

# Making Steel Products by Investment Casting Method Using Local Material

by Rendi Reynaldi

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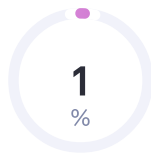
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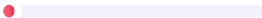
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## Writing Issues

<b>297</b>	<b>Correctness</b>	
79	Determiner use (a/an/the/this, etc.)	
28	Comma misuse within clauses	
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20	Faulty subject-verb agreement	
12	Incorrect noun number	
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32	Misspelled words	
2	Text inconsistencies	
49	Improper formatting	
6	Confused words	
6	Incomplete sentences	
7	Closing punctuation	
6	Incorrect verb forms	
2	Misplaced words or phrases	
1	Modal verbs	
5	Unknown words	
2	Misuse of modifiers	
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1	Pronoun use	
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66	Passive voice misuse	
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87 Word choice 

1 Monotonous sentences 

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words per sentence

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Making Steel Products by Investment Casting Method Using Local Materials

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## Abstract

Investment casting, also known as lost wax precision casting process is the technology used to produce a casting<sup>1</sup> products which have complex geometry shapes, surface smoothness, shape and<sup>2</sup> dimensional precision, thus<sup>3</sup> the resulting products performs<sup>4</sup> high quality and added value. Impeller could be<sup>5</sup> considered as one of the example<sup>6</sup> of the investment casting product. In Indonesia, the investment<sup>7</sup> casting technology has not yet been widely applied<sup>8</sup>. Only few<sup>9</sup> industries use this technology. The manufacturing technology,

machineries <sup>10</sup> and materials <sup>11</sup> are still imported. By analyzing the required <sup>12</sup> process and materials, which <sup>13</sup> is then followed by some trials and analysis, this study provides an alternative use of local materials and simple technology to produce good <sup>14</sup> quality products. This <sup>15</sup> can subsequently be applied in small-medium scale industries and in <sup>16</sup> educational <sup>17</sup> institute. <sup>18</sup> The research has resulted a <sup>19</sup> formula of modeling wax, slurry <sup>20</sup> and the <sup>21</sup> processing <sup>22</sup> techniques. The experiments performed in this research to produce the impeller used steel (DIN standard GS30Mn5) as the main <sup>23</sup> material.

Keywords: Investment casting, wax <sup>24</sup>, ceramic slurry, impeller, GS30Mn5

## INTRODUCTION

Along with the increasing needs of foundry products in the manufacture of small dimension <sup>25</sup>, precision <sup>26</sup> and smooth surfaces, metal casting industries are required <sup>27</sup> to develop the technology so that it can fulfill those needs. Investment <sup>28</sup> casting method is one alternative to improve productivity and product quality castings, especially its ability to produce precision, small tolerances, surface finish, minimum machining, shape and size of the complex objects that can not <sup>30</sup> be produced by other casting methods. <sup>31</sup> In addition, investment casting method <sup>32</sup> can be used for very specific types of material <sup>33</sup> retaining high hardness that can <sup>34</sup> not be processed by machining of those casting products so that the results can be directly used <sup>37</sup> <sup>38</sup> . Only a few numbers of industries develop investment casting technology due to some reasons i.e <sup>39</sup> the <sup>40</sup> technology of investment casting it self <sup>41</sup> <sup>42</sup> , and the availability of raw materials and machinery. Most of these materials are imported <sup>43</sup> <sup>44</sup> so the production cost is relatively expensive. The

high cost operation problem of investment casting can be overcome by substitution of materials and machinery imported by local materials, as did Hafid et al (2002) in the manufacture of FCD rocker arm 70. Therefore, this research is aimed to produce the optimum formula of wax and slurry in the steel investment casting technology by using local materials.

The main factors affecting the precision of products investment casting are model (pattern), the slurry, process design and the equipment of investment casting involved. The model is highly dependent on the characteristics of the wax against shrinkage, strength, and reaction to the slurry. Slurry quality is highly dependent on the characteristic and composition of materials. Wax is used as a medium for making ceramic patterns, normally use paraffin with a melting point 50 - 70°C, expansion 2%, viscosity of 450 cPs. The melting properties, coefficient of contraction /shrinkage and the ability of paraffin to flow is strongly influenced by their chemical composition. Naturally, paraffin can cause problems due to the

expansion of paraffin, which is greater than the expansion of ceramic tiles during the dewaxing step. This subsequently lead to cracking. The original paraffin wax does not meet the desired characteristics, so that additives must be added to improve its characteristics, for example isophtalic acid, petroleum ether, etc. Slurry is used to make a high quality ceramic mold in term of shape and thickness, refractories characteristics, uniform particle size and even the reaction with the liquid metal and the thermal expansion. This research will cover the design of chemical composition of slurry, size/characteristics of base materials of slurry, wetting agents and mold making process. The other factor which plays a role in determining precision products is the process design of

investment casting. The research is aimed to produce a slurry formula-based wax and local materials as well as determining the appropriate technology in processing these materials. The outcomes of this study are the formula of the wax and slurry, the processing technique in slurring, dewaxing, firing and pouring as well as the mastery of investment casting technology .

The Outcomes in this research will impact on improving industrial capabilities in for examples producing local spare parts as substitution for which being imported, development in tool and machine manufacturing industries due to increasing capability in producing high precision casting, surface finish through the appropriate materials, increasing the industrial capability of providers of basic and refractory materials for investment casting process, developing the industrial capability in manufacturing prothese for medical need.. This research generally impart great contribution for both public and the society of manufacture industries in providing precision products as well as high quality and low cost by substituting imported materials with local ingredients.

□THEORY

Basically there are two distinct process for making investment casting molds i.e the solid investment process and the ceramic shell process. The later process has become predominant technique for engineering application.

There are some factors in ceramic shell investment casting process which should be considered :

Pattern materials

The primary material for pattern is wax. It is usually modified to improve their properties through the addition of materials such as resins, plastics, fillers, plasticizers, antioxidant and dyes.[4] There are several waxes available i.e paraffins,

microcrystalline, Ozocerite, Candelilla, Carnauba and beeswax. [9]

Additives <sup>122</sup> are often used for improving the <sup>123</sup> wax properties. These additives are polyethylene, <sup>124</sup> ethyl cellulose, nylon, ethylene vinyl acetate, and <sup>125</sup> ethylene vinyl acrylate. Resins are also often used to reduce shrinkage of wax patterns. The most useful <sup>126</sup> resins soften gradually and continuously with increasing temperature, and they do not exhibit the large solid to liquid expansions during heating, or the reverse contractions during cooling.

<sup>127</sup> Fillers are also used to reduce solidification shrinkage <sup>24,128</sup> of wax. These are insoluble <sup>129</sup> in, and higher melting <sup>130</sup> than, the base wax, and they produce an injectable suspension when the mixture is molten. Fillers do not contribute to the solidification shrinkage of the wax mixture because they do not melt. <sup>131</sup> Fillers that have been <sup>132,133</sup> used <sup>134</sup> in pattern waxes include polystyrene, various dicarboxamides <sup>135</sup> and related compounds, isophthalic acid, pentaerythritol, and hexamethylenetetramine. The <sup>136</sup> fillers should be in the form of small, <sup>137</sup> equally

size spheres.<sup>[5]</sup> Figure 1 shows <sup>138</sup> the manner in which fillers reduce expansion during heating.

Figure 1. Effects of filler materials on the volumetric thermal expansion of a pattern wax

Mold refractory

<sup>496</sup> Investment shell molds <sup>139</sup> are made by applying a series of ceramic coatings to the pattern clusters. Each <sup>140</sup> coating consists of a <sup>141</sup> fine ceramic layer with coarse ceramic particles embedded in its outer surface.



