Alternative materials for grey cast iron corn-mill plates by computer-aided selection and weighted property methods: the case of Ghana

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Abstract

Most locally-manufactured corn-mill plates in tropical countries are made of grey cast iron due to its relatively low cost, good wear resistance, good hardness and other mechanical properties in general. However, these corn-mill plates are prone to corrosion and abrasive wear resulting to contamination of milled corn which is consumed by humans. This work focuses on the use of computer-aided selection and weighted property methods to identify alternative materials for grey cast iron corn-mill plates. Requirements such as non-toxicity, good corrosion resistance, good wear resistance, low friction coefficient, high thermal conductivity, low specific gravity, high compressive strength and low cost were used in the initial material selection stages. The derivation of material performance index in addition to Ashby's materials selection chart are used to find suitable materials to replace grey cast iron. The decision method showed that white cast iron with high-chromium alloy had the highest weighted performance index (93.75%), while nodular graphite cast iron had the least weighted performance index (65.55%). High-chromium alloyed white cast iron was therefore considered as substitute for the grey cast iron corn-mill plates.

Keywords Corn-mill plates · Materials selection · Material index · Weighted property index · Attrition · Cast iron

1 Introduction

In Ghana, corn-based delicacies such as 'banku', 'akple', 'kenkey', corn-porridge, etc. are some of the most consumed foods. Corn, being the starting material, is milled by either wet or dry processes. Milling is achieved by the use of a pair of grooved or striated metallic plate's surfaces. One of the plates is stationary while the other rotates in a burr mill [1]. In the food processing industry, attrition milling process is widely used to create smaller mass units from larger mass units of the same food material [2]. The relative motion of these Corn-mill plates causes friction at their surfaces, resulting in wearing of the plates in service.

According to [1], this condition is mostly observed in local-corn mill-plates during wet milling [3] as compared to the foreign milling plates. The foreign corn-mill plates are however relatively expensive than the locally-produced corn-mill plates, hence are less preferred by most Ghanaian corn-mill operators.

Prior researches [1, 4–6] indicate that iron particles from locally-produced corn-mill plates contaminate the milled Corn. This in essence can be attributed to the distribution and characteristics of the micro-constituents [7] formed in the alloys during production. Other factors include the pH of the environment, chemical composition, microstructure and hardness of the corn-mill plate materials [3].

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Cast iron having good wear resistance, hardness and also being cost effective [8], has widely been used for manufacturing corn-mill plates locally. According to [2], cast iron with major composition of 95% elemental iron is used to manufacture local corn-mill plates. The paramount drawback of this material, however, is its susceptibility to corrosion attack when used with acidic foods which in conjunction with mechanical wearing, causes the contamination of the food products [3]. The long-term exposure to these metallic contaminants accounts for health-related issues caused by their excessive intake and accumulation in the human body [1]. Therefore, there is the need to improve the quality of locally-produced corn-mill plates or provide an alternative material for the milling plates in order to minimize the health risks associated with them.

Efforts have been made by researchers to improve the surfaces of these materials for better performance under service conditions [9–11]. However, the surface modification methods come with its associated drawbacks such as high cost and impurities used for the treatment. There are over 160,000 materials now available [12] with range of different characteristics and applications. It is therefore necessary to perform a systematic materials selection in order to narrow down and/or rank the alternative materials. The large variety of materials and manufacturing processes accessible to the engineer, in addition to the complex relationships between the various materials choice parameters, typically build the choice of materials for a given application a tough task. If the method of selection is carried out unsystematically, there will be the risk of overlooking a potential material. This risk can be reduced by adopting a systematic material selection procedure.

Computer-aided material selection software application or materials selection chart is very useful in screening a huge number of materials at the concept design stage.

The quality of corn-mill plates therefore depends on the materials' chemical composition; microstructure and properties as well as environmental conditions. Therefore, with the needed functional requirements, alternative materials could be obtained from the list of materials universe. During the materials selection process, the materials engineer or the designer has virtually all materials available. The selection of an optimal material for a design from among two or more alternative materials on the basis of two or more properties is a multi-objective decision-making problem. The main purpose of the present work is to select alternative material with improved properties than existing material for producing local corn-mill plates. This was achieved using CES EduPack software (Version 12.2.13) and weighted property method.

