QUESTION 2

THE EXAMINATION PAPERS FOR QUESTION 2 CONSIST OF:

PAPER 1 – Text of Question (8 sheets)

PAPER 2 – Figures showing the theory of the client's invention (1 sheet)

PAPER 3 – Example of client's invention (1 sheet)

PAPER 4 – Patent A Extract (1 sheet)

PAPER 5 – Article B Extract (2 sheets)

TEXT OF QUESTION

Your client, Thokar Pty Ltd, is an Australian manufacturer of refined steel used in a wide range of products.

You receive a telephone call from the Research and Development Manager of Thokar, Dr Michael Smith. Dr Smith invites you out to a meeting at the client's steel production facility to discuss a new invention. Dr Smith tells you the new invention represents a significant advance (in his view) over the well established basic oxygen process (BOP) used for many years in the manufacture of steel.

You arrive at your client's facility and meet with Dr Smith. You immediately tell Dr Smith that your memory of the basic oxygen process is a little hazy, and Dr Smith patiently reminds you that the basic oxygen process is one of the simplest chemical processes which has been in use for over a hundred years. Dr Smith reminds you that the basic oxygen process is a method of producing steel from a ferrous melt, such as molten pig iron. The principle involved is that of oxidation of impurities in the pig iron by oxygen that is blown onto and through the molten iron. The heat of oxidation raises the temperature of the mass and keeps it molten during the operation. The process is carried out in a large container called a converter or reactor, which is made of steel and has a lining of refractory material. The capacity is generally from 8 to 30 tonnes of molten iron. Converters are often egg shaped. At its narrow upper end there is an opening through which the iron to be treated is introduced and the finished product is poured out. A lance is placed above the mouth of the converter, and oxygen is blown on to the pig iron under pressure, and circulates through the molten pig iron in the converter. Dr Smith further reminds you that as oxygen passes through the molten pig iron, impurities such as silicon, manganese and carbon unite with the oxygen to form various oxides. These oxides form a "slag" which is left behind when the refined steel is produced at the end of the process.

Dr Smith also reminds you that for high quality steel production, the carbon content of the pig iron needs to be reduced, and that this is also effected by blowing oxygen onto the pig iron. During the process, the carbon unites with the oxygen to form carbon monoxide which evolves from the melt, and is often call an "off-gas". The refining process, that is blowing the melt with oxygen, is often called decarburization, due to reduction in carbon content of the melt through CO evolution.

Dr Smith reminds you that the basic oxygen process is quite quick and that it takes about an hour, and is much faster than the other process which his company does not use, being the open-hearth process used in steel making.

Dr Smith tells you that the carbon content of the steel during the refining process can be measured by sampling the molten iron being refined with oxygen. A refined low-carbon steel is produced when the carbon content is no higher than about 0.1%.

Dr Smith tells you that when low carbon steel is made by the basic oxygen process (Dr Smith sometimes referring to this process as BOP), it is often subject to contamination by atmospheric nitrogen. Dr Smith tells you that pig iron often contains small amounts of nitrogen which are removed during refinement. However, atmospheric nitrogen can contaminate steel quite significantly. Dr Smith tells you that such contamination tends to cause premature age hardening of steel, which leads to strain-aging, poor surface properties and undesirable appearance of the final product.

Dr Smith tells you that up until now Thokar had not really worried too much about the nitrogen content of the low-carbon content steel they produced. However, competition for refined steel had become so intense that their production quality had to lift, and low nitrogen content steel had to be produced by the BOP process as well.

Dr Smith tells you that his R&D department has been able to come up with a very effective BOP process, which produces a low carbon content steel, having a carbon content no higher than about 0.1% w/w, which additionally has a nitrogen content no higher than 0.005% w/w. Dr Smith tells you that this has been done without doing any major modifications to their standard "converter".

Dr Smith then goes on to tell you the new BOP process which Thokar have discovered.