Slurry is a basic component for making ceramics. Slurry is basically consists of refractory materials, a binder and the solvent. Based on the layer of investment casting mold the slurry are grouped into primary and backup slurry. After the firing process and at pouring the primary slurry will come into direct contact with the liquid metal. Thus, the main properties required for the primary slurry is high sintering temperatures, high melting temperature, unreactive to the liquid and having a very fine grain size. Fine grain size will produce high quality castings with smooth surfaces, which would then be able to improve or ensure the precision, size and shape of the casting. Backup slurry is an supporting material added to slurry after the primary slurry formed. Basic refractory materials commonly used in investment casting is mullite (alumino silicate) (Al<sub>6</sub>Si<sub>2</sub>O<sub>13</sub>), silica (SiO<sub>2</sub>) or zircon, (zirconium silicate, ZrSiO<sub>4</sub>). These refractories materials are blended with binders materials such as colloidal silica, ethyl silicate and sodium silicate.

METHODOLOGY

Technically, investment casting method consists of several stages, as illustrated in Table 1, the ceramic mold is formed by dipping the wax pattern into slurry, draw off wax pattern from ceramic mold by dewaxing process to produce cavity in the mold, pouring molten metal and knocking the mold .

Processes

explanation

### Stage 1

Casting wax<sup>24</sup> into the mold is done by gravity or injection method.

Attaching<sup>186</sup> the fins pattern to the cylinder plate.

### Stage 2

Coating<sup>187</sup> is done<sup>188</sup> by dipping the wax pattern that has been assembled<sup>189</sup> into a ceramic slurry. Dipping<sup>190</sup> is done<sup>191</sup> repeatedly until ceramic<sup>191</sup> layer is of + 5 mm thick. Dewaxing, a wax pattern is drawn off from the ceramic mold by melting the wax<sup>24</sup> so that it will create cavities in a ceramic mold<sup>192</sup> left by the melted wax pattern

### Stage 3

Firing is heating the mold at the temperature of 1000 - 1100 oC in order to<sup>193</sup> sinter the ceramic mold<sup>194</sup> so that its strength is increased<sup>195</sup>. Pouring is carried out at temperature<sup>196</sup> of 800 ° C, the reason is that thin sections can be fully charged<sup>197</sup> and the mold will not fracture due to thermal shock.

## Stage 4

### Knockout

knocking is done by vibrating the mold or hit it with a hammer.

Gating<sup>198</sup> system is cut<sup>199</sup> using hand grinders<sup>200</sup>

### Table 1. The Experimental Stage

In general, investment casting wax is a complex composition of several components such as synthetic or natural waxes, <sup>201</sup>synthetic or natural resins, organic fillers <sup>202</sup>and water (Argueso, 1986). Additives <sup>203</sup>are used to improve the properties of <sup>24,204</sup>wax. Resins or plastics <sup>205</sup>are added to strengthen the wax. <sup>24</sup>Fillers <sup>206</sup>are made of fine powder. <sup>207</sup>in general, <sup>208</sup>isophtalic acid, polystyrene, bisphenol A and <sup>210</sup>hydrofill <sup>211</sup>are used as <sup>212</sup>filler (Wolff, 1999). These components <sup>213</sup>were added to improve the properties and control the shrinkage or dimensions of the <sup>24</sup>wax. The <sup>214</sup>most preferred <sup>215</sup>properties of the overall mentioned above is the volumetric expansion. This property affects the dewaxing process <sup>216</sup>in order to obtain <sup>217</sup>crack-free mold and the final model dimension. Malkin (1989); Thompson (1959) and Roberts (1980) recommend the following aspects to produce <sup>218</sup>a good wax

systems: apply the lowest possible temperature to nearly congealing point, use the temperature dies as high as possible, perform the injection process at the highest pressures as possible.

To overcome the crack that may occur in the ceramic mold, the wax melting is done in a pressurized room, so that the pressure due to the expansion of the wax can be compensated by external pressure. In general, melting of wax is done in an autoclave. Firing of ceramic mold is performed after dewaxing process. In addition to form and stabilize the ceramic, the firing process also removes any remaining wax or a wetting agent that may be still stuck in the ceramic mold. The temperature of the mold is held at 800oC when pouring the molten steel. This is done to avoid thermal shock which can be experienced by a mold that can cause mold cracking. Moreover holding at a high temperature is necessary for liquid metal to flow fluently in the mold and reduce the risk of shrinkage.

RESULTS AND DISCUSSION Optimization Parameter of Wax Parameters are set to get the optimum wax formula, which are:

- % volume and diameter shrinkage according to the standard wax,max 2%
- Fineness of the wax surface
- Hardness and elasticity that resembles a standard wax

The ability of slurry in binding / adhesion

Optimization Parameter of Slurry

Parameters are set to get the optimum slurry formula, which are;

A layer of slurry with a certain thickness The ability of slurry to adhere to the wax

The strength of the slurry coating after dewaxing and firing (no cracks, smooth surface)

## Optimization results of Wax<sup>24</sup>

Based on data obtained from 13 variations in the wax composition, volume shrinkage is remain found. The linear shrinkage<sup>249</sup> has met standards. The effect of blending beeswax into paraffin increased strength and adhesion of wax to the slurry. Paraffin<sup>250</sup> tend to be brittle that may causing crack on pattern, in addition<sup>24,251</sup> paraffin leaves a high content of oil on the pattern surface which<sup>252</sup> cause<sup>253</sup> the surface to be slippery and restrict the adhesion of slurry<sup>254</sup>. The addition of beeswax also increase<sup>255</sup> resistance of wax pattern to cracking. The effect of addition<sup>256</sup> of 20% arpus / gondorenum / gum resin improve<sup>257,258</sup> the surface texture of wax<sup>259</sup> which becomes more<sup>260,261</sup> finer and a few increasing<sup>262</sup> in hardness but the melting point of wax<sup>263</sup> is higher because arpus<sup>264</sup> tend to has a higher melting point (at least 78oC). Pouring of wax<sup>265</sup> is done at a temperature of 75oC and metal patterns / dies<sup>266</sup> is heated to about 50oC due to this condition will yield the best surface texture. The reason of dies heating to a temperature of 50oC is to avoid freezing of the defective wax<sup>267</sup> or uneven surfaces. The temperature of dies lower than 50oC still produce surface defects on wax<sup>268</sup> pattern. It can be concluded<sup>269</sup> that the the wax<sup>270</sup> formula gives better results when the composition ratio of beeswax to paraffinis (30 : 70) by the addition of 20% arpus<sup>271</sup> to the total weight of wax<sup>272</sup>, and then pouring of wax<sup>273</sup> into dies is performed<sup>274</sup> at 75oC during heating of dies at the temperature of 50oC.

### □Design of Wax Pattern Dies

Dies are divided<sup>275</sup> into two parts, the main disc and blades<sup>276</sup>. Figure 2 shows the design of the impeller. Figure 3 shows dies design of the main disk and figure 4 shows dies of blade<sup>277</sup>. Blades and assembling parts are shown<sup>278</sup> in Figure 2-4.

Figure 2. Impeler<sup>283</sup>

Figure 3. disc mold

Figure 4. The Impeler<sup>294</sup> blade mold

Assembling<sup>295</sup> process will produce a model consisting of the prototype of product<sup>296</sup> and its gating system, which allows the metal fluid enter<sup>297</sup> the cavity.

Table 2 describe assembling method<sup>298</sup><sup>299</sup>

of the model<sup>300</sup> .<sup>301</sup> The best results were obtained<sup>302</sup> by the method of melting.<sup>303</sup><sup>304</sup><sup>305</sup><sup>306</sup>

Table 2. Assembling Wax Model

No

Method

Materials

result

1.

adhesion

Lem Kuning

adhere easily. Low bonding strength. Bonding is flexible and easy to change<sup>307</sup>

2.

adhesion

Quick Bonder (alpha- cyanacrylate)<sup>308</sup>

adhere easily, high bonding strength but it can not persist for long time. The adhesion have<sup>311</sup> no plasticity.

