Final Diploma

Patent Examination Board

FD4 Infringement and Validity

Tuesday 25 October 2022

10:00 to 15:30 UK British Summer Time (GMT + 1 hour)

Examination time: 5 hours 30 minutes plus 10 minutes upload time

The 5 hours 30 minutes is allocated as follows:

10 minutes – Downloading and printing the question paper;
5 hours – Answering the questions;
20 minutes – Four screen breaks of 5 minutes each.

At 15.30 you MUST immediately stop answering the questions. You then have **10 minutes** in which to upload your Answer document to the PEBX system.

You MUST upload your Answer document to the PEBX system by 15.40. After 15.40 you will not be able to upload it and your examination will be void.

INSTRUCTIONS TO CANDIDATES

1. The whole assessment task is to be attempted.
2. The total number of marks available for this paper is 100.
3. You must use the Answer document for your answers.
4. Do not attempt to change the font style, font size, font colour, line spacing or any other preset formatting.
5. Start each part of your answer on a new page. Press the Control key and the Enter key simultaneously to begin a new page.
6. Do not state your name anywhere in the answers.
7. This question paper consists of **14 sheets**, including this sheet, and comprises:
   Assessment task (1 sheet)
   Client letter (2 sheets)
   Document A GB2500006B (6 sheets, including one page of drawings)
   Document B *Automotive Engineering Trade Monthly*, March 2022 (2 sheets)
   Document C *Journal of Steel Processing*, vol 53, June 1980 (1 sheet)
   A spare set of Claims (Document A) (1 sheet)

8. A spare set of Claims is also provided in your Answer document for you to use if you wish.

AT THE END OF THE EXAMINATION

9. Save your Answer document to your computer as a Word document. Convert the Answer document to a PDF. Check the Answer document to make sure that amended Claims are shown as you want in the Answer document. Upload the PDF-ed Answer document to the PEBX system.

Assessment task

Your client sends you the letter and documents listed on the Instructions to Candidates.

Your task is to prepare advice to your client on whether the attached granted patent may be enforced and defended.

You should prepare notes on which you would base your advice in which you:

a) **provide an opinion on infringement and validity, in the UK only;**

b) **identify other patent-related legal issues pertinent to the facts presented;**

c) **outline possible actions that may be taken to strengthen your client's legal position;**

d) **summarise the opinions formed in a) to c) above.**

Note the following:

a) You should accept the facts given to you and base your answer on those facts.

b) You should not make use of any other special knowledge that you may have of the subject matter concerned.

Allocation of marks

Construction: 20 marks
Infringement: 16 marks
Novelty: 24 marks
Inventive Step: 22 marks
Amendment: 2 marks
Sufficiency: 5 marks
Advice: 11 marks
Total: 100 marks

Dear Patent Attorney

We are Carbotreat Ltd. Our company provides heat treatment services to manufacturers of steel components. We have been in business for over 40 years. Originally, we operated a gas carburization service for our clients, heat treating their steel components to produce a harder outer layer or ‘case’. Gas carburization is well-known and has been widely available in the UK for nearly 100 years.

A few years ago, we developed an improved carburizing process using ammonia, which we patented. This has become our main service and I enclose a copy of our recently granted patent, **GB2500006B** (Document A) and a copy of the single prior art document cited in prosecution of our application, *Journal of Steel Processing*, vol 53, June 1980 (Document C).

Most of our business comes from the automotive industry. While we initially developed our patented process to treat valve seat inserts, most of our business these days comes from treating crankshafts for engine tuning companies for use in competition engines. While this uses essentially the same process as described in the patent, we have made a number of refinements. The first is that the temperature of the second stage of the process must be between 800 and 850 Celsius. Above 850 Celsius, the ammonia dissociates into nitrogen and hydrogen in the furnace rather than at the component surface, this in turn dilutes the treatment atmosphere and prevents a proper case layer from forming. Below 800 Celsius, the temperature is insufficient to provide carburization. Outside these temperatures, results become highly unpredictable and from time to time fail to provide any useful improvement in properties. The second is that we need to ensure that the component is at the lower temperature when the second stage starts. Because of the larger thermal mass of a crankshaft, it can take up to 30 minutes from dropping the furnace temperature until the crankshaft temperature reaches equilibrium. We have found that this is relatively easy to determine with a few practical tests. Both of these are critical to achieving a consistent result.

