◆Author Guidelines

Manuscripts should be submitted as camera-ready. Papers will not be edited before printing. Please read and follow the guidelines below.

1. Papers

Papers should be submitted in PDF through the paper submission system.
(http://www.unitecr2011.org/final_submission.html).
The data MAXIMUM size for abstract is 3M and for proceedings is 4M. No larger data will be accepted.Please be sure to scale down your data (especially the photos or picture) to an appropriate size when sending over abstract or proceeding.
They should be studies which have not been published as printed materials and involve worthwhile conclusions or facts concerning refractories. Templates to copy and paste your paper are available at the "Final Paper" page.

2. Manuscript preparation

1. Key points

1. **Volume:** A proceeding should not exceed four pages and an abstract should be one page.
2. **Format:** A4 in landscape (W 297 x L 210mm) with margins of:
   25mm on the top, 20mm on the bottom, left and right for a **proceeding**
   25mm on the top, 10mm on the bottom, 30mm on the left and right for an **abstract**
3. **Columns:** Two columns with a space of 7mm between them in each page except the title and author's information on the top of the first page. (A template attached is available)
4. **Font:** Times or Times New Roman in 11 point except the title.
5. **Space:** The text should be typed in single space with one blank line before the title of each section.
6. **Indent:** One tab before starting each paragraph.

2. Specifics

1. **Title**: Centered on the top of the page in 14-point bold-faced type Times or Times New Roman.
2. **Author's information:** One blank line under the title and the author's name and affiliation. Put an asterisk (*) after the name of the

speaker. One blank line after the author's name and affiliation.

3. **Format:** 55 lines in two columns rows. (cf. MS-Word template)
4. **Headings and subheadings:** Bold font

3. Figures and Tables, etc.

1. **Figures and Tables:** A figure caption should be shown as "**Fig.1**" in 11-point bold-faced type on the lower side of each figure. Photographs and other images should be treated as figures and should not be captioned as "Photo 1".
   A table caption should be shown as "**Table 1**" in 11-point bold-faced type on the upper side of each table.
2. **Abbreviations:** All brevity codes and abbreviations must be defined when they appear in a sentence for the first time so that the readers will be able to understand them easily.
   e.g. 1. LCA (Life Cycle Assessment),
   PECS (Pulse Electric Current Sintering)
3. **Units, symbols and mathematical expressions:**
   The International System of Units (SI) must be used to indicate units. Unit symbols must be block letters, and neither plural forms (such as "hrs.") nor periods must be used. Combined unit symbols must take the form of a product, for example Pa·s, $W{\cdot}m^{-1}{\cdot}K^{-1}$, $m{\cdot}s^{-2}$, $kg{\cdot}m^{-3}$.
   In order to distinguish between a prefix and a unit symbol, ms^{-1} (milli-second^{-1}) or $m{\cdot}s^{-1}$ (meter per second), middle point '·' must be used for every unit.
4. **References:** Please refer to the sample.
   When a magazine is referred,
   J. J. Cleveland and R. C. Bradt: J. Am. Ceram. Soc., **61**, 478-481(1978).
   H. W. Chang and S. K. Rhee: Carbon, **16**[1] 17-20 (1977).
   When a book is referred,
   W. D. Kingery, H. K. Bowen and D. R. Uhlmann: Introduction to Ceramics, 2nd ed., John Wiley & Sons, New York (1960) pp. 413-430.
   T. L. Barr: Modern ESCA, CRC Press, Boca Raton (1993) pp.121.
5. **Others:** Avoid directly mentioning the brand names of goods. Try to express them using the generic names. Abstract printing will be in black and white.

4. Sample Paper: Sample papers are available as the templates.
(http://www.unitecr2011.org/final_submission.html)

Author Guidelines for abstract

25 mm

Author's information: Put an asterisk (*) after the name of the speaker.

Title: 14-point bold-faced type

Evaluation of Rheological Properties of Tap-hole Materials and Estimation of Injected Condition in the Blast Furnace

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Eizo Maeda*, Satoi Terayama, Masakazu Iida and Kazuyoshi Nakai (Shinagawa Refractories Co., Ltd.)