3.

Melting

Partial melting of the surface of the model and then combine them. The molten part solidify<sup>312</sup> quickly, thus<sup>313</sup> it is hard to be bonded. The propeties<sup>314</sup> of the wax<sup>24</sup> on the bonding interface

is the same as the properties of the wax model.<sup>315</sup>

4.

Adhesion

wax

The assembling is done<sup>316</sup> by dipping the blade

into the molten wax<sup>24</sup> and put it into the main<sup>317</sup> disc. Bonding<sup>318</sup> strength is low, The binder

solidify faster so<sup>319</sup> the adhesion is difficult<sup>320</sup>.

Figure 5 shows the results of modeling Optimization Result of Slurry<sup>321</sup>

wax<sup>322</sup>. Assembling is done<sup>323</sup> by melting of

□partial

□Some variables are set<sup>324</sup> in the experiment of slurry. The Formulas and the analysis are presented<sup>325</sup> in Table



3. Tested wax<sup>24</sup> contains beeswax: paraffin (30:70) and 20% arpus<sup>326</sup>, the viscosity of slurry<sup>327</sup> is set to + 100 cps.<sup>328</sup>

Figure 5. Wax model



Table 3. Slurry Formulation

No

Formula

observation

1

Al2O3<sup>329</sup> : SiO2 (50 :50)<sup>330</sup>

Slurry<sup>331</sup> is adhered but fragile

2

Al2O3 : SiO2 (50 :50) + 10 % bentonit<sup>332</sup> on total weight of oxide

Adhere strong enough

3

Al2O3<sup>333</sup> : SiO2 (50 :50)<sup>334</sup> + 10 % Poly Vinyl Alcohol on total<sup>335</sup> weight of oxide

Adhere strong enough but cracks in fourth layers

4

SiO<sub>2</sub> : clay (50 :50)

Adhere, cracks in second layers

5

layer 1 : Colloidal silica :

tepung Zr (135 mL : 600 g) + 1 mL Poly Vinyl Alcohol 5 %

layer 2 : Colloidal

silica : tepung Zr (135 mL : 600 g) layer 3-5 :

Colloidal Silica : tepung Zr (158 mL : 600 g), after dipping, sprinkled with

Zircon powder 325#

layer 6-7: Colloidal

Silica : Zr powder (158 : 600 g), after sprinkled with multit powder 60 #

Stick well

The result of observation to formula in experiments 1 and 2 are less well to the □formation of the ceramic layer. Each coating process result in slurry

thickness of about 1-2 mm which dry within 24 hours at room temperature. At the fourth layers, slurry was cracked. The analyses of this phenomenon are: High viscosity of slurry and the dipping process of wax resulted an uneven surface of the slurry.

Slurry is less homogenous due to manual mixing and tend to produce lumps.

However, the dispersed slurry is stable enough without any precipitation.

a fair amount of air bubbles has generated during mixing / homogenization of the slurry so it caused the holes when the drying process and initiating cracks on the surface of slurry.

In terms of the bonding strength, the slurry adhered well onto the surface of the wax without treatment by washing the surface and dipping it into wetting agent.

Figure 6 shows the results of the model with a slurry coating process.

Figure 6. Ceramic molding

The melting process of wax is conducted in some variation as shown in table 4.

Table 4. Dewaxing method

No

Method

Result

1

Heating in an oven

The temperature of wax and mold increased almost simultaneously. The wax expanded rapidly which finally compressed ceramic molds from the whole directions. Because the expansion level of wax is higher than the ceramic mold and the absence of outlet for ceramic in each section, then the ceramic molds were broken

2

Evaporation in free air

Evaporation is done by passing steam into the wax surface. Because melting of wax is only performed at the part which contact with free air, then the expansion during melting can be directly eliminated by the drainage of the wax so that this process can be done without causing a

crack in the ceramic mold. Wax melting process is running very slow.

3

Melting in pressure cooker

This process is done by evaporation accompanied by pressure which come from the outside of the ceramic molds. The expansion of wax and mold due to heating can be compensated by providing pressure on the mold, so it doesn't cause cracks on mold.

Firing

Firing was carried out with several goals: to remove water from the mold, to remove residual wax from the mold, changing the colloidal silica which is used as a binder into that as a refractory material and stabilize the mold by sintering of sand or refractory materials.

Sinter point of refractory sand materials must be tested to produce good mold.

Preheating in the oven until the temperature of 200 ° C performed for 2 hours.

Firing was carried out in the oven

and the burner (Fig. 7) at 50 ° C above the sinter point of refractory materials.

During the combustion can be observed the formation of water vapor at a temperature of 100 ° C, followed by the burning of the wax residue. In the sintering temperature of the mold reinforcement occurs. Some parts of the backup slurry on the outer mold aside from the bond.

## Casting

□

### Figure 7. Burning of mold

□ produced indicated by the sharpness of the contours of the object at an angle.

There is shrinkage at the surface of the <sup>414</sup>main disc <sup>415</sup>as a result of <sup>416</sup>lack of liquid supply to compensate for the contraction. Measurements <sup>417</sup>are performed on the object indicates that the total <sup>418</sup>contraction on the disc diameter of 1.1%. This shrinkage is smaller compared to casting in sand molds for the same metal.

The metal used to test the ceramic mold is low manganese steel DIN standard GS30Mn5 with 0.3% carbon content and manganese content of 1.25%. Casting<sup>4</sup> was carried out at liquid metal temperature of 1610oC. This higher temperature allows for observation of the ceramic mold strength at high thermal loads. Casting process is done in several stages. Heating of ceramic mold to 800 ° C, metal smelting, sand bed preparation, pouring metal into molds, cooling, spending the casting form mold, cleaning and testing.<sup>420, 421, 422, 423, 424, 425, 426, 427</sup>

The fracture of ceramic molds which<sup>428</sup> were observed<sup>429</sup> after the metal casting process<sup>430</sup> indicates that the folding lines has<sup>431</sup> the same contour as the lines on the wax models.<sup>432, 433, 434, 435</sup> This indicates that the slurry and the ceramic mold which<sup>436</sup> were formed as a whole has been able to produce a contour in the mold that was the same with wax models.<sup>437, 438</sup> Surface smoothness of slurry is excellent so as producing<sup>439, 440</sup> a smooth cast surfaces. There is no reaction between the ceramic mold and liquid metal,<sup>441</sup> because the mold did not adhere to the casting. The high-strength of ceramic mold<sup>442</sup> was characterized<sup>443</sup> by the absence of cracks in the mold<sup>444</sup> during the casting process. The mold stability was also good due to the absence of cracks that caused by increasing<sup>445</sup> in temperature during the casting process followed by a decrease in temperature during the cooling process.<sup>446, 447, 448, 449</sup> Figure 8 shows the casting resulted from this research using GS30Mn5 materials. Contours of the objects have been well<sup>450, 451</sup>

□

Figure 8. casting products.

CONCLUSION Conclusion<sup>452</sup>

Local beeswax and paraffin can be used<sup>453</sup> as a base wax for investment casting. The formula of wax gives better results at the composition ratio of beeswax :<sup>24</sup> paraffin (30 : 70)<sup>455</sup> and the addition of 20% arpus<sup>456</sup> to the total weight of wax, this<sup>24</sup> is supported by casting of wax at 75oC and heating the metal dies at 50oC.<sup>457</sup> Gravity casting has been able to fill the entire cavity of the mold. Shrinkage occurs at the surface of the disc and the inlet. With the addition of mold pressure and temperature increase (to 50oC), contour<sup>458</sup> of the object is well formed<sup>459,460</sup>. Method<sup>461</sup> of assembling should be done<sup>462</sup> by melting the surface of the model.

