Spot Welding of Bimetallic White Cast Iron-Nodular Cast Iron

by Rendi Reynaldi

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5	Wrong or missing prepositions
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31	Determiner use (a/an/the/this, etc.)
4	Closing punctuation
1	Modal verbs
12	Punctuation in compound/complex sentences
7	Comma misuse within clauses
29	Improper formatting
3	Incomplete sentences
5	Incorrect noun number
3	Misplaced words or phrases
2	Confused words
4	Misspelled words
1	Unknown words
1	Conjunction use
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Measures average sentence length

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words per sentence

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Abstract. A bimetallic product is the result of the manufacturing process in the form of unification of two materials that have different characteristics so as to[1] obtain a product that has two different properties to be able to meet the specific technical demands as needed.[2] Bimetallic products can be used in[3] for punch and dies[4] for manufacturing tooling. In the manufacture of the dies, hard surfaces and strong[5] inner surfaces are required, thus often applying surface

hardening processes[6] to obtain both properties. The process[7] of making and repairing this tool is by applying[8] bimetallic[9] system with spot welding. The basic[1] part is made of nodular cast iron, while the surface is made[11] of white cast iron. By applying[12] electrical current for specific exposure time, a bonding area is built[1] at the interface of both material s. This[14] might consist of fusion[15] and diffusion area. For the thickness of 3mm for each of both materials[16], electrical[17] current of 40A and exposure time of 15 seconds results a[18] joint[19] interface without any crack and acceptable metallurgical bonding. Testing and analysis of the results have been conducted[20] through microstructure analysis and energy dispersive spectrometry.[21] The results of this study can be applied further on the manufacture of all technical products that require the fusion of two different material properties[22,23]

INTRODUCTION

Bimetallic goods are widely used[24] as elements in many technical applications which operate in mainly two different conditions. Punch and Dies as forming tools require hard surface until certain depth, while the inner part should performs[25] high impact[26] resistance and toughness. The manufacturing of bimetal products can apply several different methods. In general, the technology of bimetal making consists of two materials which[27] are unified[28] on three systems, i.e.[29] solid-solid, liquid-semi liquid, and liquid-solid. Most of these are based[30] on the metallurgical bonding along[31] the interface between the two constituent materials.

Hessamoddin Moshayedi [1] discovered that the thickness of a nugget is usually less than the thickness[32] of two sheets of metal.[33] The indentation of this nugget is not significant for plate thickness up to 1 mm, but more significant on thick plates / objects.[34] When[35] the change in thickness causes a concentrated voltage at the edges, which may result in initial cracking. Once the welding process in the voltage[36] can still occur / formed[37] in the object.[38]

Daniel J. B. [2] defined a pattern of electrical resistance calculations for symmetric nuggets through the calculation of[39] the total resistance R (t) defined by

R (t) = 2.RB (t) + RC (t) + 2.RELM (t) (1) Z. Han [3] found an association between holding cycle with total crack length at resistance spot welding for steels indicating the optimal value of 19 capping cycles as hold time with the shortest crack. The experiments are performed[40] on high tensile steel with 12KA current, load 1600 Lbs. Triyono [4] proved that there are differences in electrical resistance due to differences in the thickness of objects. This condition causes a heat imbalance if spot[41,42]

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welding[43] is performed[44] on objects of different thickness.[45] As a result, an asymmetrical welding nugget will be formed,[46] in which the nuggets[47] size and depth of thinner side penetration will be smaller than the thicker side of the bag. It is found[48] that the 2-1 mm welding nuggets and 3-1 mm specimens of the asymmetric shape while the symmetrical weld nuggets appear in the joints of the same thickness (1-1 mm joints).