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Headings and subheadings: Bold-face type

Introduction

The user's demands for refractory materials to plug the tap-hole and allow stable operation of the blast furnace have become more and more severe in recent years. T... to know how the ... made a quantitative evaluation of the condition of tap-hole materials used to plug the furnace, from the standpoint of rheology.

Experimental Procedure

In the refractories field, the rheological properties are usually evaluated by ... shear stress of tap-hole materia... rate using a capillary rheometer ...1).

The text should be typed in single space.

The measurement method involved the fo... the diameter and length of the capillary and ... are known, and an Instron-type testing mach... the partition of the pressure cylinder was g... crosshead speed. In this case, a shear rat... tap-hole materials, and the shear stress was ... injection force *F*. The cross head speeds we... forces were measured. A shear stress-shear ... combining these results.

The test materials were commonly use... materials. The effect of viscosity and the content of coal tar were investigated.

The pressure changes were measured during tap-hole material injection in an actual operation. We estimated the plug condition of the tap-hole material in a blast furnace based on the rheological characteristics that were determined, and the relationship between the amount of material injected and the pressure of the actual operation.

Results and discussion

The resistance increased with the material injection into the capillary. The resistance became a maximum value when the material reached the exit and that value was maintained during the injection. The maximum value was the extrusion force for the extruding velocity.

The rheological prop... tap-hole materials was fou... typical Bingham fluid as ... the relationship of the shear st... τw and the shear rate $d\gamma/dt$ as $\tau_w = \tau_0 + \mu_B \cdot d\gamma/dt$ where τ_0 is the yield stress and μ_B is a constant corresponding to viscosity (**Fig. 1**).

...iscosity and the ...he yield stress ...nt μ_B were ... increased for ... mixes, high ...er content of ... increase of μ_B ...n in τ_0.

...sure changes ...aterial injection in an actual operation, we discussed the accumulation of tap-hole material in the blast furnace. The material was extruded into the furnace in a shape of a rope which was about 80 mm in diameter and about 30 m in length. The rope-like material was presumed to accumulate (**Fig. 2**), and react with the slag in the free space of the furnace during 10 and more years of service.

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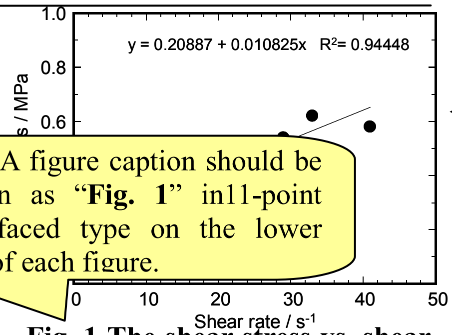

Fig. 1 The shear stress vs. shear rate plot of material A.

Figure: A figure caption should be shown as "**Fig. 1**" in11-point bold-faced type on the lower side of each figure.

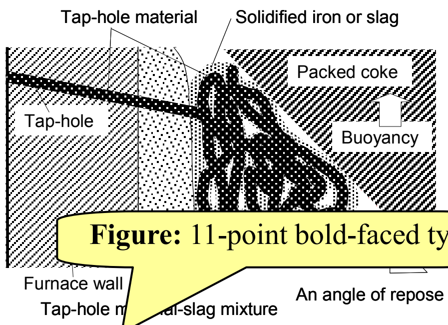

Figure: 11-point bold-faced type

Fig. 2 An estimated illustration of the injection of the tap-hole material into blast furnace.

7 mm

Reference

1) Toshiaki Nakae ed.: Rheological Engineering and Its Application, Fuji Techno-system, (2000) pp. 211-214.

10 mm

Author Guidelines for **proceeding**

25 mm

Title: 14-point bold-faced type

Evaluation of Rheological Properties of Tap-hole Materials and Estimation of Injected Condition in the Blast Furnace

Author's information: Put an asterisk (*) after the name of the speaker.

One blank line

Eizo Maeda*, Satoi Terayama, Masakazu Iida and Kazuyoshi Nakai
Shinagawa Refractories Co., Ltd.

The text should be typed in single space.