Slurry<sup>463</sup> is less homogeneous due to manual mixing and tends to produce lumps. However, the slurry is stably dispersed<sup>464</sup> without deposition with the aid of polyvinyl alcohol wetting agent 5%. A fair amount of air bubbles is generated during mixing / homogenization<sup>465</sup> of the slurry so that when the drying caused the holes and initiate cracks on the surface of slurry<sup>466,467</sup>. In terms of bonding strength<sup>468</sup>, the slurry adhered well onto the surface of the wax<sup>24</sup> without treatment by washing the surface and dipping it into wetting agent<sup>470</sup>. Dewaxing can be done<sup>474</sup> with water vapor pressure to compensate for expansion. Pressure magnitude and duration of evaporation depends on the shape and dimensions of the mold. After dewaxing process<sup>476</sup>, the mold is heated<sup>477,478</sup> at a temperature of 200°C for 2hours firing the mold with a burner produces a better uniform burning on the outside and inside the mold<sup>480</sup>. Wax residue can be removed easily with the use of these burners. Firing temperature is the same with sintering<sup>482</sup> temperature of refractory material used. Holding mold temperature at 800oC for liquid steel casting has successfully prevented cracking molds during casting.

Recomendations<sup>483</sup>

Use wax<sup>24</sup> with different melting points for the sprue and model. Melting<sup>484</sup> point of wax sprue should be lower to facilitate expenditure<sup>485</sup> of wax<sup>24</sup> in the mold. Modeling should be done by the method of injection in order to<sup>486</sup> have a better contour. Gravity modeling of the charging should take into account the distortion of the larger forms. Further research is necessary in<sup>487</sup> designing equipment that can be applied<sup>488</sup> to investment casting for a simple<sup>489</sup> small-medium<sup>490</sup> scale industries.

## □ REFERENCES

Journal article

S. Saau and S. Viswanathan (1999), Critical Material Properties For Predicting Pattern Tooling Dimensions In Investment Casting, Metals and Ceramics Division Oak Ridge National Laboratory Oak Ridge, TN 37831- 6083

Hafid, Tatang T., Rudi S. R., A. Wahid, Mitsuo Ninomiya (2002), Implementasi Teknologi Investment Casting Dalam Rangka Pembuatan Produk Cor Substitusi Impor Dengan Pemanfaatan Bahan Lokal, Jurnal Riset, p. 45 – 57.

Sylvia, J.G. (1972), Cast Metals Technology, Philiphine<sup>491</sup> :<sup>492</sup> Addison- Wesley Publishing Company Inc.

Solomon, P (1975), Disposable Pattern, Composition for Investment Casting. U.S. Patent 3,887,382.

J. Booth, Pattern Waxes for Investment Casting, Foundry Trade J., 6 Dec 1962, p 707

Electronic publication, information from the internet

[www.freepatentsonline.com/image](http://www.freepatentsonline.com/image)

[-4758613-1.html](http://www.freepatentsonline.com/image-4758613-1.html)

[www.hitchiner.com](http://www.hitchiner.com)

Timothy M. Wolff, M. Argueso & Co., Inc., Muskegon<sup>493</sup>, Michigan, Investment Casting Waxes<sup>494</sup> : Influences Which Eliminate Wax Pattern Defects.pdf.



Refference<sup>495</sup> books

ASM Handbook. Vol.15, Casting.

1.	<del>a</del> casting	Determiner Use (a/an/the/this, etc.)	Correctness
2.	, and	Comma Misuse within Clauses	Correctness
3.	<del>, thus</del> → . Thus, ; thus	Punctuation in Compound/Complex Sentences	Correctness
4.	performs → perform	Faulty Subject-Verb Agreement	Correctness
5.	be considered	Passive Voice Misuse	Clarity
6.	example → examples	Incorrect Noun Number	Correctness
7.	the investment	Determiner Use (a/an/the/this, etc.)	Correctness
8.	been widely applied	Passive Voice Misuse	Clarity
9.	a few	Determiner Use (a/an/the/this, etc.)	Correctness
10.	machineries → machinery, types of machinery, pieces of machinery	Incorrect Noun Number	Correctness
11.	, and	Comma Misuse within Clauses	Correctness
12.	required → necessary	Word Choice	Engagement
13.	which is then	Wordy Sentences	Clarity
14.	good → right	Word Choice	Engagement
15.	This	Intricate Text	Clarity
16.	in	Wordy Sentences	Clarity
17.	an educational	Determiner Use (a/an/the/this, etc.)	Correctness

18.	<del>institute</del> → institutes	Incorrect Noun Number	Correctness
19.	in a	Wrong or Missing Prepositions	Correctness
20.	<del>slury</del> → slurry	Misspelled Words	Correctness
21.	, and	Comma Misuse within Clauses	Correctness
22.	<del>the</del> processing	Determiner Use (a/an/the/this, etc.)	Correctness
23.	<del>main</del> → primary	Word Choice	Engagement
24.	wax; Wax	Text Inconsistencies	Correctness
25.	<del>dimension</del> → dimensions	Incorrect Noun Number	Correctness
26.	, and	Comma Misuse within Clauses	Correctness
27.	are required	Passive Voice Misuse	Clarity
28.		Intricate Text	Clarity
29.	The investment	Determiner Use (a/an/the/this, etc.)	Correctness
30.	, and	Comma Misuse within Clauses	Correctness
31.	<del>complex</del> → involved	Word Choice	Engagement
32.	<i>Investment casting method is one alternative to improve productivity and product quality castings, especially its ability to produce precision, small tolerances, surface finish, minimum machining, shape and size of the complex objects that can not be produced by other casting methods.</i>	Hard-to-read text	Clarity
33.	<del>In addition</del> → Also, Besides	Wordy Sentences	Clarity
34.	the investment	Determiner Use (a/an/the/this,	Correctness

		etc.)	
35.	<del>very specific</del> → particular	Word Choice	Engagement
36.	<del>of material</del> → of material	Improper Formatting	Correctness
37.	<i>be directly used</i>	Passive Voice Misuse	Clarity
38.		Intricate Text	Clarity
39.	, i.e	Punctuation in Compound/Complex Sentences	Correctness
40.	, the	Punctuation in Compound/Complex Sentences	Correctness
41.	<del>it self</del> → itself	Confused Words	Correctness
42.	self,	Punctuation in Compound/Complex Sentences	Correctness
43.	<i>are imported</i>	Passive Voice Misuse	Clarity
44.	, so	Punctuation in Compound/Complex Sentences	Correctness
45.	<del>high cost</del> → high-cost	Misspelled Words	Correctness
46.	<del>et al</del> → et al.	Comma Misuse within Clauses	Correctness
47.	<i>is aimed</i>	Passive Voice Misuse	Clarity
48.		Intricate Text	Clarity
49.	<del>products</del> → product	Incorrect Noun Number	Correctness
50.	, and	Comma Misuse within Clauses	Correctness
51.	<del>to the</del> → to the	Improper Formatting	Correctness
52.	<del>characteristic</del> → characteristics	Incorrect Noun Number	Correctness

53.	<i>is used</i>	Passive Voice Misuse	Clarity
54.	<del>normally</del> → usually, frequently, regularly, typically	Word Choice	Engagement
55.	the viscosity, or a viscosity	Determiner Use (a/an/the/this, etc.)	Correctness
56.	<del>coefficient of</del> → coefficient of	Improper Formatting	Correctness
57.	<del>of contraction</del> → of contraction	Improper Formatting	Correctness
58.	, and	Comma Misuse within Clauses	Correctness
59.	<del>is</del> → are	Faulty Subject-Verb Agreement	Correctness
60.		Intricate Text	Clarity
61.		Passive Voice Misuse	Clarity
62.	<del>expansion</del> → Expansion	Improper Formatting	Correctness
63.	<del>greater</del> → higher	Word Choice	Engagement
64.	<del>expansion</del> → development, increase	Word Choice	Engagement
65.	<del>tiles during</del> → tiles during	Improper Formatting	Correctness
66.	<i>expansion of paraffin, which is greater than the expansion of ceramic tiles during the dewaxing step.</i>	Incomplete Sentences	Correctness
67.	<i>This</i>	Intricate Text	Clarity
68.	<del>lead</del> → leads	Faulty Subject-Verb Agreement	Correctness
69.	<del>characteristics</del> → features, components, symptoms	Word Choice	Engagement
70.	example,	Comma Misuse within Clauses	Correctness