There are[49] differences[50] in[51] electrical[52] resistance[53] due[54] to[55] different[56] objects.[57] Thin objects[58] have[59] lower[60] electrical[61] resistance. Electrical resistance affects the heat generated and the formation of nuggets. Low electrical resistance causes less heat and smaller size zone sizes. In contrast, thick plates produce higher heat and larger fusion zones. This condition causes a heat imbalance if spot welding is performed[62] on objects of different thickness[63]. As a result, an asymmetrical welding nugget will be formed[64], where the size of the nugget and the penetration depth of the thin sides of the sides will be smaller than the thick sides of the bag. This phenomenon is evidenced[65] in Figure 1. The macrostructures are a) 1-1 mm (b) 2-1 mm (c) 3-1 mm [4]. It is found[66] that the weld nuggets are 2-1 mm and 3-1 mm specimens of asymmetric shape while symmetrical welding nuggets appeared on the joints of the same thickness (1 -

1 mm joints). The heat imbalance will occur when different thicknesses of the same material, the same thickness[67] of different materials, or a combination of the two join using spot resistance welds [5]

FIGURE 1. Macrostructure (a) 1-1 mm (b) 2-1 mm (c) 3-1 mm [11]

To generate crack-free nuggets and corresponding sizes, appropriate current settings, holding time and compression are required. Han [3] found that the minimum crack length for the steel was obtained at a holding time of 17 cycles. The basic concept of technology applied in this research is the spot welding of two different types of metallic material to produce a bimetallic material . These two materials were joint metallurgical by mean of fusion and diffusion bonding at the contact area. The proper temperature of preheating and the contact interface temperature should be the concern of this work as well. The preheating temperature should avoid the initiation of crack. This research focuses on the spot welding process without any preheating.

METHODOLOGY

The study includes bimetallic material by means of spot welding which comprises of two parts, hard material and ductile material. Both materials are coupled and pressed together while sufficient electrical current is flown. Table 1 and 2 describe the chemical composition of the component materials of bimetallic material used in this study.

TABLE 1. Chemical composition of the NiHard1 white cast iron casting

C (%wt.)	Si (%wt.)	Mn (%wt.)	P (%wt.)	S (%wt.)	Ni (%wt.)	Cr (%wt.)
3.36	0.38	0.27	0.007	0.009	3.9	2.07

TABLE 2. Chemical composition of the ductile cast iron

C (%wt.)	Si (%wt.)	Mn (%wt.)	P (%wt.)	S (%wt.)
3.74	2.2	0.27	-	0.01

The thickness of the specified object ranges from 5-10 mm for each constituent material. The shape of the object is in a shape [85] of a plate. The determination of barrier value is done [86] by method [87] of direct measurement on object [88]. The energy needed at spot welding is converted [89] from the amount of energy required to melt [90] a number of [91] materials at the interface area. The amount of current and welding time is determined [92] by the amount of energy required. $E = 0.24$

I^2Rt. The experiments are conducted with varying current and time variations to obtain fusion area thickness in the interface zone. The trial results are tested [93] with an optical microscope. This test is carried[94] out through a series of sample preparation and observation processes. EDS testing is conducted[95] to analyze the chemical composition of material[96] at the interface area. The results of microstructure testing are analyzed based on phase change, fusion zone formation, heat affected[97] zone.[98] This analysis also studies the effects of thermal shock on the material microstructure and material resistance. The phase change is examined[99] for both the base material and the interface zone.

RESULTS AND DISCUSSION OF STUDIES

Each of bimetallic[100] products is examined and visually assessed. For further qualitative and quantitative evaluation metallographic[101] analysis is conducted. Testing and microscopically examination is conducted[102,103] on the whole samples of bimetallic[104] product in order to[105] evaluate[106,107] the[108] possibility of[109] cracks in[110] the[111] joint[112] area[1] and[114] base[115] material[116] and the[117] microstructure in this area.[118]

a) b)

c) d)

FIGURE 2 .[119] Microstructure[120] of a bimetallic material, a) interface zone consists of diffusion bonded zone and separate zone, b)interface zone with fusion bonding, c) base material d) fusion area and crack

There are mainly three zones present in the joint[121] area of bimetallic[122] product microstructure, as shown in Figure 2. The basic material[123] of inner[124] ring consists of eutectic nodular graphite in the matrix of pearlite and ferrite (c).[125] The second zone, which is the basic[126] material of hard plate[127] has microstructure typical for white cast iron Nihard 1 grade. The formation of ledeburitic[128,129] microstructure of martensite and chromium carbide is clearly described.[130] The third zone is the interface or transition zone which[131] can be diffusion bonded microstructure, fusion bonded microstructure or a[132] combination of these.[133]

Microstructure changes on the base material

The grain size of Nihard 1[134] microstructure near to the interface shows significant[135] difference to the similar microstructure in the base material.[136] The grain close to the interface is finer[137] and marked by the presence of blade shape carbide.