Dr Smith tells you that Thokar have found that nitrogen contamination in the refining process occurs when the carbon content of the steel is low. At high carbon levels the rate of carbon monoxide generation during the oxygen blow or decarburization period produces off-gas carbon monoxide at a rate sufficient to prevent significant infiltration of the surrounding atmosphere into the reaction vessel. At high carbon levels Dr Smith says that his R&D group has found that the carbon monoxide boil produced by blowing oxygen onto the pig iron melt is sufficient to remove (also known as sparge) some of the nitrogen that may be dissolved in the steel. During the initial stages of decarburization therefore, the nitrogen levels in the steel decreases. Dr Smith tells you that the real essence of what R&D have found is that beyond a certain carbon level however, as the carbon level drops, the nitrogen content of the melt begins to increase. Dr Smith tells you that they have found that as the carbon level drops, the rate of carbon monoxide formation by the decarburization reaction which has evolved from the pig iron, known as off-gas evolution, drops, this making it possible for atmospheric nitrogen to enter the head space of the vessel and be absorbed by the melt. Further, R&D have shown that the oxygen jet used in the decarburization helps carry nitrogen down into the melt at that stage. Thus, as the off-gas flow rate decreases with decreasing carbon content, infiltration of atmospheric nitrogen into the vessel is increased.

Dr Smith refers you to two figures, labelled Figures 1 and 2 (see PAPER 2), which illustrate the concept of the invention.

Dr Smith tells you that Figure 1 is a graph illustrating the nitrogen content of a pig iron melt as a function of carbon content in typical commercial refining system without using the present invention. Dr Smith says it is clear from their studies that as the carbon content (C (%)) goes down, as illustrated going from a starting point of 0.2%, the nitrogen content decreases to a minimum and then starts to rise. The minimum nitrogen level (N*) occurs at carbon content C* as depicted in Figure 1. In the system shown in Figure 1, at a carbon content of less than 0.08%, the nitrogen content of the melt starts to increase. Dr Smith describes that the curves A and B simply represent a range of melt temperatures and that for convenience of explanation he will focus on a standard melt temperature which is depicted at curve B.

Dr Smith refers you to Figure 2 and says this is a graphic representation of the change in carbon monoxide off-gas flow rate F (measured in m^3/min) as a function of carbon content (C) for the same system for which data is shown in Figure 1. Dr Smith says that as you would expect, as the carbon content of the steel goes down as a consequence of CO being evolved from the melt, the CO off-gas flow rate decreases with decreasing melt carbon content as there is less carbon available for CO production. For illustration purposes, Dr Smith tells you that he has labelled the 0.08% carbon content figure as C* as in Figure 1 and that this corresponds to an off-gas flow rate of about 15,000m^3 per minute shown at F* in Figure 2.

What we have surprisingly found, Dr Smith says, is that at a melt carbon content which corresponds to the minimum or near minimum nitrogen content in the melt, a nitrogen-free fluid is added to the oxygen blow at a flow rate such that the total off-gas flow rate from the vessel is maintained at a level which is at least equal to the off-gas flow rate at the minimum nitrogen content. You ask Dr Smith why an inert gas is not blown in with the oxygen at the beginning of the BOP. Dr Smith tells you that evolved CO is collected and sold as a commercial product. Hence, Thokar do not add the inert gas at the determined flow rate until at or near the minimum nitrogen content.

It is further explained that increasing the flow rate of oxygen towards the end stage of the decarburization process rather than adding an inert gas is not a useful option. Excessive amounts of oxygen at this critical end stage of the process can cause unwanted oxidation of some minor impurity metals beneficial to the strength and quality of the steel so produced.

Dr Smith explains to you that the nitrogen free fluid can be introduced through the same lance which blows oxygen onto the surface of the melt.

Dr Smith takes you back to Figure 1 and tells you that while all BOP systems exhibit curved shapes similar to Figure 1, the numerical relationship between N and C and their values are specific to each BOP system and its manner of operation, and must be plotted from data during actual process runs. Dr Smith tells you the reason for this variation from system to system are variations in oxygen blow rate, lance operating position, lance design, melt weight, and temperature vessel geometry and so on. Dr Smith emphasises that what is important is their finding that as the carbon content C decreases, the nitrogen content N also decreases until a minimum is reached, at which point the nitrogen content begins to rise again. By ensuring that the flow rate of an inert gas is blown onto the melt at or before this minimum to give an off-gas flow rate which is at least at a level of that experienced at the minimum nitrogen content, atmospheric nitrogen is not able to contaminate the melt.

Dr Smith tells you that the nitrogen free fluid includes, but is not limited to, argon, helium, neon, krypton, xenon, carbon monoxide, gaseous hydrocarbons such as methane and ethane and mixtures thereof. Dr Smith says that argon is preferred.

Dr Smith refers again to Figure 2 and says that BOP systems from various steel producers will have their own curve for this relationship, again depending on system characteristics and manner of operation as he has already described. Dr Smith tells you that in a standard BOP system, off-gas flow rates can be easily determined, using for example a flow meter, or even by preparing a graph of carbon content versus time. Dr Smith also tells you that nitrogen levels in the melt can be readily measured, for example using X-ray fluorescence. Similarly, carbon content in the melt can be easily measured by well known methods.