We recently became aware of a UK company called Ferrocase Ltd, providing a heat treatment service that uses endothermic gas (as defined in the patent) and ammonia, when one of our long-standing customers told us it was moving some of its work to Ferrocase. We did some research and found the enclosed article from the March 2022 edition of *Automotive Engineering Trade Monthly* (Document B). Is there anything we can do to stop Ferrocase from offering

Cont…

our process? Any loss of business is damaging to us, so we want to do what we can to preserve our market. We would appreciate an outline of the procedure for enforcing the patent.

Yours sincerely

A. Neeling, Managing Director
Carbotreat Ltd

GB2500006B – HEAT TREATING STEEL COMPONENTS

Filing Date: 06.03.2019
Date of Publication of Application: 30.09.2020
Grant of Patent 31.01.2022

This invention relates to a method for treating steel components involving heat treating the component in a controlled atmosphere so as to modify the surface properties of the component.

Steel is an alloy of iron, typically having a carbon content of between 0.002% and 2.1% by weight. Alloy steel is steel to which other alloying elements have been intentionally added to modify its characteristics, e.g. manganese, nickel, chromium, molybdenum, boron, titanium, vanadium, tungsten, cobalt, and niobium. The inclusion of these alloying elements can give steel improved mechanical properties and corrosion resistance. However, they are expensive and often need complex processing.

It is well known to modify the physical or chemical properties of steel components by heat treatment. By submitting the component to heating and cooling, the crystal structure of the steel can be changed into forms that are stronger or tougher.

One form of heat treatment for metals that has been used for many years is known as case hardening. In case hardening, heating and cooling the component in a controlled manner leads to the surface layer of the metal component being modified so as to be hard, while the inner part of the component remains in a softer form. Steels having a carbon content of 0.1–0.3 weight % are known as 'low-carbon steels' and do not normally case harden due to the low carbon content. There is no noticeable change in the properties of the surface layer following heat treatment. However, if the carbon content of the steel surface can be raised during heat treatment, a harder surface layer can form. This addition of carbon to the surface of the steel component is known as carburizing. One way in which carbon is added during carburization is to perform the heat treatment in a carbon-rich environment that provides carbon atoms which adsorb onto the steel surface. The carbon-rich environment can be a gas that dissociates to provide carbon atoms. This is known as gas carburization. A number of gases have been used, but the most common gas used for gas carburization is known as 'endothermic gas'. Endothermic gas is produced by incomplete combustion of hydrocarbons in air, such as natural gas (methane) or propane. A typical example has a composition of:

- N_2 (nitrogen): 45.1% (volume)
- CO (carbon monoxide): 19.6% (volume)
- CO_2 (carbon dioxide): 0.4% (volume)
- H_2 (hydrogen): 34.6% (volume)
- CH_4 (methane): 0.3% (volume)

A typical gas carburization process involves heating the component in a furnace to 900–950 Celsius while feeding endothermic gas from a gas generator to provide a carbon-rich atmosphere. Carbon atoms, mainly from the breakdown of carbon monoxide, diffuse and adsorb onto the metal near the surface. The treatment is continued for up to six hours and results in a modified surface layer (known as the 'case') of up to 6.5 mm deep.

Following the heat treatment, the component is removed from the furnace and rapidly cooled ('quenched'), typically in an oil bath, to retain the modified surface properties. This can lead to distortion and changed dimensions of the component. Consequently, gas carburization is usually followed by machining operations to restore the component to its desired shape and finish.

This invention provides a modified gas carburization process that reduces the need for post-treatment machining or grinding.

The invention defined in the claims is characterized by the addition of a nitrogen-rich gas to the furnace atmosphere. This leads to the adsorption of nitrogen atoms on to the component surface. This allows a shallower but harder case to be produced using lower temperatures and for shorter times, thus avoiding the distortion found in previous gas carburization processes, particularly during quenching.

The process is a two-stage process, comprising an initial treatment with the carbon-rich gas ('carburizing') followed by a second treatment in which the nitrogen-rich gas is added to the furnace so that both carbon-rich gas and nitrogen-rich gas are present in the furnace atmosphere ('carbonitriding').

Carburizing gas, typically endothermic gas, can be generated next to the furnace and fed into the furnace to maintain the carbon-rich atmosphere.