Microstructures of the ductile cast iron in the base material are not changed significantly. Moreover, the solid state[138] of the ductile iron annihilates the possibilities of new grain formation. Preheating of inner[139] ring does not affect the microstructure of ductile[140,141] iron base. However, there is microstructure change occurred near to the interface due to the diffusion of elements and partial melting.

The formation of microstructure at the interface

The microstructure of interface[142] area consists of ferrite, carbide, perlite and[143] graphite. Pearlite is formed in colony[144] near to the center of interface[145] area and becomes the dominant phase at the interface due to the change of nickel and silicon content at the interface. Silicon belongs to the element that promotes ferrite. In the interface area, Ni-Hard diffuses partially into the nodular cast iron, which furthermore causes a decrease of silicon content, since NiHard has lower silicon. Ferrite becomes hereby[146] more unstable and get[147] coupled[148]

Atoms of carbon are derived[149] from graphite. Ferrite has subsequently[150] the maximum level of carbon content. At the fusion zone, lower silicon content and high nickel content promotes the formation of pearlite. Carbides which is formed[151] at the interface is similar to that of the base carbide material Ni- Hard,[152] as is indicated with the same chemical composition[153,154]

Austenite and martensite has[155] not been formed[156] [157], since nickel as an austenite[158] stabilizing element diffuses only partially into the alloy.[159] To verify the change in elementary[160] content of the microstructure EDS,[161] examination[162] has been conducted[163].

Microstructure observation using SEM finds two areas, namely the area[164] of fusion and diffusion. In the area[165] of fusion, the distribution of graphite is denser than that in the fusion area, since the two materials are in a liquid state.[166] Although graphite is considered stable, but[167] due to the melting process that occurred, the graphite at the interface could move freely so[168] the graphite tent to less dense.[169] Part of graphite deteriorates and[170] its carbon atom diffuses in the surrounding matrix of Fe and forms another phase, due to the higher diffusion coefficient of graphite on liquid[171] conditions. Microstructure in the fusion area is similar to the micro structure[172] in the Ni-Hard 1. However, there are differences in carbide morphology, in which carbides formed in the area[173] of fusion have a blade-shaped form. Microstructure formed at the interface is dominated[174] by pearlite, but the number of carbides is higher than the two previous specimens. There are two types of carbides at the interface in this specimen, carbide similar to that contained in the base material Ni- Hard[175] 1 and carbides without nickel content in it.[176] The first type of carbides forms in the identical conditions with the formation of eutectic carbides in the base material Ni-Hard 1. The second type is formed[177] by the diffusion of nickel and silicon, which came from the first type carbide. Due to the high temperature, nickel[178] and silicon have the ability to[179] diffuse better. This[180] has been verified[182] by the content of nickel and[183] silicon carbide, in which the first type shows higher the content of both elements.[181]

In the diffusion area, there is practically no longer ferrite present, this[184] happens because of the lower silicon content in the interface. Carbides has[185] a discrete morphology, and compositionally different from the carbide on the base material of Ni-Hard. This[186] is caused[187] by the higher temperature at the interface, in which chromium, nickel, and carbon have the ability to[188] diffuse better. Nickel diffuses into the pearlite phase, while carbon[189] and chromium diffuses[190] into carbide.

Figure 3 shows the area of spot analysis for EDS[191] examination at the interface area and the elemental content. It appears that chemical[192] composition of the interface area shows discrepancy[193] from those of the base material. As described in Figure 4, the silicon content of 1.48% at the interface area promotes the formation of ferrite, whereas the[194] content of Cr and Ni[195] as mentioned before, put themselves each on carbide and pearlite. High nickel content in the alloy and the lower silicon content cause the formation of pearlite colonies without the presence of[196] any ferrite.

The percentage of silicon content in the ferrite is higher than the percentage[197] of silicon at the interface as a whole.

