Effect of Shape Variation on Feeding Efficiency for Local Exothermic-Insulating Sleeve

by Rendi Reynaldi

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Writing Issues

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1	Misuse of semicolons, quotation marks, etc.	
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5	Wordy sentences	
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27	Word choice	

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unique words

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4.9

characters per word

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Measures average sentence length

12.8

words per sentence

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Abstract. Exothermic- insulating sleeves are used to increase the yield in foundry practice. Function of the sleeve is predominant to enhance the effective casting modulus by increasing feeding efficiency. This is represented by a modulus extension factor (MEF) and shrinkage porosity of the casting. The use of an exothermic - insulating sleeve as a substitute for sand feeder can increase efficiency by up to 60%. However, exothermic-insulating sleeve in use today is imported and has limited range of shapes and sizes so that the cast steel products is limited. The research is intended to produce a variety of shapes and know about the effect of that to casting yield of C8000 cast steel. For this research the exothermic- insulating sleeve make use local and imported resource material. The research starts with the study of shape variations which are widely applied. The constant modulus will be used as a basic for the further design of the sleeve. Molten metal is poured for trials with and without the test sample (the casting) which is followed by feeder cooling rate measurement to find the value of modulus extension factor (MEF). To analyze the effect of efficiency other testing plate test is applied involving shrinkage cavity visual testing, and yield calculations. These results show that the dome - shape performed the best efficiency in the holding time, temperature above the solidus temperature (above 1360 °C) for 360 second, the shape of the cavity shrinkage apparently, highest MEF (2,02 times larger than sand riser), 90% in yield. These results which performed was accepted for exothermic-insulating properties of Indian standard.

INTRODUCTION

Feeding efficiency also called volumetric feed efficiency defined as volume of metal fed to the casting divided by the casting volume [1]. There are several factors which affecting these efficiency. First is the using of sleeve, Feedersleeves are a well-established tool in the steel foundry industry for minimizing feeder size, and hence minimizing the volume of metal melted and poured [2]. By evaluating the effect to the solidification time, the exothermic-insulating become the most effective caused by the lower net heat loss relative with exothermic and also insulating sleeve.

FIGURE 1. Net heat loss from a variety of feeder and effect from sleeve using to increase the efficiency

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Second is the effect of the shape, chwrorinov rules said that despite local variations in the rate of freezing, the influence of casting geometry is chiefly of importance in determining the overall solidification time. Once this is known, feeder heads can be designed to maintain the supply of feed metal throughout freezing. The ideal is to be able to predict the solidification time irrespective of the shape of the casting. A notable step in this direction was taken with the discovery of the Chworinov Rule, which postulates that the total freezing time of any casting is a direct function of the ratio of its volume to its surface area (V/A). The overall solidification time for a given volume of metal is thus found to be greatest when the ratio V/A is a maximum, i.e. in the case of a sphere, becoming progressively less for cylinders, bars and plates. Determination of the V/A ratio or of some analogous factor can thus be applied to the estimation of relative freezing times of feeder heads and the casting sections they are intended to feed, as well as giving guidance as to the best shape for a feeder head. It is the Chworinov rule which provides the basis for those later approaches to the feeding problem which use a shape factor or 'modulus' as the criterion of total freezing time [3].

FIGURE 2. Effect of shape variation to feeder efficiency

By kind of these reasons this experiment will investigate the optimum efficiency between a dome shape and cylinders as exothermic-insulating shape

and sand riser, involving value of Modulus Extension Factor (MEF), and finally casting yield (%) as standardized by Indian standard.

EXPERIMENTAL SETUP

There are several testing, which has to do for investigating the feeder efficiency involving plate test and solidification test. The efficiency also called volumetric feed efficiency obtained by calculating percent feed metal supplied to the casting relative to a sand feeder [4]. Another test which required for determining the effect of exothermic-insulating shaped variation as chworinov said is solidification test. This test should be done to know the value of modulus extension factor (MEF).