71.	<del>isophthalic</del> → isophthalic	Misspelled Words	Correctness
72.		Intricate Text	Clarity
73.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness
74.	is used	Passive Voice Misuse	Clarity
75.	<del>high quality</del> → high-quality	Misspelled Words	Correctness
76.	<del>term</del> → terms	Incorrect Noun Number	Correctness
77.	<del>refractories</del> → refractory	Confused Words	Correctness
78.	, and	Comma Misuse within Clauses	Correctness
79.		Intricate Text	Clarity
80.	the chemical	Determiner Use (a/an/the/this, etc.)	Correctness
81.	<del>slurry</del> → mud	Word Choice	Engagement
82.	, and	Comma Misuse within Clauses	Correctness
83.	is aimed	Passive Voice Misuse	Clarity
84.	<del>determining</del> → learning	Word Choice	Engagement
85.		Intricate Text	Clarity
86.	, and	Comma Misuse within Clauses	Correctness
87.	casting technology	Misspelled Words	Correctness
88.		Intricate Text	Clarity
89.	a substitution	Determiner Use (a/an/the/this, etc.)	Correctness
90.	being imported	Passive Voice Misuse	Clarity

91.	<del>capability</del> → capacity, skill, ability	Word Choice	Engagement
92.	<del>increasing</del> → improving	Word Choice	Engagement
93.	<del>capability</del> → capacity, ability	Word Choice	Engagement
94.	<del>basic</del> → primary, necessary	Word Choice	Engagement
95.	the investment	Determiner Use (a/an/the/this, etc.)	Correctness
96.	<del>capability</del> → capacity, skill, ability	Word Choice	Engagement
97.	<del>→</del> → ., ...	Closing Punctuation	Correctness
98.	<del>impart</del> → imparts	Faulty Subject-Verb Agreement	Correctness
99.	<del>great</del> → significant	Word Choice	Engagement
100.	<del>manufacture</del> → manufacturing	Confused Words	Correctness
101.		Intricate Text	Clarity
102.	Basically,	Comma Misuse within Clauses	Correctness
103.	<del>Basically there</del>	Wordy Sentences	Clarity
104.	<del>are</del> → is	Faulty Subject-Verb Agreement	Correctness
105.	<del>process</del> → processes	Incorrect Noun Number	Correctness
106.	<del>making investment</del> → investing	Wordy Sentences	Clarity
107.	, i.e	Punctuation in Compound/Complex Sentences	Correctness
108.	, the	Punctuation in Compound/Complex Sentences	Correctness
109.	<del>solid</del> → stable, robust, reliable	Word Choice	Engagement

110.	<del>predominant</del> → effective	Word Choice	Engagement
111.	a predominant	Determiner Use (a/an/the/this, etc.)	Correctness
112.	<del>application</del> → applications	Incorrect Noun Number	Correctness
113.	the ceramic	Determiner Use (a/an/the/this, etc.)	Correctness
114.	be considered	Passive Voice Misuse	Clarity
115.	the pattern, or a pattern	Determiner Use (a/an/the/this, etc.)	Correctness
116.	<del>the addition</del> → the addition	Improper Formatting	Correctness
117.	, and	Comma Misuse within Clauses	Correctness
118.		Intricate Text	Clarity
119.	, i.e	Punctuation in Compound/Complex Sentences	Correctness
120.	<del>paraffins</del> → paraffin, kinds of paraffin, bowls of paraffin	Incorrect Noun Number	Correctness
121.	, and	Comma Misuse within Clauses	Correctness
122.	are often used	Passive Voice Misuse	Clarity
123.	<del>the wax</del>	Determiner Use (a/an/the/this, etc.)	Correctness
124.	<del>ethyl cellulose</del> → ethylcellulose	Confused Words	Correctness
125.	<del>ethylene vinyl</del> → ethylene-vinyl	Misspelled Words	Correctness
126.	<del>resins</del> → adhesives	Word Choice	Engagement
127.		Comma Misuse within Clauses	Correctness



	Fillers,		
128.	<del>of wax</del> → of wax	Improper Formatting	Correctness
129.	in,	Punctuation in Compound/Complex Sentences	Correctness
130.	than,	Punctuation in Compound/Complex Sentences	Correctness
131.	<del>Fillers</del> → Cartridges, Pads, Cylinders	Word Choice	Engagement
132.	<del>that have been</del>	Wordy Sentences	Clarity
133.	<del>have been</del> → have been	Improper Formatting	Correctness
134.	been used	Passive Voice Misuse	Clarity
135.	, and	Comma Misuse within Clauses	Correctness
136.	<del>fillers</del> → pads, cartridges, cylinders, liners	Word Choice	Engagement
137.	equally.	Closing Punctuation	Correctness
138.	<del>the manner in which</del> → how	Wordy Sentences	Clarity
139.	are made	Passive Voice Misuse	Clarity
140.	<del>coating</del> → sheet, coat	Word Choice	Engagement
141.	<del>fine</del> → beautiful	Word Choice	Engagement
142.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness
143.	<del>a basic</del> → an essential, a necessary, a fundamental, a primary	Word Choice	Engagement
144.	<del>for</del> → of	Wrong or Missing Prepositions	Correctness

145.	<del>Slurry</del> → Sludge, Mud, Manure	Word Choice	Engagement
146.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness
147.	<del>basically</del>	Wordy Sentences	Clarity
148.	is basically consisted	Incorrect Verb Forms	Correctness
149.	, and	Comma Misuse within Clauses	Correctness
150.	mold,	Punctuation in Compound/Complex Sentences	Correctness
151.	<del>slurry</del> → mud	Word Choice	Engagement
152.	<del>are</del> → is	Faulty Subject-Verb Agreement	Correctness
153.	a primary, or the primary	Determiner Use (a/an/the/this, etc.)	Correctness
154.	<del>slurry</del> → sludge, mud	Word Choice	Engagement
155.	pouring,	Punctuation in Compound/Complex Sentences	Correctness
156.	<del>slurry</del> → sludge, mud	Word Choice	Engagement
157.	<del>is</del> → are	Faulty Subject-Verb Agreement	Correctness
158.	, and	Comma Misuse within Clauses	Correctness
159.	<del>having</del> → has	Incorrect Verb Forms	Correctness
160.	<del>a very fine</del> → an excellent, a wonderful	Word Choice	Engagement
161.	<del>Fine</del> → Excellent, Beautiful	Word Choice	Engagement
162.	<del>Fine grain</del> → Fine-grain	Misspelled Words	Correctness