214 This[198] is an indication that most of the silicon put itself in the ferrite.

Chemical composition of phase at the interface area.[199]

FIGURE 3.area of spot analysis

FIGURE 4. Selected Area at the interface for testing of chemical composition with EDS

CONCLUSION

215 Based on the obtained results, it can be concluded[200] that influential parameters for creation[201] of[202] a metallurgical bonding at the interface of bimetallic spot welding without the presence of crack,[203] i.e.[204] NiHard and ductile cast iron are electrical current, exposure time and the available pressure. On the side of the base material of the bimetallic casting, no change in graphite size and distribution occurred during the welding process. Some changes in elemental content, particularly Cr, Ni and[205] C[206] have taken place and contributed to the changes of microstructure.[207] There is a transition zone formed at the interface as a result of fusion[208] of both materials which[209] influences the chemical content of each prevailing microstructure, mainly in the solid solution matrix. The chemical composition obtained in this zone determines the properties of carbides and matrix structure. Fusion[210] process at the interface results[211] broader

transition zone and causes microstructure changes, in which the graphite is dispersed and reduced in its number and size. The hardness of carbide in this area is slightly lower than that in the base material.

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1.	~~so as to~~ → to	Wordy Sentences	Clarity
2.		Intricate Text	Clarity
3.	~~in~~	Wrong or Missing Prepositions	Correctness
4.	~~dies~~ → die	Faulty Subject-Verb Agreement	Correctness
5.	~~strong~~ → sturdy, firm, durable, stable	Word Choice	Engagement
6.	~~processes~~	Wordy Sentences	Clarity
7.	~~process~~ → method	Word Choice	Engagement
8.	~~applying~~ → using	Word Choice	Engagement
9.	a bimetallic	Determiner Use (a/an/the/this, etc.)	Correctness
10.	~~basic~~ → essential, fundamental, necessary, primary	Word Choice	Engagement
11.	*is made*	Passive Voice Misuse	Clarity
12.	~~applying~~ → using	Word Choice	Engagement
13.	*is built*	Passive Voice Misuse	Clarity
14.	*This*	Intricate Text	Clarity
15.	the fusion	Determiner Use (a/an/the/this, etc.)	Correctness
16.	~~materials~~ → elements	Word Choice	Engagement
17.	an electrical	Determiner Use (a/an/the/this, etc.)	Correctness
18.	in a	Wrong or Missing Prepositions	Correctness

19.	~~a joint~~ → a common	Word Choice	Engagement
20.	*been conducted*	Passive Voice Misuse	Clarity
21.	*Testing and analysis of the results have been conducted through microstructure analysis and energy dispersive spectrometry.*	Hard-to-read text	Clarity
22.		Intricate Text	Clarity
23.	properties.	Closing Punctuation	Correctness
24.	*are widely used*	Passive Voice Misuse	Clarity
25.	~~performs~~ → perform	Modal Verbs	Correctness
26.	perform high-impact	Wordy Sentences	Clarity
27.	, which	Punctuation in Compound/Complex Sentences	Correctness
28.	*are unified*	Passive Voice Misuse	Clarity
29.	i.e.,	Comma Misuse within Clauses	Correctness
30.	*are based*	Passive Voice Misuse	Clarity
31.	along with	Wrong or Missing Prepositions	Correctness
32.	~~thickness~~ → width, diameter	Word Choice	Engagement
33.		Intricate Text	Clarity
34.	~~plates / objects~~ → plates/objects	Improper Formatting	Correctness
35.	~~. When~~ → when	Incomplete Sentences	Correctness
36.	~~voltage~~ → energy	Word Choice	Engagement
37.	~~occur / formed~~ → occur/formed	Improper Formatting	Correctness

38.	*Once the welding process in the voltage can still occur / formed in the object.*	Incomplete Sentences	Correctness
39.	~~the calculation of~~ → calculating	Wordy Sentences	Clarity
40.	*are performed*	Passive Voice Misuse	Clarity
41.	the spot, or a spot	Determiner Use (a/an/the/this, etc.)	Correctness
42.	spot.	Closing Punctuation	Correctness
43.	~~welding~~ → Welding	Improper Formatting	Correctness
44.	*is performed*	Passive Voice Misuse	Clarity
45.	~~thickness~~ → thicknesses	Incorrect Noun Number	Correctness
46.	*be formed*	Passive Voice Misuse	Clarity
47.	~~nuggets~~ → nugget's, nuggets'	Incorrect Noun Number	Correctness
48.	*is found*	Passive Voice Misuse	Clarity
49.	~~There are~~ → There are	Improper Formatting	Correctness
50.	are differences	Improper Formatting	Correctness
51.	~~differences in~~ → differences in	Improper Formatting	Correctness
52.	~~in electrical~~ → in electrical	Improper Formatting	Correctness
53.	electrical resistance	Improper Formatting	Correctness
54.	~~resistance due~~ → resistance due	Improper Formatting	Correctness
55.	~~due to~~ → due to	Improper Formatting	Correctness
56.	~~to different~~ → to different	Improper Formatting	Correctness

