). Changes in policy conditions for SRF products are also problematic for SRF use facilities, as the market for formed SRF products is shrinking due to a decrease in the delivery cost of non-formed SRFs.

Proposal of Management Standards (Draft) for the Optimal Management of Residues

The status of management, as well as the relevant regulations regarding residues from SRF manufacturing facilities, were assessed, and the characteristics of the residues were identified through on-site investigations, including sampling and analysis. Based on these, standards for the management of residues were reviewed, and a proposal for improvement was derived. The residues generated in the process of SRF manufacturing were subject to screening; the trommel screens in operation were generally those with a cylindrical rotary particle size of 15~35 mm. In the case of screening non-combustible materials, such as earth and sand from waste, a cylindrical rotary particle size of 25 mm was considered to be appropriate for screening. Based on the analysis results by the particle size of the residues, post-treatment standards for residues based on LOI, organic foreign substance content, heating value, and carbon content were derived for municipal and industrial wastes. Table 3 shows the details applicable to the respective tests.

Table 3. Considerations and improvements on the management of residues from SRF facilities.

Items	Management Standards (Draft)		
Selection target	- Residues subject to disposal that are generated in the SRF manufacturing process (Outlet at the rear end of the particle size sorter (e.g., 50~60 mm or less))		
Methods for linked processing	- Combustibles (incineration treatment), incombustibles (landfill treatment)		
Selection condition	- Cylindrical rotary particle size screening (appropriate particle size around 25 mm)		
Available indicators for classification of the methods for post-treatment of screening residues (Incineration vs. Landfill)	Property	Municipal wastes	Industrial wastes
	Loss on ignition (%)	30	30
	Organic foreign substance content (%)	20	15
	Heating value (kcal/kg)	1500	3000
	Carbon content (%)	18	27
Test inspection	- Korea Standard Test Method for Waste, loss on ignition (ES 06301.1c) - Recycled aggregate quality standard, standard test method for impurity contents of recycled aggregate (KS F 2576) - Test analyses for the quality control of solid refuse fuel, heating value - Test analyses for the quality control of solid refuse fuel, element analysis		

4. Conclusions

Residues generated during the manufacturing of SRFs are mostly landfilled at 35–40% of input waste, but institutional standards for efficient final disposal are needed due to the environmental load and potential loss of resources due to organic residues. In Korea, there are no management standards for residues generated after manufacturing SRFs, and most of them are incinerated or landfilled for final disposal. Therefore, this study aimed to present appropriate management standards to increase the yield of solid fuel products and minimize residues. This study presented an assessment of the management status of residues from SRF manufacturing facilities, the production yield according to the process configuration, and the discharge characteristics of the residues in the case of final disposal. Furthermore, the LOI, organic foreign substance content, heating value, and carbon content were analyzed by the particle size of the selected residues of municipal and industrial wastes brought into the SRF manufacturing facilities.

It was considered that additional management would be necessary for the wastes brought into the SRF manufacturing facilities, such as the careful screening of non-conforming raw materials and, after primary grinding, mixing wastes with high moisture content with raw materials with low moisture content or sending them through a drying process.

In order to efficiently treat the residues generated in the SRF manufacturing process in the subsequent linked processes, it is necessary to additionally sort combustibles and incombustibles using a trommel particle size screener. The appropriate screening particle size of the sorter was determined to be around 25 mm to have an effective screening effect. As a post-treatment management plan to minimize residues generated in the manufacturing process of SRF, the standards of 30% loss on ignition, 20% organic foreign substance contents, 1500 kcal/kg heating value, and 18% carbon content are suitable for municipal waste. For industrial waste, it is judged that the standards of 30% of loss on ignition, 15% of organic foreign substance contents, 3000 kcal/kg of heating value, and 27% of carbon content are suitable. It is necessary to separate cases of municipal or industrial waste use as input raw materials to establish and operate management standards.

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