163.	<del>high quality</del> → high-quality	Misspelled Words	Correctness
164.	<del>be able to</del>	Wordy Sentences	Clarity
165.	, and	Comma Misuse within Clauses	Correctness
166.	<del>casting</del> → cast	Word Choice	Engagement
167.	The backup	Determiner Use (a/an/the/this, etc.)	Correctness
168.	<del>an supporting</del> → a supporting	Determiner Use (a/an/the/this, etc.)	Correctness
169.	<del>slurry</del> → sludge, mud	Word Choice	Engagement
170.	<del>Basic</del> → Necessary	Word Choice	Engagement
171.	<del>is</del> → are	Faulty Subject-Verb Agreement	Correctness
172.	aluminosilicate	Confused Words	Correctness
173.	silica; Silica	Text Inconsistencies	Correctness
174.	are blended	Passive Voice Misuse	Clarity
175.	, and	Comma Misuse within Clauses	Correctness
176.	is formed	Passive Voice Misuse	Clarity
177.	a slurry, or the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
178.	a wax, or the wax	Determiner Use (a/an/the/this, etc.)	Correctness
179.	<del>mold</del> → image, shell	Word Choice	Engagement
180.	the dewaxing, or a dewaxing	Determiner Use (a/an/the/this, etc.)	Correctness
181.	a cavity	Determiner Use (a/an/the/this, etc.)	Correctness

		etc.)	
182.	<del>mold</del> → image, frame, shape	Word Choice	Engagement
183.	<del>mold</del> → shape, frame, image	Word Choice	Engagement
184.	<i>Technically, investment casting method consists of several stages, as illustrated in Table 1, the ceramic mold is formed by dipping the wax pattern into slurry, draw off wax pattern from ceramic mold by dewaxing process to produce cavity in the mold, pouring molten metal and knocking the mold.</i>	Hard-to-read text	Clarity
185.	<del>explanation</del> → explanation	Misspelled Words	Correctness
186.	I am attaching, or We are attaching	Incomplete Sentences	Correctness
187.	The coating	Determiner Use (a/an/the/this, etc.)	Correctness
188.	is done	Passive Voice Misuse	Clarity
189.	been assembled	Passive Voice Misuse	Clarity
190.	is done	Passive Voice Misuse	Clarity
191.	the ceramic	Determiner Use (a/an/the/this, etc.)	Correctness
192.	<del>mold</del> → shape, frame, image	Word Choice	Engagement
193.	<del>in order to</del> → to	Wordy Sentences	Clarity
194.	<del>mold</del> → image, shell	Word Choice	Engagement
195.	is increased	Passive Voice Misuse	Clarity
196.	a temperature	Determiner Use (a/an/the/this, etc.)	Correctness

197.	<i>be fully charged</i>	Passive Voice Misuse	Clarity
198.	The gating	Determiner Use (a/an/the/this, etc.)	Correctness
199.	<i>is cut</i>	Passive Voice Misuse	Clarity
200.	grinders.	Closing Punctuation	Correctness
201.	<del>synthetic</del> → artificial	Word Choice	Engagement
202.	, and	Comma Misuse within Clauses	Correctness
203.	<i>are used</i>	Passive Voice Misuse	Clarity
204.	<del>wax</del> → beeswax	Word Choice	Engagement
205.	<i>are added</i>	Passive Voice Misuse	Clarity
206.	<del>Fillers</del> → Cartridges, Pads, Liners	Word Choice	Engagement
207.	<i>are made</i>	Passive Voice Misuse	Clarity
208.	<del>in</del> → In	Improper Formatting	Correctness
209.	<del>isophthalic</del> → isophthalic	Misspelled Words	Correctness
210.	<del>hydrofill</del> → hydrofoil, hydro fill	Misspelled Words	Correctness
211.	<i>are used</i>	Passive Voice Misuse	Clarity
212.	<del>filler</del> → fillers	Incorrect Noun Number	Correctness
213.	<i>were added</i>	Passive Voice Misuse	Clarity
214.	<del>properties</del> → features	Word Choice	Engagement
215.	<del>is</del> → are	Faulty Subject-Verb Agreement	Correctness
216.	<del>in order to</del> → to	Wordy Sentences	Clarity
217.	a crack-free	Determiner Use (a/an/the/this, etc.)	Correctness

		etc.)	
218.	<del>good</del> → sound	Word Choice	Engagement
219.	a good wax system, good wax systems	Determiner Use (a/an/the/this, etc.)	Correctness
220.	the nearly, or a nearly	Determiner Use (a/an/the/this, etc.)	Correctness
221.	<del>temperature</del> → heat	Word Choice	Engagement
222.	<del>highest</del> → most elevated	Word Choice	Engagement
223.	<i>To overcome the crack that may occur in the ceramic mold, the wax melting is done in a pressurized room, so that the pressure due to the expansion of the wax can be compensated by external pressure.</i>	Intricate Text	Clarity
224.	<i>To overcome the crack that may occur in the ceramic mold</i>	Misplaced Words or Phrases	Correctness
225.	<i>be compensated</i>	Passive Voice Misuse	Clarity
226.	the melting	Determiner Use (a/an/the/this, etc.)	Correctness
227.	The firing	Determiner Use (a/an/the/this, etc.)	Correctness
228.	<i>is performed</i>	Passive Voice Misuse	Clarity
229.	the dewaxing	Determiner Use (a/an/the/this, etc.)	Correctness
230.	addition,	Comma Misuse within Clauses	Correctness
231.	<del>form</del> → forming	Incorrect Verb Forms	Correctness
232.	<i>be still stuck</i>	Passive Voice Misuse	Clarity

233.		Intricate Text	Clarity
234.	<del>mold</del> → image, frame, pattern, shell	Word Choice	Engagement
235.	<i>This</i>	Intricate Text	Clarity
236.	<i>is done</i>	Passive Voice Misuse	Clarity
237.	, which	Punctuation in Compound/Complex Sentences	Correctness
238.	<del>a mold</del> → an image, a pattern, a fungus, a frame	Word Choice	Engagement
239.	<del>cause</del>	Wordy Sentences	Clarity
240.	, holding	Punctuation in Compound/Complex Sentences	Correctness
241.	<del>mold</del> → image, shape, frame, pattern	Word Choice	Engagement
242.	<i>are set</i>	Passive Voice Misuse	Clarity
243.	, max	Improper Formatting	Correctness
244.	The fineness	Determiner Use (a/an/the/this, etc.)	Correctness
245.	binding/adhesion	Improper Formatting	Correctness
246.	<i>are set</i>	Passive Voice Misuse	Clarity
247.	<del>slurry</del> → mud, manure, sludge	Word Choice	Engagement
248.	<del>slurry</del> → mud	Word Choice	Engagement
249.	<del>shrinkage</del> → decrease, reduction	Word Choice	Engagement
250.	<del>adhesion of</del> → adhesion of	Improper Formatting	Correctness
251.	the wax	Determiner Use (a/an/the/this, etc.)	Correctness

252.	<del>tend</del> → tends	Faulty Subject-Verb Agreement	Correctness
253.	<del>causing</del> → cause, be causing	Modal Verbs	Correctness
254.	a crack	Determiner Use (a/an/the/this, etc.)	Correctness
255.	the pattern, or a pattern	Determiner Use (a/an/the/this, etc.)	Correctness
256.	<del>, in</del> → ; in, . In	Punctuation in Compound/Complex Sentences	Correctness
257.	<del>in addition</del> → also, besides	Wordy Sentences	Clarity
258.	addition,	Comma Misuse within Clauses	Correctness
259.	, which	Punctuation in Compound/Complex Sentences	Correctness
260.	<del>cause</del> → causes	Faulty Subject-Verb Agreement	Correctness
261.	<del>cause</del> → create	Word Choice	Engagement
262.	slurry .	Improper Formatting	Correctness
263.	<del>increase</del> → increases	Faulty Subject-Verb Agreement	Correctness
264.	the addition	Determiner Use (a/an/the/this, etc.)	Correctness
265.	<del>arpus</del> → carpus, corpus, campus	Misspelled Words	Correctness
266.	<i>gondorenum</i>	Unknown Words	Correctness
267.	<del>improve</del> → improves	Faulty Subject-Verb Agreement	Correctness
268.	, which	Punctuation in Compound/Complex Sentences	Correctness
269.		Misuse of Modifiers	Correctness