57.	different objects	Improper Formatting	Correctness
58.	~~Thin objects~~ → Thin objects	Improper Formatting	Correctness
59.	~~objects have~~ → objects have	Improper Formatting	Correctness
60.	~~have lower~~ → have lower	Improper Formatting	Correctness
61.	lower electrical	Improper Formatting	Correctness
62.	*is performed*	Passive Voice Misuse	Clarity
63.	~~thickness~~ → thicknesses	Incorrect Noun Number	Correctness
64.	*be formed*	Passive Voice Misuse	Clarity
65.	*is evidenced*	Passive Voice Misuse	Clarity
66.	*is found*	Passive Voice Misuse	Clarity
67.	~~thickness~~ → depth	Word Choice	Engagement
68.	*To generate crack-free nuggets and corresponding sizes*	Misplaced Words or Phrases	Correctness
69.	, and	Comma Misuse within Clauses	Correctness
70.	*was obtained*	Passive Voice Misuse	Clarity
71.	~~material~~ → content	Word Choice	Engagement
72.		Intricate Text	Clarity
73.	~~mean~~ → means	Incorrect Noun Number	Correctness
74.	~~as well~~	Wordy Sentences	Clarity
75.	~~by means of~~ → using, utilizing, employing, through	Wordy Sentences	Clarity
76.	, which	Punctuation in	Correctness

		Compound/Complex Sentences	
77.	~~of~~	Wrong or Missing Prepositions	Correctness
78.	~~material~~ → plastic, metal, stuff, content	Word Choice	Engagement
79.	, and	Comma Misuse within Clauses	Correctness
80.	~~ductile~~ → plastic	Word Choice	Clarity
81.	~~materials~~ → elements, documents	Word Choice	Engagement
82.	*are coupled*	Passive Voice Misuse	Clarity
83.	*is flown*	Passive Voice Misuse	Clarity
84.	~~Table~~ → Tables	Incorrect Noun Number	Correctness
85.	~~a shape~~ → the shape	Determiner Use (a/an/the/this, etc.)	Correctness
86.	*is done*	Passive Voice Misuse	Clarity
87.	the method, or a method	Determiner Use (a/an/the/this, etc.)	Correctness
88.	the object, or an object	Determiner Use (a/an/the/this, etc.)	Correctness
89.	*is converted*	Passive Voice Misuse	Clarity
90.	~~melt~~ → meet	Confused Words	Correctness
91.	~~a number of~~ → several, some, many	Wordy Sentences	Clarity
92.	*is determined*	Passive Voice Misuse	Clarity
93.	*are tested*	Passive Voice Misuse	Clarity
94.	*is carried*	Passive Voice Misuse	Clarity

95.	*is conducted*	Passive Voice Misuse	Clarity
96.	the material	Determiner Use (a/an/the/this, etc.)	Correctness
97.	~~heat affected~~ → heat-affected	Misspelled Words	Correctness
98.		Intricate Text	Clarity
99.	*is examined*	Passive Voice Misuse	Clarity
100.	the bimetallic	Determiner Use (a/an/the/this, etc.)	Correctness
101.	, metallographic	Punctuation in Compound/Complex Sentences	Correctness
102.	*is conducted*	Passive Voice Misuse	Clarity
103.	~~conducted~~ → done, performed, held	Word Choice	Engagement
104.	the bimetallic	Determiner Use (a/an/the/this, etc.)	Correctness
105.	~~in order~~ → in order	Improper Formatting	Correctness
106.	~~in order to~~ → to	Wordy Sentences	Clarity
107.	~~order to~~ → order to	Improper Formatting	Correctness
108.	~~to evaluate~~ → to evaluate	Improper Formatting	Correctness
109.	the possibility	Improper Formatting	Correctness
110.	~~of cracks~~ → of cracks	Improper Formatting	Correctness
111.	~~in the~~ → in the	Improper Formatting	Correctness
112.	~~the joint~~ → the joint	Improper Formatting	Correctness
113.	~~joint area~~ → joint area	Improper Formatting	Correctness

