Honing Sludge and Electro Furnace Dust Briquetter

1. Introduction

In 1998, the NTN Iwata Works became the first member of the NTN Group to acquire ISO 14001 certification. At that point, among NTN’s waste, grinding sludge was the type that accounted for the largest environmental impact. In 1998, all of NTN produced approximately 8,000 tons of grinding sludge that was disposed of by industrial waste disposal agents. As a part of our efforts to acquire ISO 14001 certification, we began a commitment to recycling technologies with the aim of both recycling grinding sludge and reducing industrial waste disposal costs. Through the use of a solid-liquid separation technique for grinding sludge. We successfully established the recycling system that is illustrated schematically in Fig. 1. In 2000, we developed a grinding sludge recycling machine capable of commercial operation and began a full-scale grinding sludge recycling operation. Three years later, we succeeded in recycling nearly all the grinding sludge produced by the entire NTN Group. Consequently, we achieved “zero emissions” of waste, mitigating environmental impacts, which is the main objective of ISO 14001, as well as cost reduction by eliminating industrial waste disposal expenses. To further promote our waste reduction efforts, in 2002, we founded UNI TOP, an environmental venture company that boasts a unique grinding sludge briquetting technique.

We have also succeeded in meeting the needs of our customers for technical assistance in their solid-liquid separation and solidifying efforts. We are now committed to the commercialization of a briquetter for honing sludge and electric-arc-furnace dust.

Being an ISO14001-certified company, NTN is responsible for helping establish recycling technology to contribute to our recycling-oriented society. At first NTN started recycling grinding sludge with a grinding sludge briquetting machine, achieving Zero-emission with cost reduction. In 2002 NTN has established UNITOP, an environmental venture business based on briquetting technology. Honing sludge and electro furnace dust were picked up as the next targets. After testing, practical machines for honing sludge and electro furnace dust were developed. These machines will contribute to environmental load reduction.

Fig. 1 3R recycling for grinding sludge

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2. Honing Sludge Briquetters

In 2004, NTN received a request from an automaker that wished for us to develop a briquetter that could solidify the sludge that results from the honing work on engine cylinder bores. We first attempted to meet this request with our grinding sludge briquetting technique. Regrettably, the sludge started to leak through the mechanical gaps between the die and the pressurizing shaft when pressurizing was begun. We investigated the cause of difficulty in solid-liquid separation and solidification, learning that the unique shape of the swarf (shavings) from the honing process is the cause. A microscopic photograph of honing swarf is shown in Fig. 2, while a microscopic photograph of grinding swarf is provided in Fig. 3. Through comparison of the two photos, it is apparent that grinding shavings are curled and can easily become entangled with each other, while honing shavings are rolled and cannot easily become entangled. To realize solid-liquid separation and solidification of honing sludge, the authors first tested a method, as shown in Fig. 4, in which the mechanical gaps are blocked with pieces of filter paper that allow only the coolant to drain away while retaining the honing swarf in the honing sludge briquetting system. As a result, the authors verified that honing sludge could undergo solid-liquid separation and solidification through the use of this system.

Encouraged by this finding, the authors fabricated the prototype honing sludge briquetting system shown in Fig. 5. In the fall of 2005, this system was commissioned at a customer automaker’s site and allowed to run continuously on a trial basis. The automaker was satisfied with the basic functions of this system. Fig. 6 illustrates the prototype machine schematically, and Fig. 7 shows the honing sludge used in the authors’ test. Fig. 8 is a view of a briquette obtained from the authors’ test, and Fig. 9 illustrates a view of the filtered and recovered coolant. For reference, a photographic view of the coolant in process is shown in Fig. 10. From a comparison of Fig. 9 and Fig. 10, the readers can see that the coolant is cleaned by filtration through solid-liquid separation and solidification using paper filters. The authors’ newly developed honing sludge briquetter has the following advantages:

1) Reliable solid-liquid separation and solidification: Labor time saving through stable operation

Fig. 2 Magnified honing swarf

Fig. 3 Magnified grinding swarf

Fig. 4 Test method of honing sludge briquetting

Machine dimensions

<table>
<thead>
<tr>
<th>Width</th>
<th>1,265mm</th>
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<tr>
<td>Depth</td>
<td>596mm</td>
</tr>
<tr>
<td>Height</td>
<td>1,560mm</td>
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Fig. 5 Test machine for honing sludge briquetting
2) Separation into briquettes and clean coolant: Filtration is achieved in conjunction with solid-liquid separation
3) Driven completely by electric power: Energy saving, quiet running, optimal pressure control
4) Compact design: The briquetter can be installed onsite, so honing sludge can be processed immediately after generation

3. Electric Arc Furnace Dust Briquetter

In cooperation with Daiwa Steel Corporation, NTN has developed an electric arc furnace dust briquetter. By further advancing the technology that has been developed through its grinding sludge briquetters. This high-performance system is based on Daiwa’s unique pelletizing technology and NTN's unique briquetting technology. In this system, electric arc furnace (EAF) dust and carbon are premixed and pelletized. The resultant pellets are loaded into the EAF dust briquetter without blending with a binder, which is often used in conventional EAF dust briquetters.

Incorporating a novel pelletizer, our EAF dust briquetter can produce briquettes of stable strength to help improve melting efficiency in the electric arc furnace. As a result, our EAF dust briquetter will lead to reductions in the amount of industrial wastes and electric power consumption for the furnace. In summary, our EAF dust briquetter can be defined as an eco-friendly system that will contribute to rapid recovery of investment.