	<del>more</del>		
270.	<del>increasing</del> → increases	Confused Words	Correctness
271.	, but	Punctuation in Compound/Complex Sentences	Correctness
272.	<del>arpus</del> → corpus, carpus	Misspelled Words	Correctness
273.	, and	Punctuation in Compound/Complex Sentences	Correctness
274.	<del>is</del>	Redundant Words	Correctness
275.	<del>of</del> → for	Wrong or Missing Prepositions	Correctness
276.	the wax	Determiner Use (a/an/the/this, etc.)	Correctness
277.	be concluded	Passive Voice Misuse	Clarity
278.	<del>the the</del> wax	Misspelled Words	Correctness
279.	<del>paraffinis</del> → paraffin, paraffins, paraffinic	Misspelled Words	Correctness
280.	30 :	Improper Formatting	Correctness
281.	<del>arpus</del> → corpus, carpus	Misspelled Words	Correctness
282.	is performed	Passive Voice Misuse	Clarity
283.	are divided	Passive Voice Misuse	Clarity
284.	<del>main</del> → central	Word Choice	Engagement
285.	, and	Comma Misuse within Clauses	Correctness
286.	the dies	Determiner Use (a/an/the/this,	Correctness

		etc.)	
287.	<del>main</del> → central, primary	Word Choice	Engagement
288.	, and	Punctuation in Compound/Complex Sentences	Correctness
289.	<del>blade</del> → module	Word Choice	Engagement
290.	the blade	Determiner Use (a/an/the/this, etc.)	Correctness
291.	<del>Blades</del> → Edges, Modules, Leaves	Word Choice	Engagement
292.	are shown	Passive Voice Misuse	Clarity
293.	<del>Impeler</del> → Impeller	Misspelled Words	Correctness
294.	<del>Impeler</del> → Impeller, Impaler	Misspelled Words	Correctness
295.	The assembling	Determiner Use (a/an/the/this, etc.)	Correctness
296.	the product	Determiner Use (a/an/the/this, etc.)	Correctness
297.	to enter	Incorrect Verb Forms	Correctness
298.	the assembling	Determiner Use (a/an/the/this, etc.)	Correctness
299.	method.	Closing Punctuation	Correctness
300.	<del>of</del> → Of	Improper Formatting	Correctness
301.	<del>of the</del> → of the	Improper Formatting	Correctness
302.	<del>the model</del> → the model	Improper Formatting	Correctness
303.	of the model.	Incomplete Sentences	Correctness
304.	<del>The best</del> → The best	Improper Formatting	Correctness

305.	<del>results were</del> → results were	Improper Formatting	Correctness
306.	were obtained	Passive Voice Misuse	Clarity
307.	is flexible and easy to change	Incomplete Sentences	Correctness
308.	<del>cyanaacrylate</del> → cyanoacrylate	Misspelled Words	Correctness
309.	, but	Punctuation in Compound/Complex Sentences	Correctness
310.	a long	Determiner Use (a/an/the/this, etc.)	Correctness
311.	<del>have</del> → has	Faulty Subject-Verb Agreement	Correctness
312.	<del>solidify</del> → solidifies	Faulty Subject-Verb Agreement	Correctness
313.	<del>, thus</del> → . Thus, ; thus	Punctuation in Compound/Complex Sentences	Correctness
314.	<del>propeties</del> → properties	Misspelled Words	Correctness
315.	is the same as the properties of the wax model.	Incomplete Sentences	Correctness
316.	is done	Passive Voice Misuse	Clarity
317.	<del>main</del> → central	Word Choice	Engagement
318.	The bonding	Determiner Use (a/an/the/this, etc.)	Correctness
319.	, so	Punctuation in Compound/Complex Sentences	Correctness
320.	<del>difficult</del> → severe	Word Choice	Engagement
321.	Slurry.	Closing Punctuation	Correctness
322.	<del>wax</del> → Wax	Improper Formatting	Correctness

323.	<i>is done</i>	Passive Voice Misuse	Clarity
324.	<i>are set</i>	Passive Voice Misuse	Clarity
325.	<i>are presented</i>	Passive Voice Misuse	Clarity
326.	<del>arpus</del> → corpus, carpus, campus	Misspelled Words	Correctness
327.	the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
328.	<i>is set</i>	Passive Voice Misuse	Clarity
329.	Al2O3 :	Improper Formatting	Correctness
330.	50 :	Improper Formatting	Correctness
331.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness
332.	<del>bentonit</del> → bentonite	Misspelled Words	Correctness
333.	Al2O3 :	Improper Formatting	Correctness
334.	50 :	Improper Formatting	Correctness
335.	the total	Determiner Use (a/an/the/this, etc.)	Correctness
336.	SiO2 :	Improper Formatting	Correctness
337.	50 :	Improper Formatting	Correctness
338.	1 :	Improper Formatting	Correctness
339.	tepung	Unknown Words	Correctness

340.	2 :	Improper Formatting	Correctness
341.	silica :	Improper Formatting	Correctness
342.	tepung	Unknown Words	Correctness
343.	mL :	Improper Formatting	Correctness
344.	Silica :	Improper Formatting	Correctness
345.	tepung	Unknown Words	Correctness
346.	mL :	Improper Formatting	Correctness
347.	after dipping	Misplaced Words or Phrases	Correctness
348.	Silica :	Improper Formatting	Correctness
349.	158 :	Improper Formatting	Correctness
350.	<del>multit</del> → multi	Misspelled Words	Correctness
351.	the formula, or a formula	Determiner Use (a/an/the/this, etc.)	Correctness
352.	slurry.	Closing Punctuation	Correctness
353.	the thickness	Determiner Use (a/an/the/this, etc.)	Correctness
354.	<del>thickness</del> → Thickness	Improper Formatting	Correctness
355.	, which	Punctuation in Compound/Complex Sentences	Correctness
356.	<del>dry</del> → dries	Faulty Subject-Verb Agreement	Correctness

357.	<del>tempeprature</del> → temperature	Misspelled Words	Correctness
358.	<del>layers</del> → layer	Incorrect Noun Number	Correctness
359.	the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
360.	was cracked	Passive Voice Misuse	Clarity
361.	The high	Determiner Use (a/an/the/this, etc.)	Correctness
362.	the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
363.	in an	Wrong or Missing Prepositions	Correctness
364.	<del>slurry</del> → mud	Word Choice	Engagement
365.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness
366.	<del>tend</del> → tends	Faulty Subject-Verb Agreement	Correctness
367.	, without	Punctuation in Compound/Complex Sentences	Correctness
368.	<del>a fair</del> → A fair	Improper Formatting	Correctness
369.	<del>bubbles has</del> → bubbles has	Improper Formatting	Correctness
370.	mixing/homogenization	Improper Formatting	Correctness
371.	, so	Punctuation in Compound/Complex Sentences	Correctness
372.	<del>so</del> → . Hence,	Hard-to-read text	Clarity
373.	the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
374.	<del>slurry</del> → mud	Word Choice	Engagement

375.		Intricate Text	Clarity
376.	<del>surface</del> → exterior	Word Choice	Engagement
377.	a wetting	Determiner Use (a/an/the/this, etc.)	Correctness
378.	, as	Punctuation in Compound/Complex Sentences	Correctness
379.	methode	Unknown Words	Correctness
380.	. The	Improper Formatting	Correctness
381.	, which	Punctuation in Compound/Complex Sentences	Correctness
382.	<del>molds</del> → patterns, images, shells	Word Choice	Engagement
383.	<del>mold</del> → shell, pattern, image	Word Choice	Engagement
384.	an outlet	Determiner Use (a/an/the/this, etc.)	Correctness
385.	<del>molds</del> → patterns, images	Word Choice	Engagement
386.	<del>Evaporatio</del> → Evaporation	Misspelled Words	Correctness
387.	is done	Passive Voice Misuse	Clarity
388.	the melting	Determiner Use (a/an/the/this, etc.)	Correctness
389.	is only performed	Passive Voice Misuse	Clarity
390.	<del>contact</del> → contacts	Faulty Subject-Verb Agreement	Correctness
391.	<del>melting</del> → fusion	Word Choice	Engagement
392.	be done	Passive Voice Misuse	Clarity
393.	The wax	Determiner Use (a/an/the/this, etc.)	Correctness