FIGURE 3. Kind of test which should be taken by exothermic-insulating sleeve (Indian standard)

Shape and modulus

The dome shape/H-sleeve (Ø1 39 mm, Ø2 60 mm × h= 67,93 mm) and cylinders shape/H-sleeve (Ø54 mm × h=
84 mm) taken from literature [5] have a same modulus which is 1 cm and 15 mm in thickness . The value of the
modulus is calculated by mathematical and simulated by using solid cast 8.4 simulator. Moreover the value of thickness also taken from other experiment which done by foseco.

a b[80] c d FIGURE 4. Dome feeder (a), dome sleeve (b), cylinders feeder (c) and cylinders sleeve (d) Casting material

Creusabro steel which[81] also called C8000[82] become[83] a material for determining feeding efficiency. C8000 is low alloy carbon steel which[84,85] has liquidus temperature about (1480-1500)°C and about (1360-1440) °C of solidus temperature based on the CE value.[86] In additional[87,88] C8000[89] categorized as short[90] freezing range [6]. As a short[91] freezing range material, in the solidification process, the dendrite length will be directly

proportional to the equilibrium freezing range and inversely proportional to the average temperature gradient in the two-phase region. In simple term a chance for getting a sound casting is easier than other alloy which categorized as long freezing ranges.

Solidification test

As told before solidification test should be taken in identifying the MEF value of the sleeve. The test will be taken in feeder cavity which have been set with thermocouple detector to record the solidification time which shown by thermal gradient per second. The minimum value of MEF is 1,60 for exothermic-insulating sleeve which have up to 150 mm in diameter [7].

Plate test

Assuming the shrinkage total is 4,5%, The plate test dimension is 400x400x22 mm for cylinder sleeve and cylinder sand feeder, dome-sleeve have 400x300x22 mm in dimension. Will be kept in constant condition:

Chill material : St 37

Chill thickness : 20 mm Hydraulic height (mould height) : 200 mm Mould : greensand

Pouring temperature : 1600 °C± 50° C

Feeder top cover : 7 mm silica sand cover

The scheme of feeder and chill position was determine refer to steel feeding risering by SFSA.

a b

FIGURE 5. Plate test casting design for cylinders sleeve and cylinders feeder (a) and for dome sleeve (b)

RESULT AND DISCUSSION SOLIDIFICATION PROCESS Temperature Gradient

The solidification process taken in these conditions :

TABLE 1. Actual C8000 composition Pouring temperature (°C) : 1628

Pouring time (second) : 11

The effect of shape variation to temperature gradients in solidification process have been shown below :

FIGURE 6. Temperature gradients from several feeder in same solidification process

Based on fig. 4, the graphic can give other specific information about thermal properties.

a b

c

FIGURE 7. Cooling rate and effect from dome-sleeve (a), h-sleeve (b), and sand feeder (c) to hold temperature.

Dome-sleeve can make molten metal held at a working area (above 1360°C) as long as 360 second[129], better than H-sleeve which[130] can be held[131,132] as long as 110 second[133], and sand riser which just hold[134,135] as long as 50 second[136]. These phenomena come because several[137] factors. First[138] is surface area. With the constant

modulus, The surface area of dome sleeve is smaller than cylinder sleeve, it's[139] meant the solidification from dome sleeve will longer than cylinder relative to the higher modulus. Second is the surface cover condition. All of the surface[140] of dome shape which covered by sleeve[141] can minimize the heat loss from metal when the solidification process happened. Hence the solidification time from dome-sleeve will longer than cylinder sleeve.

Heat loss direction

FIGURE 8. Illustrations about correlation between top condition to heat loss

Modulus extension factor (MEF)

The value of MEF is determined from solidification time sand feeder module /sleeve feeder module, the result from the solidification time is below :

MEF H-sleeve = ெ□ளஉ□ ெள□□ள ே□o□□ ஸ ஏG□□ ஸ □G □□

ெ□ளஉ□ ெ□o□□ரு□

□ஏG□□

MEF Dome-sleeve = ெ□ளஉ□ ெள□□ள ே□o□□

ெ□ளஉ□ □□□□o□□ரு□

□□ ஏā□ ஸ □ā □□

□ā

Based on that result, showing that MEF parallel with temperature gradient and proved that shape have an effect on how to increase solidification time by increasing MEF value.