3.1 EAF dust recycling

The concept for EAF dust recycling is shown in Fig. 11. The dust occurring in the electric arc furnace is captured with a filter. It is mixed with water and
carbon, which functions as a reducing agent and fuel, and the mixture is formed into pellets. The resultant pellets are not suitable for direct loading into an electric arc furnace due to their low mechanical strength and difficulty in handling. Therefore, the pellets are formed into briquettes with the authors’ newly developed briquetter, and then the briquette is loaded into the electric arc furnace. Since EAF dust is repeatedly recycled, the concentration of zinc, which has a relatively low boiling point, in the EAF dust will increase and pose a problem in operating the electric arc furnace. Therefore, when the zinc concentration reaches a specific upper limit, the iron content is separated from the zinc content. The iron content is reloaded into the furnace while the zinc content is recycled as a valuable material. Thanks to this recycling scheme, the disposal of EAF dust by landfill, no longer necessary. The number of zinc removal cycles can be decreased, thereby dramatically reducing the costs associated with industrial waste disposal.

3.2 Overview of the authors’ briquetter

1) Formation principle

The principle of this briquette formation method is schematically illustrated in Fig. 12. The pellets are loaded into the die, and then the upper and lower punches apply force to the pellets in the die to convert the pellets into a briquette.

2) Effects of various factors on the strength of briquettes

The authors investigated the effects of factors associated with materials and formation conditions on the mechanical strength of the briquettes obtained. The results of these investigations are shown in Figs. 13 through 16. The mechanical strength of the briquettes was translated into indexes by dropping each briquette from 1 meter above to a 5-cm thick layer of raw material powder and then counting the number of fractured pieces resulting. The greater the index is, the greater the mechanical strength of the briquette. By appropriately selecting the water and carbon content in the pellets and the formation...
pressure for the briquette, the necessary formation strength can be obtained for the briquette. A lower formation speed is advantageous in attaining a higher briquette formation strength. However, the authors have selected an appropriate formation speed in consideration of the throughput of the briquetter.

3) Briquetter configuration
After the pellets are loaded into the inlet hopper, a cycle consisting of metering, water spraying, loading into the die, formation and discharge is executed automatically. Through setup for optimal briquetting conditions and rationalized machine design, stable briquette strength and higher productivity are attained. The major technical data for the authors’ EAF dust briquetter are summarized in Table 1.

<table>
<thead>
<tr>
<th>Model</th>
<th>HDM-150</th>
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<tr>
<td>Base materials</td>
<td>Pellets consisting of EAF dust, blended with carbon and water</td>
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<tr>
<td>Briquette size</td>
<td>Dia. 150 mm x 120 mm H, approx. 6.5 kg</td>
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<tr>
<td>Cycle time</td>
<td>17 sec</td>
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<tr>
<td>Machine size</td>
<td>3600 W x 5550 D x 4300 H (mm); weight: approx. 1500 tons</td>
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<tr>
<td>Throughput</td>
<td>800 tons/month (24 hours/day operation for 30 days)</td>
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<td>Power supply</td>
<td>200 V, 3-phase, 50 kVA capacity</td>
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3.3 Advantages of the authors’ technology
1) A pelletizing technology to produce pellets by adding a measured amount of carbon and water to the EAF dust, useful in obtaining briquettes of stable mechanical strength (patent pending).
2) This technology provides reliable briquetting of the pellets (patent pending).
3) The briquetter can be directly connected to the pelletizer to establish a fully automated briquetting system.
4) Non-processed EAF dust is not loaded into the furnace. This helps improve the working environment.

3.4 Benefits from adoption of the authors’ briquetter
1) Prevention of EAF dust from being emitted as industrial waste and reuse of iron resources ⇒ Helps achieve zero emissions
2) Elimination of binder expenses, as well as the fees for commissioning briquetting work to an outside agent ⇒ First in the industry! Realization of briquetting without using a binder
3) Decrease electricity expenses through improvement of melting efficiency with electric arc furnaces (in comparison to conventional EAF dust recycling)
   ⇒ Realization by mixing in carbon and use of heavier briquettes
4) By concentrating zinc, dramatic reduction in the amount of dezincification processing
   ⇒ Improved melting efficiency leads to simpler dezincification process, which helps realize significant cost reductions
5) Significant cost-reduction for transportation to outside agents and improved logistics
   ⇒ Significantly reduced burden of transportation to outside agents through improvements in dezincification process, etc.
6) Improved working environment, and simpler handling of briquettes
   ⇒ No handling of powder is needed, greatly improving the working environment

4. Conclusion
   Through further developments in these technologies as, described below, the authors strongly believe that NTN’s unique honing sludge briquetting technology and EAF dust briquetting technology will contribute to the mitigation of environmental impacts.

**Honing sludge briquetting technology**

This technology will be applicable to various sludge types that cannot be solidified or briquetted with a grinding sludge briquetter. NTN is currently attempting to apply this unique technology to solid-liquid separation for ultrafinish-derived sludge so as to further mitigate environmental impacts from NTN’s production activities.

**EAF dust briquetting technology**

The authors began the development work for this technology because it appeared to be advantageous in converting pellets into molded briquettes. Currently, we expect that our novel technology for directly converting powdered materials into briquettes will be commercialized and eventually adopted in various powder-solidification applications to realize the recycling of resources that were previously difficult to recover.