		etc.)	
394.	a pressure, or the pressure	Determiner Use (a/an/the/this, etc.)	Correctness
395.	is done	Passive Voice Misuse	Clarity
396.	<del>come</del> → comes	Faulty Subject-Verb Agreement	Correctness
397.	<del>mold</del> → shape, mildew, decay	Word Choice	Engagement
398.	be compensated	Passive Voice Misuse	Clarity
399.	<del>pressure</del> → strength	Word Choice	Engagement
400.	<del>mold</del> → shape, frame, pattern, image	Word Choice	Engagement
401.	The firing	Determiner Use (a/an/the/this, etc.)	Correctness
402.	was carried	Passive Voice Misuse	Clarity
403.	<del>mold</del> → image, frame, shell, womb	Word Choice	Engagement
404.	, which	Punctuation in Compound/Complex Sentences	Correctness
405.	, and	Comma Misuse within Clauses	Correctness
406.	<del>mold</del> → image, shape, frame, pattern	Word Choice	Engagement
407.	be tested	Passive Voice Misuse	Clarity
408.	The firing	Determiner Use (a/an/the/this, etc.)	Correctness
409.	was carried	Passive Voice Misuse	Clarity
410.	<del>sinter</del> → sintering	Misuse of Modifiers	Correctness
411.		Intricate Text	Clarity



412.	<del>can be observed</del> → ,	Wordy Sentences	Clarity
413.	mold,	Comma Misuse within Clauses	Correctness
414.	<del>main</del> → central	Word Choice	Engagement
415.	<del>as a result of</del> → due to	Wordy Sentences	Clarity
416.	a lack	Determiner Use (a/an/the/this, etc.)	Correctness
417.	are performed	Passive Voice Misuse	Clarity
418.	<del>contraction</del> → decrease	Word Choice	Engagement
419.	The casting	Determiner Use (a/an/the/this, etc.)	Correctness
420.	was carried	Passive Voice Misuse	Clarity
421.	a liquid	Determiner Use (a/an/the/this, etc.)	Correctness
422.	The casting	Determiner Use (a/an/the/this, etc.)	Correctness
423.	is done	Passive Voice Misuse	Clarity
424.	<i>Casting was carried out at liquid metal temperature of 1610oC. This higher temperature allows for observation of the ceramic mold strength at high thermal loads. Casting process is done in several stages.</i>	Monotonous Sentences	Engagement
425.	, and	Comma Misuse within Clauses	Correctness
426.		Intricate Text	Clarity
427.	<i>Heating of ceramic mold to 800 ° C, metal smelting, sand bed preparation, pouring metal into</i>	Incomplete Sentences	Correctness

*molds, cooling, spending the casting form mold, cleaning and testing.*

428.	, which	Punctuation in Compound/Complex Sentences	Correctness
429.	were observed	Passive Voice Misuse	Clarity
430.	process,	Punctuation in Compound/Complex Sentences	Correctness
431.	has → have	Faulty Subject-Verb Agreement	Correctness
432.		Intricate Text	Clarity
433.	This	Intricate Text	Clarity
434.	indicates → shows, suggests	Word Choice	Engagement
435.	, which	Punctuation in Compound/Complex Sentences	Correctness
436.	were formed	Passive Voice Misuse	Clarity
437.	mold → image, shape, frame, pattern	Word Choice	Engagement
438.		Intricate Text	Clarity
439.	producing → to produce	Incorrect Verb Forms	Correctness
440.	producing → providing, creating	Word Choice	Engagement
441.	metal,	Punctuation in Compound/Complex Sentences	Correctness
442.	mold → image, pattern, frame, shape	Word Choice	Engagement
443.	mold → shell	Word Choice	Engagement
444.	was characterized	Passive Voice Misuse	Clarity
445.	mold → image, frame, shell, pattern	Word Choice	Engagement

446.	<del>good</del> → excellent	Word Choice	Engagement
447.	<del>absence</del> → lack	Word Choice	Engagement
448.	<del>that</del> caused	Pronoun Use	Correctness
449.	<del>increasing</del> → increases	Incorrect Verb Forms	Correctness
450.		Intricate Text	Clarity
451.	well.	Closing Punctuation	Correctness
452.	<del>Conlusion</del> → Conclusion	Misspelled Words	Correctness
453.	<i>be used</i>	Passive Voice Misuse	Clarity
454.	<del>beeswax</del> :	Improper Formatting	Correctness
455.	<del>30</del> :	Improper Formatting	Correctness
456.	<del>arpus</del> → corpus, carpus	Misspelled Words	Correctness
457.		Intricate Text	Clarity
458.	the contour	Determiner Use (a/an/the/this, etc.)	Correctness
459.	<i>is well formed</i>	Passive Voice Misuse	Clarity
460.	<del>well formed</del> → well-formed	Misspelled Words	Correctness
461.	The method	Determiner Use (a/an/the/this, etc.)	Correctness
462.	<i>be done</i>	Passive Voice Misuse	Clarity
463.	The slurry	Determiner Use (a/an/the/this, etc.)	Correctness

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464.	<i>is stably dispersed</i>	Passive Voice Misuse	Clarity
465.	mixing/homogenization	Improper Formatting	Correctness
466.	the slurry	Determiner Use (a/an/the/this, etc.)	Correctness
467.	slurry → mud	Word Choice	Engagement
468.	strength ,	Improper Formatting	Correctness
469.	slurry → mud	Word Choice	Engagement
470.	by washing → by washing	Improper Formatting	Correctness
471.	surface → exterior	Word Choice	Engagement
472.	a wetting	Determiner Use (a/an/the/this, etc.)	Correctness
473.		Intricate Text	Clarity
474.	be done	Passive Voice Misuse	Clarity
475.	<i>After dewaxing process, the mold is heated at a temperature of 200°C for 2hours firing the mold with a burner produces a better uniform burning on the outside and inside the mold.</i>	Intricate Text	Clarity
476.	the dewaxing	Determiner Use (a/an/the/this, etc.)	Correctness
477.	<del>mold</del> → image, frame, pattern	Word Choice	Engagement
478.	<del>mold is</del> → mold is	Improper Formatting	Correctness
479.	is heated	Passive Voice Misuse	Clarity
480.	<del>mold</del> → image, frame, shell, pattern	Word Choice	Engagement
481.	<del>mold</del> → frame, shell, womb, cavity	Word Choice	Engagement

482.	the sintering	Determiner Use (a/an/the/this, etc.)	Correctness
483.	<del>Recomendations</del> → Recommendations	Misspelled Words	Correctness
484.	The melting	Determiner Use (a/an/the/this, etc.)	Correctness
485.	the expenditure	Determiner Use (a/an/the/this, etc.)	Correctness
486.	<del>in order to</del> → to	Wordy Sentences	Clarity
487.	<del>in</del> → for	Wrong or Missing Prepositions	Correctness
488.	be applied	Passive Voice Misuse	Clarity
489.	<del>a</del> simple	Determiner Use (a/an/the/this, etc.)	Correctness
490.	<del>small-medium</del> → small-medium	Misspelled Words	Correctness
491.	<del>Philiphine</del> → Philippine	Misspelled Words	Correctness
492.	Philiphine :	Improper Formatting	Correctness
493.	, Muskegon	Improper Formatting	Correctness
494.	Waxes :	Improper Formatting	Correctness
495.	<del>Refference</del> → Reference	Misspelled Words	Correctness
496.	<i>Investment shell molds are made by applying a series of ceramic coatings to the pattern clusters. Each coating consists of a fine ceramic layer with coarse ceramic particles embedded in its outer surface.</i>	C 8 - investment casting - LinkedIn SlideShare <a href="https://www.slideshare.net/cpandiv/c-8-investment-casting">https://www.slideshare.net/cpandiv/c-8-investment-casting</a>	Originality