PLATE TEST Shrinkage appearance

TABLE 2. Actual C8000 composition Pouring temperature (°C) : 1568 (H-sand), 1567 (dome sleeve)

Pouring time (second) : 11 (H-sleeve), 10 (H-sand)

9 (dome sleeve)

The result showed that the dome-sleeve and H-sleeve have the better feeding than sand[150] riser, showing by the shrinkage appearance which smooth (columnar zone), different with sand riser which have equiaxed[151] zone[152] in the center of the feeder (dendritic). The condition happen caused by the sleeve effect which[153] can make the liquid metal prevent to be solid quickly. So the feeding process going[15] to be effective.

(a) (b)

(c)

FIGURE 9. Shrinkage appearance at the feeder from the plate test result

Casting yield/volumetric feeding efficiency

By looking the[155] shrinkage appearance data, it simpler[156] to says that the dome sleeve and H-sleeve/cylinder sleeve will have greater[157] efficiency than sand riser. The result of the casting yield is below:

TABLE 3. efficiency data

Dome-sleeve have a greater[158,159] efficiency than H-sleeve, it's parallel with the solidification time result involving the
MEF value and holding effect.

CONCLUSION

The exothermic-insulating shape variation gives an effect to[160] the feeding efficiency caused by the modulus extension factor value, holding temperature

effect and also heat transfer from each shape. The effect obtained from the solidification testing and plate testing. Showing that with the constant modulus and thickness the dome sleeve Dome-sleeve can make molten metal held at working area (above 1360°C) as long as 360 second, better than H-sleeve which can be held as long as 110 second, and sand riser which just hold as long as 50 second, greater MEF with 2,02 than 1,63 cylinder MEF which also accepted Indian standard minimum MEF. The final effect is shown with the efficiency testing by using plate testing, the yield is increased until 90% by dome sleeve, greater than cylinder sleeve which have 88% and sand riser which only 19%.

ACKNOWLEDGMENT

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2. Richard A. Hardin, Thomas J. Williams and Christoph Beckermann, Riser Sleeve Properties for Steel Castings and the Effect of Sleeve Type on Casting Yield. 2013

3. Beeley, Peter, "Foundry Technology", 2001, Butterworth-Heinemann, Oxford. Page 121

4. Indian standard, "Exothermic And Insulating Sleeves For Use In Foundries – Specification, 2009, Bureau of indian standard, New Delhi.

5. AMI industrial standard (cylinder) and VDG (dome)

6. ASM committee, "ASM Handbook Volume 15 of the 9th Edition", (1988 &1992 (second printing)) ASM international. Page 254

7. Indian standard, "Exothermic And Insulating Sleeves For Use In Foundries – Specification, 2009, Bureau of indian standard, New Delhi.

1.	~~bandung~~ → Bandung	Misspelled Words	Correctness
2.	*are used*	Passive Voice Misuse	Clarity
3.	The function	Determiner Use (a/an/the/this, etc.)	Correctness
4.	~~sleeve~~ → jacket, envelope	Word Choice	Engagement
5.	*This*	Intricate Text	Clarity
6.	*is represented*	Passive Voice Misuse	Clarity
7.	~~sleeve~~ → jacket	Word Choice	Engagement
8.	a limited	Determiner Use (a/an/the/this, etc.)	Correctness
9.	~~is~~ → are	Faulty Subject-Verb Agreement	Correctness
10.		Intricate Text	Clarity
11.	*The research is intended to produce a variety of shapes and know about the effect of that to casting yield of C8000 cast steel.*	Wordy Sentences	Clarity
12.	~~shapes~~ → ways	Word Choice	Engagement
13.	~~know~~ → knows	Faulty Subject-Verb Agreement	Correctness
14.	research,	Comma Misuse within Clauses	Correctness
15.	~~make~~ → makes	Faulty Subject-Verb Agreement	Correctness
16.	of local	Wrong or Missing Prepositions	Correctness
17.	~~research~~ → analysis	Word Choice	Engagement