In summary, Dr Smith tells you that Figures 1 and 2 show that for any particular BOP system, the injection of a nitrogen-free fluid is begun at a carbon content in the melt which is at or before the minimum nitrogen content (shown at N* in Figure 1). The flow rate of the injected nitrogen free fluid is that which is at least equal to the off-gas flow rate at the minimum nitrogen level in the melt (shown as F* in Figure 2).

You ask Dr Smith if there are any other important points of his process. Dr Smith replies that blowing with argon seems to give the best results, that is the purest steel. Dr Smith says that the process enables steel to be produced that has a carbon content below 0.1%, and a nitrogen content below 0.005%.

You ask Dr Smith is there anything important in reactor design, temperature or nature of the ferrous melt and the way that the oxygen is blown onto the melt, and further the way that the inert gas is blown onto the melt at the appropriate time. Dr Smith says no. Any conventional reaction vessel can be used where a ferrous melt is contained in the vessel and blown with oxygen from above. Dr Smith mentions that it is convenient to blow an inert gas into the reactor admixed with oxygen.

Dr Smith refers you to an example of the "invention" which is set out in PAPER 4.

You ask Dr Smith if anyone else has come up with a similar process and he says that he does not think so. Dr Smith refers you to two patents he has found during a search, being Patent A (PAPER 5) and Patent B (PAPER 6). Dr Smith says that these patents require modification of BOP vessels which is expensive and cumbersome to utilise, including maintenance of particular atmospheres above the melt. He says their process does not require an equipment change, use of a vacuum, or the like.

Dr Smith asks you to proceed with a patent application accompanied by a complete specification in respect of Thokar's development.

QUESTION 2

PLEASE READ THE FOLLOWING STANDARD INSTRUCTIONS CAREFULLY

Candidates are required to draft a complete specification for an Australian Standard patent. Candidates should accept as correct the information given in the question relating to technical aspects of the prior art and the client's development, but candidates should exercise their own judgement in relation to non-technical statements made by the client.

Candidates should judge the novelty of the client's development against the prior art supplied and should not have regard to any personal knowledge they may have concerning similar subject matter.

The specification should comply with Sub-Sections (2) and (3) of Section 40 of the Patents Act 1990, and should address the prior art and advances made.

All claims must be novel over the prior art and should exhibit at least a scintilla of invention. Marks will not be awarded for claims directed to features which are not material to the invention under consideration and the inclusion of such claims may affect the Examiners' assessment of the candidate's answer paper.

Care should be taken with expression in all aspects of the paper and legible writing in ink will greatly assist the Examiners to assess candidate's answer papers.

(100 marks)