114.	~~area and~~ → area and	Improper Formatting	Correctness
115.	~~and base~~ → and base	Improper Formatting	Correctness
116.	~~base material~~ → base material	Improper Formatting	Correctness
117.	~~and the~~ → and the	Improper Formatting	Correctness
118.		Intricate Text	Clarity
119.	2 .	Improper Formatting	Correctness
120.	The microstructure	Determiner Use (a/an/the/this, etc.)	Correctness
121.	~~joint~~ → common	Word Choice	Engagement
122.	the bimetallic	Determiner Use (a/an/the/this, etc.)	Correctness
123.	~~basic~~ → primary	Word Choice	Engagement
124.	the inner	Determiner Use (a/an/the/this, etc.)	Correctness
125.		Intricate Text	Clarity
126.	~~basic~~ → primary	Word Choice	Engagement
127.	plate,	Punctuation in Compound/Complex Sentences	Correctness
128.	*ledeburitic*	Unknown Words	Correctness
129.	the ledeburitic	Determiner Use (a/an/the/this, etc.)	Correctness
130.	*is clearly described*	Passive Voice Misuse	Clarity
131.	, which	Punctuation in Compound/Complex Sentences	Correctness

132.	, or	Comma Misuse within Clauses	Correctness
133.	*The third zone is the interface or transition zone which can be diffusion bonded microstructure, fusion bonded microstructure or a combination of these.*	Hard-to-read text	Clarity
134.	the Nihard	Determiner Use (a/an/the/this, etc.)	Correctness
135.	a significant	Determiner Use (a/an/the/this, etc.)	Correctness
136.	*The grain size of Nihard 1 microstructure near to the interface shows significant difference to the similar microstructure in the base material.*	Hard-to-read text	Clarity
137.	~~finer~~ → more beautiful	Word Choice	Engagement
138.	~~solid state~~ → solid-state	Misspelled Words	Correctness
139.	the inner	Determiner Use (a/an/the/this, etc.)	Correctness
140.	~~ductile~~ → plastic, malleable, flexible, pliable	Word Choice	Engagement
141.	the ductile	Determiner Use (a/an/the/this, etc.)	Correctness
142.	the interface	Determiner Use (a/an/the/this, etc.)	Correctness
143.	, and	Comma Misuse within Clauses	Correctness
144.	a colony	Determiner Use (a/an/the/this, etc.)	Correctness
145.	the interface	Determiner Use (a/an/the/this, etc.)	Correctness

146.	~~hereby~~ → at this moment, now, as a result of this, with this	Outdated Language	Clarity
147.	~~get~~ → gets	Faulty Subject-Verb Agreement	Correctness
148.	coupled.	Closing Punctuation	Correctness
149.	*are derived*	Passive Voice Misuse	Clarity
150.	subsequently has	Misplaced Words or Phrases	Correctness
151.	*is formed*	Passive Voice Misuse	Clarity
152.	~~Ni- Hard~~ → Ni-Hard	Misspelled Words	Correctness
153.		Intricate Text	Clarity
154.	composition.	Closing Punctuation	Correctness
155.	~~has~~ → have	Faulty Subject-Verb Agreement	Correctness
156.	*been formed*	Passive Voice Misuse	Clarity
157.	formed,	Punctuation in Compound/Complex Sentences	Correctness
158.	~~an~~ austenite	Determiner Use (a/an/the/this, etc.)	Correctness
159.	*Austenite and martensite has not been formed, since nickel as an austenite stabilizing element diffuses only partially into the alloy.*	Hard-to-read text	Clarity
160.	the elementary	Determiner Use (a/an/the/this, etc.)	Correctness
161.	*To verify the change in elementary content of the microstructure EDS*	Misplaced Words or Phrases	Correctness
162.	the examination, or an examination	Determiner Use (a/an/the/this, etc.)	Correctness