2 Cast iron for attrition milling

Attrition milling is the most common size reduction process used in the food processing industry. Over the years, different materials have been used for milling. These materials include stone slabs as well as mortar and pestle carved from stones and wood by craftsmen. In Ghana, attrition machines also known as corn-mill machines are more convenient, easier and healthier option [2]. Attrition machines utilize a pair of mill plates (shown in Fig. 1a) to grind corn and other staple foods such as legumes [1]. In the milling process, one of the plates rotates relatively to a stationary one which results in heat generation by friction and wearing of the contacting parts (as shown in Fig. 1b).

Cast iron is an iron alloy containing alloying elements such as carbon, silicon, chromium, nickel, copper, molybdenum and other elements to enhance mechanical, tribological and chemical properties of iron and among others

Fig. 1 **a** Unused local corn mill plate produced from grey cast iron. **b** Worn out Corn mill plate from grey cast iron

[13]. Sampare [2] reported that chilled cast iron is mostly used in Ghana for the mill plates, with a composition of at least 95 wt% iron. Iron is known to be a highly corrosive material; and cast iron has proven to be highly corrosive in acidic food media [3], thus, contaminating the food which is consumed by humans. Chilled cast iron (surface chilled iron) is a type of cast iron with a composition such that the surface is purely white cast iron, while the bulk of the material is grey cast iron.

Chilled cast iron is obtained by casting the parts against a chiller. The surfaces of the chilled cast iron cool and solidify at a faster cooling rate than the interior and, thus, it is harder and has a good wear resistance. The depth of the chilled surface depends on the chemical composition of the molten cast iron. It specifically decreases when carbon and silicon contents are high and increases with chromium and molybdenum [14]. Chilled cast iron may be alloyed with vanadium, niobium or titanium to form carbide inclusions within the pearlitic, ferritic or austenitic matrix and, thus, obtain white cast iron. Corn mill plates that are produced locally in Ghana is noted to have a shell of white cast iron at the surface due to the rapid cooling of the solidified surfaces and a core of grey cast iron since the core cools more slowly. With white cast iron, the wear resistance and antifriction properties are enhanced while maintaining a good machinability [15]. Another factor affecting the formation of the chilled surface is the solidification rate of the cast part; literature suggests that austempering heat treatment improves the mechanical properties of chilled cast iron [16]. This type of cast iron is used in the manufacturing of machine parts with simultaneous requirements of toughness and wear resistance (and hardness). Figure 1 show two different corn mills plates both produced from grey cast iron.

The paramount drawback with locally manufactured chilled cast iron mill plates, however, is the high wearing rate of the grooves which contaminates the food products. This lead to detrimental health conditions when the amount of elements that enter the food exceed the maximum allowable quantities that can be absorbed by the human body [1, 2]. The rate of deterioration occurs especially during wet grinding, where the metallic plates react with the moisture absorbed by the Corn during soaking [3].

3 Stages of materials selection

3.1 Design requirements and translation

A systematic design-oriented approach was used to select an alternative material for the corn-mill plates. All the necessary functional requirements, processability

requirements, cost and resistance to service conditions that can affect the performance of the corn-mill plate were obtained. In order to avoid wearing and food contamination by corn-mill plate's metallic particles, hardness (or wear resistance) and corrosion resistance were set as functional requirements. Thermal resistance was considered as one of the functional requirement due to the heat generated during the attrition process. Non-toxicity is very important in the food industry hence was also considered as a requirement.

The plate material must absorb the heat generated due to attrition and must possess low specific gravity to reduce energy consumption during milling. Usually, the convenient manufacturing process used in obtaining mill plates is by sand-casting, which is affordable. Thus, the selected material must be castable, withstand friction in service and should not degrade or corrode during wet and dry milling. The various requirements were then expressed as function, objective, constraints and free variables as shown in Table 1. The main objective of the material selection for the corn-mill plate was to maximize hardness/or wear resistance whilst meeting the performance goals.