END OF QUESTION 1

QUESTION 2

PAPER 2

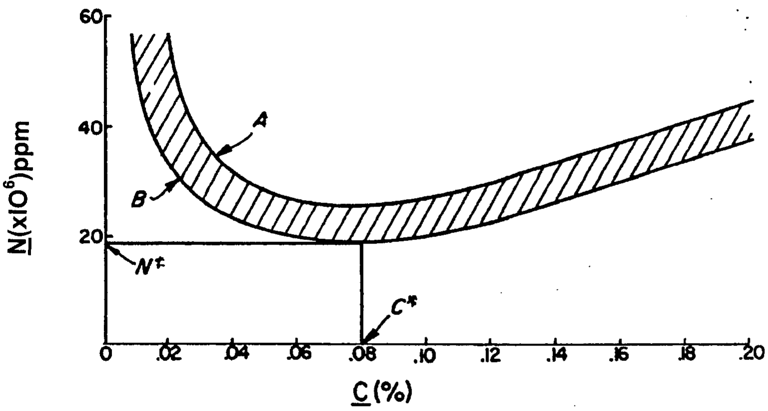

FIG. 1

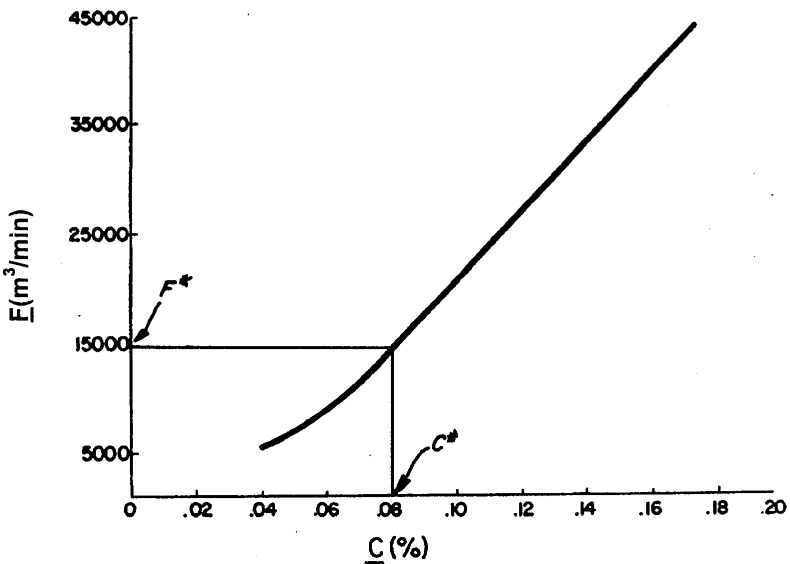

FIG. 2

EXAMPLE OF CLIENT'S INVENTION

Several pig iron melts were refined by top blowing in a BOP refining system. The invention is practised by maintaining a constant oxygen blowing rate throughout the BOP process.

Nitrogen content, off-gas flow rate, and carbon content during the BOP process were determined.

The off-gas flow rate corresponding to carbon levels in the melt which correlated with minimum nitrogen content was determined. In the particular system tested which involved a vessel volume of 5000 m^3, a vessel mouth area of 95 m^3, a pig iron charge of 235 tonnes, and an oxygen blowing rate of 20,000 m^3/min, the off-gas flow rate at a carbon content of 0.08% (which correlated with the minimum nitrogen level in the melt during the process) was 15,000 m^3/min.

In practising this invention, the inert gas argon is injected at a carbon content in the melt which corresponds to the minimum or near minimum nitrogen level, and is injected at a flow rate corresponding to the off-gas flow rate at this carbon content (15,000 m^3/min at standard pressure).

In other BOP reactors tested, different flow rates were determined corresponding to minimum nitrogen levels in the melt during the BOP process. In these reactors, at or about the minimum nitrogen content, an inert gas was blown with oxygen to maintain the off-gas flow rate determined at minimum nitrogen content of the melt.

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PAPER 4

PATENT A

METHOD FOR OPERATING BASIC OXYGEN STEEL PROCESS WITH THE INTRODUCTION OF A CARBON DIOXIDE CURTAIN

This invention relates to a method of making steel by the basic oxygen process where oxygen is blown onto a ferrous melt contained in a vessel from above the surface of the melt.

In this invention nitrogen is excluded from the melt by placing a hood over the mouth of the refining vessel, and injecting into the hood a curtain of carbon dioxide so as to exclude contamination of the melt by nitrogen from ambient air.

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PAPER 5

PATENT B

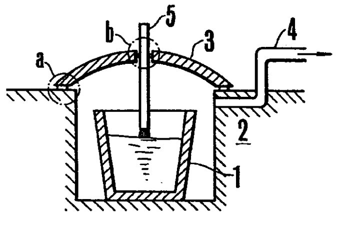
METHOD FOR PRODUCING AN EXTREMELY LOW CARBON AND NITROGEN STEEL IN A VACUUM REFINING APPARATUS

This invention concerns a method for producing an extremely low carbon and nitrogen steel in a vacuum refining apparatus, in which a tank enclosing a container containing a molten ferrous metal, particularly pig iron is maintained under airtight conditions, is evacuated, and the melt is refined with oxygen blowing thereinto.

It has been found that when oxygen is blown onto molten steel under a reduced pressure to effect decarburization (carbon removal as CO gas) an inert gas such as xenon is introduced into the evacuated head space of the reactor, and oxygen is blown onto the melt using a lance which passes through an airtight container lid, through an airtight seal, such that oxygen is blown from the lance onto the melt to refine it. The inert gas and airtight conditions prevent nitrogen contamination.

Figure 1 is set out below.

FIG.1



QUESTION 2

PAPER 5

In this figure, one represents the reaction container. The reaction container is located in pit 2. A lid 3 maintains an airtight contact through which lance 5 blows oxygen onto the surface of the melt as shown. Airtight seals are shown at positions a and b. Exhaust pipe 4 allows a vacuum to be applied. The inert gas is introduced into the evacuated space through a gas supply path (not shown).