18.	, which	Punctuation in Compound/Complex Sentences	Correctness
19.	*be used*	Passive Voice Misuse	Clarity
20.	~~basic~~ → basis	Confused Words	Correctness
21.	*is poured*	Passive Voice Misuse	Clarity
22.	, which	Punctuation in Compound/Complex Sentences	Correctness
23.	~~which is~~ → ,	Wordy Sentences	Clarity
24.	the modulus	Determiner Use (a/an/the/this, etc.)	Correctness
25.	, other	Punctuation in Compound/Complex Sentences	Correctness
26.	~~efficiency~~ → ability, energy	Word Choice	Engagement
27.	~~second~~ → seconds	Incorrect Noun Number	Correctness
28.	~~shape~~ → way, form	Word Choice	Engagement
29.	, which	Punctuation in Compound/Complex Sentences	Correctness
30.	*was accepted*	Passive Voice Misuse	Clarity
31.	, also	Punctuation in Compound/Complex Sentences	Correctness
32.	the volume	Determiner Use (a/an/the/this, etc.)	Correctness
33.	~~affecting~~ → affect	Incorrect Verb Forms	Correctness

34.	~~using~~ → use	Confused Words	Correctness
35.	the sleeve, or a sleeve	Determiner Use (a/an/the/this, etc.)	Correctness
36.	~~, Feedersleeves~~ → ; feedersleeves, . Feedersleeves	Punctuation in Compound/Complex Sentences	Correctness
37.	~~the steel~~ → the steel	Improper Formatting	Correctness
38.	~~for minimizing~~ → for minimizing	Improper Formatting	Correctness
39.	~~minimizing~~ → reducing	Word Choice	Engagement
40.	~~to~~ → on	Wrong or Missing Prepositions	Correctness
41.	~~become~~ → becomes	Faulty Subject-Verb Agreement	Correctness
42.	a sleeve	Determiner Use (a/an/the/this, etc.)	Correctness
43.	~~doi~~ → DOI	Misspelled Words	Correctness
44.	*chwrorinov*	Unknown Words	Correctness
45.	*be designed*	Passive Voice Misuse	Clarity
46.		Intricate Text	Clarity
47.	~~A notable~~ → An important	Word Choice	Engagement
48.	*was taken*	Passive Voice Misuse	Clarity
49.	~~any casting~~ → anycasting	Confused Words	Correctness
50.	~~volume~~ → amount, quantity, size	Word Choice	Engagement
51.	~~thus~~	Wordy Sentences	Clarity

52.	*is thus found*	Passive Voice Misuse	Clarity
53.	~~greatest~~ → highest	Word Choice	Engagement
54.	i.e.,	Comma Misuse within Clauses	Correctness
55.	, and	Comma Misuse within Clauses	Correctness
56.	*be applied*	Passive Voice Misuse	Clarity
57.	*are intended*	Passive Voice Misuse	Clarity
58.		Intricate Text	Clarity
59.	reasons,	Comma Misuse within Clauses	Correctness
60.	the value	Determiner Use (a/an/the/this, etc.)	Correctness
61.	~~has~~ → have	Faulty Subject-Verb Agreement	Correctness
62.		Intricate Text	Clarity
63.	~~efficiency~~ → ability, energy	Word Choice	Engagement
64.	~~which~~	Pronoun Use	Correctness
65.	~~chworinov~~ → chlorine	Misspelled Words	Correctness
66.	the solidification	Determiner Use (a/an/the/this, etc.)	Correctness
67.	*be done*	Passive Voice Misuse	Clarity
68.	the modulus	Determiner Use (a/an/the/this, etc.)	Correctness
69.	the exothermic-insulating, or an exothermic-insulating	Determiner Use (a/an/the/this, etc.)	Correctness

70.	the literature	Determiner Use (a/an/the/this, etc.)	Correctness
71.	~~a same~~ → the same	Determiner Use (a/an/the/this, etc.)	Correctness
72.	, which	Punctuation in Compound/Complex Sentences	Correctness
73.	thickness .	Improper Formatting	Correctness
74.	a solid	Determiner Use (a/an/the/this, etc.)	Correctness
75.	~~simulator~~ → simulators	Incorrect Noun Number	Correctness
76.	Moreover,	Punctuation in Compound/Complex Sentences	Correctness
77.	another experiment, other experiments	Determiner Use (a/an/the/this, etc.)	Correctness
78.	~~done~~ → was done	Incorrect Verb Forms	Correctness
79.	*foseco*	Unknown Words	Correctness
80.	~~a b~~ → A b	Improper Formatting	Correctness
81.	, which	Punctuation in Compound/Complex Sentences	Correctness
82.	C8000,	Punctuation in Compound/Complex Sentences	Correctness
83.	~~become~~ → becomes	Faulty Subject-Verb Agreement	Correctness
84.	~~steel which~~ → steel which	Improper Formatting	Correctness