Headings and subheadings: Bold-faced

Abstract

Rheological properties of tap-hole materials were characterized by using a capillary rheometer method. The materials were extruded through the ... the resistance was measured. The resistance increased with time and maintained a ma... the material was extruding t... The shear rate and shear stress... the extrusion speed and the re... From the relationship between... the shear rate, the tap-hole ma... behave as a Bingham fluid... changes of a tap-hole material... with time in a real blast furnace. By comparison of lab tests and the injection pressure changes, it was estimated that the materials were injected into the furnace in the shap... a diameter of around 80mm and ... of about 30m or less, which heaped up in free space in the furnace.

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1. Introduction

The blast furnace is a reaction chamber in which iron ore is reduced by carbon and molten pig iron is produced. Usually a blast furnace has two or four tap holes. When the molten pig iron is removed, molten slag flows out with the pig ion. ······

....

These troubles in the opening and plugging operations are considered to relate to the condition of the tap-hole materials that plug the blast furnace. In other words, to suppress the problems, it is important to know how the tap-hole materials plug the furnace. Hence, the authors thought it was important to do a quantitative evaluation of the condition of tap-hole materials used to plug the furnace, from ... of rheology.

In the rheological study of tap-hole materials, Artelt et al.[1] introduced some qualitative testing methods, but their data did not provide quantitative information. Though Kageyama et al.[2] evaluated the extendibility of plugging in the lateral direction, using their own method, the theoretical basis of the method was not clear. Kitazawa et al.3) reported the measurement of resistance at two injection speeds using a small injection mold and the resistance was not proportional to the injection speed.···········

....

Reference

7 mm

2. Experimental Procedure

...od of Obtaining Shear Rate vs. Shear Stress Plots[7]

....

Fig. 1 shows a schematic diagram of the capillary rheometer and the measurement method. If a Newtonian fluid flows in a capillary by a pressure ... is called "pressure

20 mm

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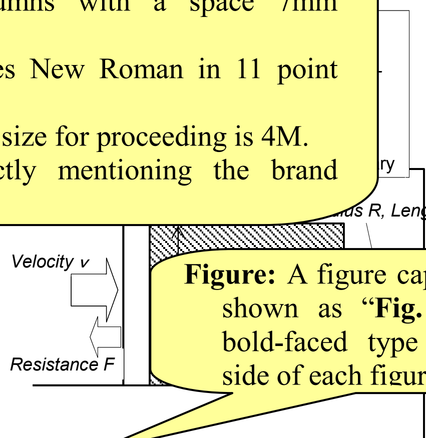

Figure: A figure caption should be shown as "**Fig. 1**" in11-point bold-faced type on the lower side of each figure.

Fig. 1 Schematic diagram of a capillary rheo-meter method and coordinates of the capillary.

2.2 Materials Tested

Table 1 shows the chemical composition of the tap-hole m... the relative co... ...es. ...est materials (A to F) we... ...only used commercial tap-hole materials. ...density varied according to the content of coal tar and the composition was about 2200 kg·m^{-3}.

....

Combined unit symbols must take the form of a product.

Table 1 Chemical composition, relative content of coal tar and particle sizes of tap-hole materials

Sample	A	B	C	D	E	F
Chemical composit... mass%						
Al_2O_3	[illegible]	17	23	24	23	26
SiO_2	[illegible]	12	13	9	6	
SiC + Si_3N_4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Coal tar** / mass%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Low viscosity typ...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Content of grains / ...						
≧1.0mm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
≦0.075mm	52	54	53	41	62	52

Table: A table caption should be shown as "**Table 1**" in 11-point bold-faced type on the upper side of each table.

* After coking at 500℃.
** The content was relative value when the content of refractory particles was 100.

2.3 Experimental Apparatus and Method

....