3.2 Screening: property limits on chart

At the translation stage of the selection process, materials in the materials universe were screened using the constraints into the limit stage by the aid of the CES Edu-pack software. All data agrees with current literature and approved standards [17–22]. The desired properties in Table 3 were set in the software. At the limit stage, the property values of grey cast iron were obtained in Table 2 in order to easily compare the alternative materials with the one to be substituted. In substituting an existing product with a new available material having improved performance, it comes with an increased cost. This is because cost is a most useful parameter when it can be related to

Table 1 Translation of design requirements for corn-mill plate

Function	A corn-mill plate
Constraints	1. Must be castable 2. High surface hardness (H 218.5 HV)* 3. Lower coefficient of friction 4. Non-toxic 5. Good thermal resistance 6. Good compressive strength 7. Low specific gravity 8. cheap
Objective	Maximize hardness (minimize wear rate)
Free variable	1. Choice of material 2. Cross-sectional area of plate (A_n)

*The hardness constraint of 218.5 HV is the mid-point hardness value for grey cast iron (flake graphite, EN GJN HV 250)

Table 2 Constraints set under limit stage

Constraints	Conditions	Set Limits
Mechanical	Hardness	$\geq 218.5 \text{ HV}^*$
	Fracture toughness	$\geq 18 \text{ MPa}\cdot\text{m}^{0.5} *$
	Compressive strength	$\geq 355 \text{ MPa} *$
Thermal	Specific heat capacity	$\geq 482.5 \text{ J/kg } ^\circ\text{C}^*$
	Thermal expansion	$\leq 12 \text{ }\mu\text{strain/ } ^\circ\text{C}^*$
Durability	Fresh water	Excellent/Acceptable
	Weak acids	Excellent/Acceptable
	Organic solvents	Excellent/Acceptable
General	Cost	$\leq 2.00 \text{ USD/kg}^{**}$

*Mid-point property values for grey cast iron (flake graphite, EN GJN HV 250)

**Cost limit set to 200% increase in cost of grey cast iron

a critical material property that controls the performance of the design. Therefore, a target cost of 2 USD/kg (200% increase) was set as an upper limit to eliminate the materials that are very expensive. Despite the relatively higher upper cost limit as compared to the price of grey cast iron, it is important to assess the worth of the product through a cost–benefit analysis [23]. The benefits of using a material with higher properties for corn-mill plates include: longer life-span and, hence, low maintenance and replacement cost; lower contamination of milled products. The latter is key in the food production industry. Besides, 2 USD/kg is within an affordable range considering the market prices of cast iron.

Engineering materials from the CES Advanced level 3 database possess properties which met the constraints defined in the limit stage hence showed in the search region window. The tree stage was also used to superimpose processing constraints, i.e. the ease with which the candidate material can be cast. The candidate materials after the screening stage were listed in the search window. Further screening was done by deriving materials performance index using the objectives and constraints identified in Table 1 as shown in Table 2. This was achieved by using both the design guideline obtained from the material index and the graph stage in the EduPack software.

3.3 Derivation of materials index and plotting index on charts

The next materials selection stage was to obtain from the subset of materials that meet the property limits, those that would maximize the objective function of the corn-mill plate. The performance equation [24] for the wear rate, Ω , of the corn-mill plate is provided. For a corn-mill plate with surface area, A , the wear rate of the

contact surfaces increase with bearing pressure P (the normal force, F_n , divided by A_n). This can be expressed as [25] as:

$$\Omega = k_a \frac{F}{A} = k_a P \quad (1)$$

where k_a is the Archard wear constant expressed in $(\text{MPa})^{-1}$ which is a measure of the propensity of a sliding couple for wear: high k_a means rapid wear at a given bearing pressure.

The bearing pressure is specified by the design. The ability of a surface to resist a static contact pressure is a function of its hardness and, hence, its maximum value P_o equals the hardness H of the softer surface. The wear rate can be written as:

$$\Omega = k_a \left(\frac{P}{P_o} \right) H. \quad (2)$$

The objective equation contains two material properties: the wear constant (k_a) and the hardness (H). Therefore by grouping the right hand side of Eq. (2) into function of function, function of geometric requirements and function of material property requirements [26] the material index (M) that maximizes performance is, thus, given as:

$$M = k_a H. \quad (3)$$

The material index was used to eliminate materials which cannot serve the purpose of the corn-mill plate. An Ashby chart of a plot of k_a against H was generated using CES EduPack software as shown in Fig. 2. The materials selection index derived in Sect. 3.3 and the constraints indicate that the alternative material required for the corn-mill plate should be hard and non-toxic. Using a slope of -1 as obtained from the materials performance index, a straight line was overlaid on the chart.