85.	, which	Punctuation in Compound/Complex Sentences	Correctness
86.		Intricate Text	Clarity
87.	~~additional~~ → new	Word Choice	Engagement
88.	~~additional~~ → addition	Confused Words	Correctness
89.	, C8000	Punctuation in Compound/Complex Sentences	Correctness
90.	a short	Determiner Use (a/an/the/this, etc.)	Correctness
91.	~~short~~ → quick	Word Choice	Engagement
92.	term,	Comma Misuse within Clauses	Correctness
93.	~~easier~~ → more comfortable, more accessible, more natural, more straightforward	Word Choice	Engagement
94.	~~alloy~~ → alloys	Incorrect Noun Number	Correctness
95.	, which	Punctuation in Compound/Complex Sentences	Correctness
96.	*be taken*	Passive Voice Misuse	Clarity
97.	*As told before solidification test should be taken in identifying the MEF value of the sleeve.*	Incomplete Sentences	Correctness
98.	*be taken*	Passive Voice Misuse	Clarity
99.	~~taken~~ → made	Word Choice	Engagement
100.	the feeder	Determiner Use (a/an/the/this, etc.)	Correctness

101.	, which	Punctuation in Compound/Complex Sentences	Correctness
102.	~~have~~ → has	Faulty Subject-Verb Agreement	Correctness
103.	a thermocouple	Determiner Use (a/an/the/this, etc.)	Correctness
104.	, which	Punctuation in Compound/Complex Sentences	Correctness
105.	the thermal	Determiner Use (a/an/the/this, etc.)	Correctness
106.		Intricate Text	Clarity
107.	the exothermic-insulating	Determiner Use (a/an/the/this, etc.)	Correctness
108.	, which	Punctuation in Compound/Complex Sentences	Correctness
109.	~~have~~ → has	Faulty Subject-Verb Agreement	Correctness
110.	, and	Punctuation in Compound/Complex Sentences	Correctness
111.	~~dimension~~ → size, aspect, proportion	Word Choice	Engagement
112.	*be kept*	Passive Voice Misuse	Clarity
113.	material :	Improper Formatting	Correctness
114.	thickness :	Improper Formatting	Correctness
115.	~~mould~~ → mold	Mixed Dialects of English	Correctness

116.	) :	Improper Formatting	Correctness
117.	Mould :	Improper Formatting	Correctness
118.	temperature :	Improper Formatting	Correctness
119.	cover :	Improper Formatting	Correctness
120.	determine to	Incorrect Verb Forms	Correctness
121.	~~risering~~ → rising	Misspelled Words	Correctness
122.	~~for~~	Wordy Sentences	Clarity
123.	*DISCUSSION SOLIDIFICATION PROCESS Temperature Gradient*	Intricate Text	Clarity
124.	the solidification	Determiner Use (a/an/the/this, etc.)	Correctness
125.	~~have~~ → has	Faulty Subject-Verb Agreement	Correctness
126.	*been shown*	Passive Voice Misuse	Clarity
127.	~~feeder~~ → feeders	Incorrect Noun Number	Correctness
128.	the same	Determiner Use (a/an/the/this, etc.)	Correctness
129.	~~second~~ → seconds	Incorrect Noun Number	Correctness
130.	, which	Punctuation in Compound/Complex Sentences	Correctness
131.	*be held*	Passive Voice Misuse	Clarity