163.	*been conducted*	Passive Voice Misuse	Clarity
164.	~~area~~ → field, city	Word Choice	Engagement
165.	~~area~~ → field	Word Choice	Engagement
166.		Intricate Text	Clarity
167.	~~but~~	Conjunction Use	Correctness
168.	, so	Punctuation in Compound/Complex Sentences	Correctness
169.		Intricate Text	Clarity
170.	, and	Punctuation in Compound/Complex Sentences	Correctness
171.	~~liquid~~ → wet, damp, moist	Word Choice	Engagement
172.	~~micro structure~~ → microstructure	Confused Words	Correctness
173.	~~area~~ → field	Word Choice	Engagement
174.	*is dominated*	Passive Voice Misuse	Clarity
175.	~~Ni- Hard~~ → Ni-Hard	Misspelled Words	Correctness
176.		Intricate Text	Clarity
177.	*is formed*	Passive Voice Misuse	Clarity
178.	~~nickel~~ → metal	Word Choice	Engagement
179.	~~have the ability to~~ → can	Wordy Sentences	Clarity
180.	*This*	Intricate Text	Clarity
181.	*This has been verified by the content of nickel and silicon carbide, in which*	Wordy Sentences	Clarity

the first type shows higher the content of both elements.

182.	*been verified*	Passive Voice Misuse	Clarity
183.	~~nickel~~ → metal	Word Choice	Engagement
184.	~~, this~~ → ; this, , and this, . This	Punctuation in Compound/Complex Sentences	Correctness
185.	~~has~~ → have	Faulty Subject-Verb Agreement	Correctness
186.	*This*	Intricate Text	Clarity
187.	*is caused*	Passive Voice Misuse	Clarity
188.	~~have the ability to~~ → can	Wordy Sentences	Clarity
189.	~~carbon~~ → coal	Word Choice	Engagement
190.	~~diffuses~~ → diffuse	Faulty Subject-Verb Agreement	Correctness
191.	the EDS	Determiner Use (a/an/the/this, etc.)	Correctness
192.	the chemical	Determiner Use (a/an/the/this, etc.)	Correctness
193.	a discrepancy	Determiner Use (a/an/the/this, etc.)	Correctness
194.	~~, whereas the~~ → . The	Hard-to-read text	Clarity
195.	Ni,	Punctuation in Compound/Complex Sentences	Correctness
196.	~~the presence of~~	Wordy Sentences	Clarity
197.	~~percentage~~ → rate	Word Choice	Engagement
198.	*This*	Intricate Text	Clarity

199.	*Chemical composition of phase at the interface area.*	Incomplete Sentences	Correctness
200.	*be concluded*	Passive Voice Misuse	Clarity
201.	the creation	Determiner Use (a/an/the/this, etc.)	Correctness
202.	~~creation of~~ → creating	Wordy Sentences	Clarity
203.	a crack	Determiner Use (a/an/the/this, etc.)	Correctness
204.	i.e.,	Comma Misuse within Clauses	Correctness
205.	, and	Comma Misuse within Clauses	Correctness
206.	C,	Punctuation in Compound/Complex Sentences	Correctness
207.		Intricate Text	Clarity
208.	the fusion	Determiner Use (a/an/the/this, etc.)	Correctness
209.	, which	Punctuation in Compound/Complex Sentences	Correctness
210.	The fusion	Determiner Use (a/an/the/this, etc.)	Correctness
211.	results in	Wrong or Missing Prepositions	Correctness
212.	~~",~~ → ,"	Misuse of Semicolons, Quotation Marks, etc.	Correctness
213.	*Human-Dedicated Sustainable Product and Process Design: Materials, Resources, and Energy AIP*	Volume 1977: Human-Dedicated Sustainable Product and ... https://printorders.aip.org/proceedings/1977	Originality
214.	*This is an indication that most of the*	This is an indication that most of the parents may not ...	Originality

		https://www.coursehero.com/file/p1bmh4d/This-is-an-indication-that-most-of-the-parents-may-not-encourage-their-girls-to/	
215.	*Based on the obtained results, it can be concluded that*	Studies on seasonal population dynamics of the citrus leaf miner, Phyllocnistis citrella stainton (lepidoptera: gracillariidae) on kinnow in submontaneous region of Punjab	Originality