All the engineering materials which lie on the gradient line will perform equally well, those below the line are better, and those farthest from the line are the best [27]. The search window showed five candidate materials. Table 3 shows the candidate materials with their corresponding chemical composition.

Metal alloys with good combinations of hardness, corrosion resistance and thermal properties resulted as most suitable candidates for the application. Polymeric materials, glasses and ceramics and composite materials were screened out owing to their poor tribological properties and ease of degradation, poor toughness, and inadequate processing procedures, respectively. Table 4 shows the list of some important properties of the candidate materials. Properties that cannot be easily quantified are rated on a scale of 1–5. Pair-wise comparison approach was then used to select the best material. A multi-objective

Fig. 2 CES generated material selection chart of normalized wear rate constant, k_a , against hardness with performance index gradient line shown. Here the Vickers hardness, H_v , was expressed in MPa. (Hardness in MPa is approximately equal to $10 \times H_v$.)

Table 3 Chemical compositions of five candidate materials

S. no.	Candidate materials	Composition (wt %)								
		C	Cr	Mn	Mo	Ni	P	S	Si	Fe
1.	Grey cast iron (EN GJL 250)	3.1	–	0.55	–	–	10^{-9} *	10^{-9} *	2.1	94.3
2.	Nodular graphite cast iron (EN GJL 500 7)	3.4–4	–	0.2–0.6	–	≤ 1	0.015–0.08	0.005–0.020	2–2.75	91.6–94.4
3.	Pearlitic malleable cast iron (EN GJMB 500-5)	2–2.65	–	0.25–1.25	–	–	≤ 0.12	≤ 0.18	0.9–1.65	94.2–96.9
4.	White cast iron (high chromium alloy) (EN GJN HV600 (XCr23))	1.8–3.6	22–28	0.15–1.5	≤ 3	≤ 2	≤ 0.1	≤ 0.1	≤ 1	58.8–76.1
5.	White cast iron (low alloy) (EN GJN HV350)	2.4–3.9	≤ 2	0.2–1	–	–	≤ 0.15	–	0.4–1.5	91.5–97

Values were obtained from CES Edupack Software

* $1e-9$ wt % indicates that there are trace amounts of the element but the actual amount is not specified. Also, the grades of the different metallic materials are specified by mechanical properties, so the composition information obtained from the CES Edupack software is approximate

optimization method was used to compromise between several conflicting objectives in the material selection process.

3.4 Pair-wise comparisons method

Pair-wise comparison method was used to consider multiple properties such as hardness, fracture toughness, compressive strength, specific heat capacity, corrosion resistance, toxicity and castability for the optimum selection of the materials. The suitability of each candidate

material was compared using weighted property method. This method quantitatively ranks the alternative materials for the corn-mill plates. The candidate materials must be able to satisfy more than one requirement for it to be considered as an optimal material for the corn-mill plates.

At this stage of the materials selection, a scaling factor (β) was first used to quantify how well the candidate materials satisfy each material requirement. The scaled property values (as shown in Table 5) were calculated based on methods described by [29].

Table 4 Properties of candidate materials obtained from CES Edu-Pack software database

Property	Candidate				
	1	2	3	4	5
Hardness (HV)	218.5	218.5	218.5	605	242.5
Fracture toughness (MPa.m ^{0.5})	18	38	44	16.5	18.5
Compressive strength (MPa)	355	366.5	400	700	700
Spec. heat capacity (J/kg.°C)	482.5	477.5	535	540	540
Corrosion resistance	4	4	4	5	5
Non-toxicity	5	5	5	5	5
Castability*	4	5	3	3	3

Data obtained from CES Edupack 2013. Mid-points of data ranges were used [20, 28]

5—Excellent, 4—Very good, 3—Good, 2—Fair, 1—Poor

*Castability is defined in terms of Si content (carbon equivalent) and casting energy

Table 5 Scaled values of properties of each candidate materials

Property	Candidate				
	1	2	3	4	5
Hardness (HV)	36.12	36.12	36.12	100	40.08
Fracture toughness (MPa m ^{0.5})	40.91	86.36	100	37.50	42.05
Compressive strength (MPa)	50.71	52.36	57.14	100	100
Spec. heat capacity (J/kg °C)	89.35	88.43	99.07	100	100
Corrosion resistance	80	80	80	100	100