132.	~~hold~~ → kept, maintained, retained	Word Choice	Engagement
133.	~~second~~ → seconds	Incorrect Noun Number	Correctness
134.	~~hold~~ → stay, keep	Word Choice	Engagement
135.	~~hold~~ → holds	Faulty Subject-Verb Agreement	Correctness
136.	~~second~~ → seconds	Incorrect Noun Number	Correctness
137.	of several	Wrong or Missing Prepositions	Correctness
138.	The first	Determiner Use (a/an/the/this, etc.)	Correctness
139.	~~, it's~~ → ; it's, , and it's, . It's	Punctuation in Compound/Complex Sentences	Correctness
140.	~~surface~~ → surfaces	Incorrect Noun Number	Correctness
141.	~~sleeve~~ → jacket	Word Choice	Engagement
142.	the correlation	Determiner Use (a/an/the/this, etc.)	Correctness
143.	*is determined*	Passive Voice Misuse	Clarity
144.	the solidification	Determiner Use (a/an/the/this, etc.)	Correctness
145.	*solidification time sand feeder module*	Intricate Text	Clarity
146.	*The value of MEF is determined from solidification time sand feeder module/sleeve feeder module, the result from the solidification time is below :*	Hard-to-read text	Clarity
147.	~~parallel~~ → parallels	Faulty Subject-Verb Agreement	Correctness
148.	~~have~~ → has	Faulty Subject-Verb	Correctness

		Agreement	
149.	~~have an effect on~~ → affect	Wordy Sentences	Clarity
150.	a sand	Determiner Use (a/an/the/this, etc.)	Correctness
151.	an equiaxed	Determiner Use (a/an/the/this, etc.)	Correctness
152.	~~zone~~ → area	Word Choice	Engagement
153.	, which	Punctuation in Compound/Complex Sentences	Correctness
154.	is going	Incorrect Verb Forms	Correctness
155.	at the	Wrong or Missing Prepositions	Correctness
156.	~~simpler~~ → more straightforward, more uncomplicated	Word Choice	Engagement
157.	~~greater~~ → higher	Word Choice	Engagement
158.	~~a~~ greater	Determiner Use (a/an/the/this, etc.)	Correctness
159.	~~greater~~ → higher	Word Choice	Engagement
160.	~~to~~ → on	Wrong or Missing Prepositions	Correctness
161.	, and	Comma Misuse within Clauses	Correctness
162.		Intricate Text	Clarity
163.	~~effect~~ → result, fact	Word Choice	Engagement
164.	*The effect obtained from the solidification testing and plate testing.*	Incomplete Sentences	Correctness
165.	~~second~~ → seconds	Incorrect Noun Number	Correctness

166.	~~sleeve~~ → Sleeve	Improper Formatting	Correctness
167.	the sleeve	Determiner Use (a/an/the/this, etc.)	Correctness
168.	*be held*	Passive Voice Misuse	Clarity
169.	~~hold~~ → stay, keep	Word Choice	Engagement
170.	~~hold~~ → holds	Faulty Subject-Verb Agreement	Correctness
171.	~~second~~ → seconds	Incorrect Noun Number	Correctness
172.	, which	Punctuation in Compound/Complex Sentences	Correctness
173.	*is shown*	Passive Voice Misuse	Clarity
174.	~~, the~~ → ; the, . The	Punctuation in Compound/Complex Sentences	Correctness
175.	*is increased*	Passive Voice Misuse	Clarity
176.	~~greater~~ → higher	Word Choice	Engagement
177.	, which	Punctuation in Compound/Complex Sentences	Correctness
178.	~~have~~ → has	Faulty Subject-Verb Agreement	Correctness
179.	, which	Punctuation in Compound/Complex Sentences	Correctness
180.	a material, or the material	Determiner Use (a/an/the/this, etc.)	Correctness
181.	the foundry	Determiner Use	Correctness

		(a/an/the/this, etc.)	
182.	~~bandung~~ → Bandung	Misspelled Words	Correctness
183.	a partner	Determiner Use (a/an/the/this, etc.)	Correctness
184.	, and	Comma Misuse within Clauses	Correctness
185.	~~which~~ → who	Pronoun Use	Correctness
186.	the experiment	Determiner Use (a/an/the/this, etc.)	Correctness
187.	~~indian~~ → Indian	Misspelled Words	Correctness
188.	~~standard~~ → rule	Word Choice	Engagement
189.	, and	Comma Misuse within Clauses	Correctness
190.	~~",~~ → ,"	Misuse of Semicolons, Quotation Marks, etc.	Correctness
191.	~~indian~~ → Indian	Misspelled Words	Correctness
192.	~~indian~~ → Indian	Misspelled Words	Correctness