20 mm

The mold used in this study was the same one used for the so-called Marshall Test of tap-hole materials. The radius of the capillary R was 10 mm, the length L was 20 mm, and the radius of the cylinder R_p was 35 mm. The inside of the mold was inclined by a slope of 25/73 between the cylinder and the capillary. This shape was slightly different from ··························

3. Results and discussion

3.1 Change of Resistance during Testing

Fig. 3 shows the relationship between the crosshead displacement and the resistance for material A; the temperature was 70 ºC, and crosshead speeds were 100 and 350 mm·min^{-1}. **Fig. 3** shows the movement of material (flow) in the mold and extrusion of the tap-hole material through the capillary; also shown is the relationship between the deformation of the material and the resistance. An egg-shaped mass of material was deformed by the movement of the plunger. As the material approached the capillary, the resistance increased. Moreover, as the material moved into the capillary, the resistance increased linearly. In contrast, when the material extruded from the exit of the capillary, the resistance showed a constant value. This constant value was maintained as the injection continued, and it was established as the injection force F. The patterns of resistance change shown in **Fig. 3** were almost the same for all materials tested in this study, except the cases described later.

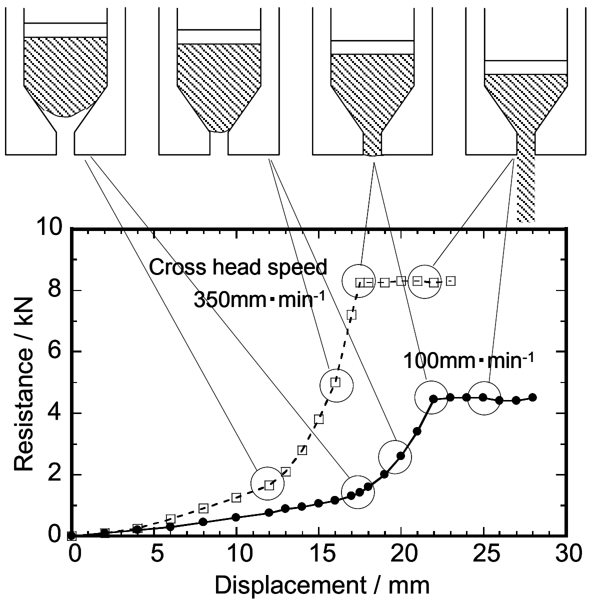

Fig. 3 Variations of resistance during extrusion and illustrations of shape changes of the material in the die.

Equation (8) can be transformed for the injection force F, as follows:

A Mathematical equation

$$F = \frac{2\pi L R_p^2 \tau}{R} \qquad (10)$$

From equation (10), we can understand the resistance change in **Fig. 3** as follows. The injection force F is proportional to the capillary wall length during injection and reaches a maximum value at the exit. Moreover, as the material continues to extrude from the exit, ·········

4 Conclusions

The rheological properties of tap-hole materials were investigated by a capillary rheometer method. In addition, the injection condition of the material into the blast furnace was presumed based on the injection pressure changes with time for a real operation.

(1) The tap-hole materials were extruded through the capillary of a mold with certain extruding velocity and the resistance changes were measured. The resistance increased with the material injection into the capillary. The resistance became a maximum value when the material reached the exit and that value was maintained during the injection. The maximum value was the extrusion force for the extruding velocity.

(2) From the extrusion force for the extruding velocity, we obtained the shear stress for the shear rate. The shear rate was changed by applying another extruding velocity, and the shear stress was obtained. Repeating similar measurements and compiling the results, we obtained plots of the shear stress and the shear …

A Mathematical equation

(3) The rheological property was fo… to be a typical Bingham fluid as shown by the r…tionship of the shear stress and the shear rate as $\tau_w = \tau_0 + \mu_B \cdot d\gamma/dt$ where τ_0 is the yield stress and μ_B is a constant corresponding to viscosity.

(4) The effect of viscosity and the content of coal tar on the yield stress τ_0, and the constant μ_B ·······

References

1) P. Artelt, H.F. Köhlau, Sprechsaal, **117** 341-346 (1984).

2) Tatsuya Kageyama, Kazushi Maruyama, Masatsugu Kitamura, and Diasuke Tanaka: Taikabutsu, **56**[3] 108 (2004).

3) Hiroshi Kitazawa, Yuji Ohtsubo, Toshiyuki Suzuki and Keisuke Asano: Taikabutsu, **56**[3] 109 (2004).

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7) Toshiaki Nakae ed.: Rheological Engineering and Its Application, Fuji Techno-system, (2000) pp. 211-214.