Weighting factor (α) for each material property was also determined by considering its importance to the performance of the mill plates. Some properties are more important than others while others may be quite similar in importance, thus determining the relative importance of the different properties assigned to these attributes is therefore necessary. The property that is considered to be the more important among two properties is assigned a 1 and the less important property is given a 0 as shown in Table 5. It is important to prevent contamination in applications that involve direct contact of engineered

parts with edibles. Thus, hardness and non-toxicity as well as corrosion resistance of the corn mill plate are key properties for consideration. Ensuring good hardness of the plates also means that they are going to last longer and will efficiently perform their function of milling, thus reducing cost. A good balance of hardness and toughness is required in the design, as excessive hardness (brittleness) will result in fracture of the plates. Corrosion resistance is significant in this application, especially during wet milling processes.

From Table 6, it can be seen that corrosion resistance has the highest weighted factor, followed by hardness. Fracture toughness, specific heat capacity and compressive strength were assigned the least weights in the decision-making process. For the present application, corrosion resistance and hardness are considered to be the most important properties. The materials with such properties are deemed high quality materials in the quest to solve the emerging problems with the existing corn-mill plates. High hardness is desirable to make the attrition process possible, without contaminating the food with metallic particulates. It is also very important that these materials are easy to be sand-cast, since it is the convenient manufacturing process for corn-mill plates in Ghana. In order to find the weighted property index for each candidate material, the scaled property values were first multiplied by the assigned weighting factor, to give the weighted scaled values [30]. The weighted property index was obtained by summing all the weighted scaled values for each candidate material [31]. The index was then used to compare candidate materials for its suitability in the corn-mill plates.

Table 7 shows the performance indices of all the candidate materials. White cast iron, high-chromium alloy (EN GJN HV600 (XCr23); former BS 3E) passed the selection stages with the highest performance index, i.e. 93.75%; thus, it proved to be the best material option for the application followed by low alloy white cast iron (EN GJN HV350; former BS 1C) with a performance of 76.23%. Cast iron, grey, flake graphite, EN GJL 250; Cast iron, nodular graphite, EN GJL 500 7 and Cast iron, pearlitic malleable,

Table 6 Determination of relative importance of properties using pairwise comparison

Properties	1/2	1/3	1/4	1/5	2/3	2/4	2/5	3/4	3/5	4/5	Positive decisions	Weighting factor (α)
1. Hardness	1	1	1	0							3	0.3
2. Fracture toughness	0				0	1	0				1	0.1
3. Compressive strength		0			1			0	0		1	0.1
4. Spec. heat capacity			0			0		1		0	1	0.1
5. Corrosion resistance				1			1		1	1	4	0.4
Total											10	1.0

Table 7 Scaled values of properties of each candidate materials

Property	Candidate				
	1	2	3	4	5
Hardness (HV)	36.12	36.12	36.12	100	40.08
Fracture toughness (MPs m ^{0.5})	40.91	86.36	100	37.50	42.05
Compressive strength (MPa)	50.71	52.36	57.14	100	100
Spec. heat capacity (J/kg °C)	89.35	88.43	99.07	100	100
Corrosion resistance	80	80	80	100	100

Fig. 3 Performance indexes of the five candidate materials

EN GJMB 500-5 had low performance indices of 60.93%, 65.55% and 68.46%, respectively.

Figure 3 shows the performance indices for the five candidate materials. It clearly indicates that high-chromium alloyed white cast iron has the highest weighted performance index followed by white cast iron with low alloy content. Pearlitic malleable cast iron and nodular graphite cast iron, with performance indices of 68.46% and 65.55% respectively, also proved to be a better substitute for grey cast iron with flakey graphite. The grey cast iron whose performance index is 60.93% is the material to be substituted. All candidate materials are castable and non-toxic

for which reason these properties were not included in the pair-wise comparison method. White cast iron with high chromium content has shown to possess high qualities owing to its relatively higher cost as compared to the rest of the candidate materials.

The performance index indicated in Fig. 3 showed the potential material for the job without regard to the cost of the material. However, cost of material plays a vital role in material selection and therefore, cost is considered separately as a modifier to the materials performance index (γ). It is also important to consider the cost of material before making any final design or ranking. Therefore, a figure of merit (FOM) for the candidate materials is calculated before ranking using Eq. (4):

$$FOM = \gamma / C\rho \quad (4)$$

where C is the relative cost of material per unit mass; ρ is density of material.

Table 8 presents the FOM and ranking of the candidate materials for corn mill plate application. From Table 8 it can be seen that white cast iron (low alloy) showed the highest figure of merit followed by Pearlitic Malleable Cast Iron (EN GJMB 500-5), Grey Cast Iron (EN GJL 250), Nodular Graphite Cast Iron (EN GJS 500 7) and White Cast Iron—High Cr (EN GJN HV600(XCr23)).

3.5 Implication of results

Locally-manufactured corn-mill plates are made of grey cast iron, a ferrous metal containing flake graphite. The paramount drawback of these plates is the poor corrosion resistance and relatively low hardness which result in food contamination by corrosion and worn-out debris leading to health related issues. This corn-mill plate material contaminates corn-based milled foods with high quantities of iron and other heavy metals particles. The grey cast iron which used for the production of corn-mill plates would have health implications for the consumers who depend on it for their milling needs. The replacement of this material, therefore, seems inevitable.

Research has shown that consumption of heavy metals from the worn-out debris from these materials can cause

Table 8 Relative cost and figure of merit of candidate materials

Candidate material	Relative cost	Density (g/cm ³)	C _p	γ	FOM	Rank
Grey Cast Iron (EN GJL 250)	1	7.2	7.2	60.93	8.46	3rd
Nodular Graphite Cast Iron (EN GJS 500 7)	1.140625	7.13	8.13	65.55	8.06	4th
Pearlitic Malleable Cast Iron (EN GJMB 500-5)	0.96875	7.27	7.04	68.46	9.72	2nd
White Cast Iron—High Cr (EN GJN HV600(XCr23))	2.96875	7.8	23.16	93.75	4.05	5th
White Cast Iron—Low Alloy (EN GJN HV350)	1	7.7	7.70	76.23	9.9	1st

diseases like cancer, liver failure, damage to the nervous system, kidney failure, etc. These diseases may affect consumers, most of whom may not be aware of such dangers anyway. Therefore, the utilization of the proposed alternate material will safeguard the health of the people and improve on the quality of the food. When the grey cast iron is substituted with high-chromium alloyed white cast iron, there will be low possibility of consumption of iron into the human body. This is as a result of the use of the alternate material with improved wear resistance.

As suggested by Kwofie et al. (2011) [1], the selection of an optimal material with adjusted chemical composition and controlled microstructure will improve the wear and corrosion resistance of the plates. Thus, the rational and systematic decision-making process adopted in this work is essential to select the most appropriate material. The systematic material selection technique used in this work can aid a materials designer or engineer in defining the material requirements for a required function, and then finding the material that would suit the function best. The materials selection stages used in this work provides a clearer understanding on materials selection with multiple and/or conflicting requirements.

It is noteworthy to mention that improving the quality of the plates not only will solve health issues of concern but will also positively affect economics by minimizing the need to constantly replace the worn-out corn mill plates. The introduction of alternate material to substitute existing grey cast iron could help reduce the foreign exchange burden on importation. Operators who use the imported plates because it lasts longer will no longer use them.

4 Conclusion

In this paper, a case study on the selection of materials for corn mill plates was conducted. The CES Edupack software and Ashby's material selection charts were used for the initial screening of the candidate materials. Five ferrous metals (cast irons) were obtained as candidate materials and these include grey cast iron with flake graphite; nodular graphite cast iron; pearlitic malleable cast iron; white cast iron with high-chromium alloy; white cast iron with low alloy content. The digital logic method showed that white cast iron with high chromium alloy had the highest weighted property index when low cost is not a priority. As predicted, unalloyed cast iron (grey cast iron) obtained the lowest property index, proving it is less fit for the application. However, when figure of merit (FOM) is considered as a modifier to the materials performance index, white cast iron (low alloy) showed the highest FOM followed by Pearlitic Malleable Cast Iron (EN GJMB 500-5), Grey Cast Iron (EN GJL 250), Nodular Graphite Cast Iron (EN GJS 500

7) and White Cast Iron—High Cr (EN GJN HV600(XCr23)). It is recommended that experimental work should be carried out to further establish the suitability of the proposed candidate materials.

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Availability of data and material Data and materials will be provided upon request.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest regarding the publication of this paper.

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