The nitrogen-rich gas is a gas that dissociates to provide nitrogen atoms at the surface of the component. The nitrogen-rich gas is typically ammonia (NH_3), which dissociates into nitrogen and hydrogen. Nitrogen gas (N_2) does not dissociate into nitrogen atoms at the temperatures used in heat treating steel and so cannot be used as the nitrogen-rich gas. This gas can be fed separately into the furnace from a storage tank. This can be done so that the treatment atmosphere in the furnace contains up to 11% ammonia by volume. If more than this is used, the carburizing atmosphere becomes too diluted and the modification of surface properties becomes inconsistent.

The gas flow rate is typically in the range 6–9 litre/min.

The temperature in the furnace is preferably no more than 955 Celsius. In one embodiment, the steel component is heated in the carbon-containing gas at a temperature of 900–955 Celsius for a first period, after which the nitrogen-containing gas is introduced into the treatment atmosphere while heating the component at a temperature of about 815–900 Celsius for a second period. Temperatures in this lower range, typically around 850 Celsius, are sufficient to dissociate the ammonia to provide nitrogen atoms for adsorption onto the metal surface while maintaining a carburization effect from the endothermic gas.

The first period is selected to provide a predetermined carburized case depth, e.g. up to 2.5mm. This is followed by a second period to give a nitrogen-rich case depth of 0.07mm–0.75mm.

This invention is particularly useful for low-carbon steels (carbon content of 0.1–0.3 weight %) with low natural hardenability. The carburizing provides a case layer which is then further hardened by carbonitriding.

Drawings:

Figure 1 is a schematic view of a carburizing furnace suitable for performance of the invention.

Figure 2 is a part view of a valve seat insert in a cylinder head.

Examples:

The method is performed in a standard carburizing furnace 1 (see Fig. 1) with an endothermic gas generator 2. The furnace has been modified to include a separate feed 3 from an ammonia storage tank with a control valve 4. An electrical supply 5 is connected to power the furnace 1 under the control of a temperature controller 6. Gas exits the furnace via an exhaust 7. The parts 8 to be treated are supported on a conventional load plate 9.

In this example (see Fig. 2), the steel component is a valve seat insert 10 for use in the inlet and exhaust ports 12 in the cylinder head 14 of an internal combustion engine. Valve seat inserts are often made from nickel steel to reduce erosion at the very high temperatures found in an engine. However, nickel steel is expensive and so lower grade steel can be used if it is case hardened. The relatively small size of the inserts means that they are prone to distortion under heat treatment and so often need post treatment machining to ensure their dimensions.

The valve seat inserts are placed in the furnace 1 and the temperature raised to 950 Celsius while feeding endothermic gas from the generator 2. The inserts are held at this temperature for a period of about two hours, sufficient to produce a carburized case layer of 2.0mm–2.5mm.

At the end of this first period, the temperature in the furnace is lowered to 850 Celsius and the ammonia valve 4 is opened. The feed rate is adjusted so that ammonia comprises 10–11% volume of the atmosphere in the furnace. The valve seats are held at this temperature for up to three hours to produce a layer of adsorbed carbon and nitrogen of about 0.5mm depth.

Following treatment, the inserts are removed from the furnace and cooled by oil quenching and cleaned.

In another example, the component is a crankshaft for an engine. While crankshafts are not subjected to high temperatures like valve seat inserts, they are subjected to high mechanical forces. Because of the larger size of the crankshaft compared to the valve seat inserts, the treatment times in each of the stages is usually about 50% longer.

Gas mixtures, flow rates, and temperature/time profiles can be adjusted according to the type of component to be treated, the type of steel used, and the amount of case hardening required.

CLAIMS

1. A method of heat treating a steel component, comprising:

heating the steel component in a treatment atmosphere to an elevated temperature for a period of time sufficient to form a modified layer on the surface of the steel component;

wherein the treatment atmosphere comprises:

a carbon-containing gas suitable for creating a carbon-enriched layer on the surface of the steel component; and

a nitrogen-containing gas suitable for creating a nitrogen-enriched layer on the surface of the steel component.

2. A method as claimed in claim 1, wherein the elevated temperature is no more than 900 Celsius.

3. A method as claimed in claim 1 or 2, wherein the carbon-containing gas is endothermic gas, and the nitrogen-containing gas is ammonia.

4. A method as claimed in claim 3, wherein the treatment atmosphere contains up to 11% by volume ammonia, the balance being endothermic gas.

5. A method as claimed in any preceding claim comprising:

heating the steel component in the carbon-containing gas at a temperature of 900–955 Celsius for a first period;

introducing the nitrogen-containing gas; and

heating the steel component in the treatment atmosphere including the nitrogen-containing gas at a temperature of about 850 Celsius for a second period.

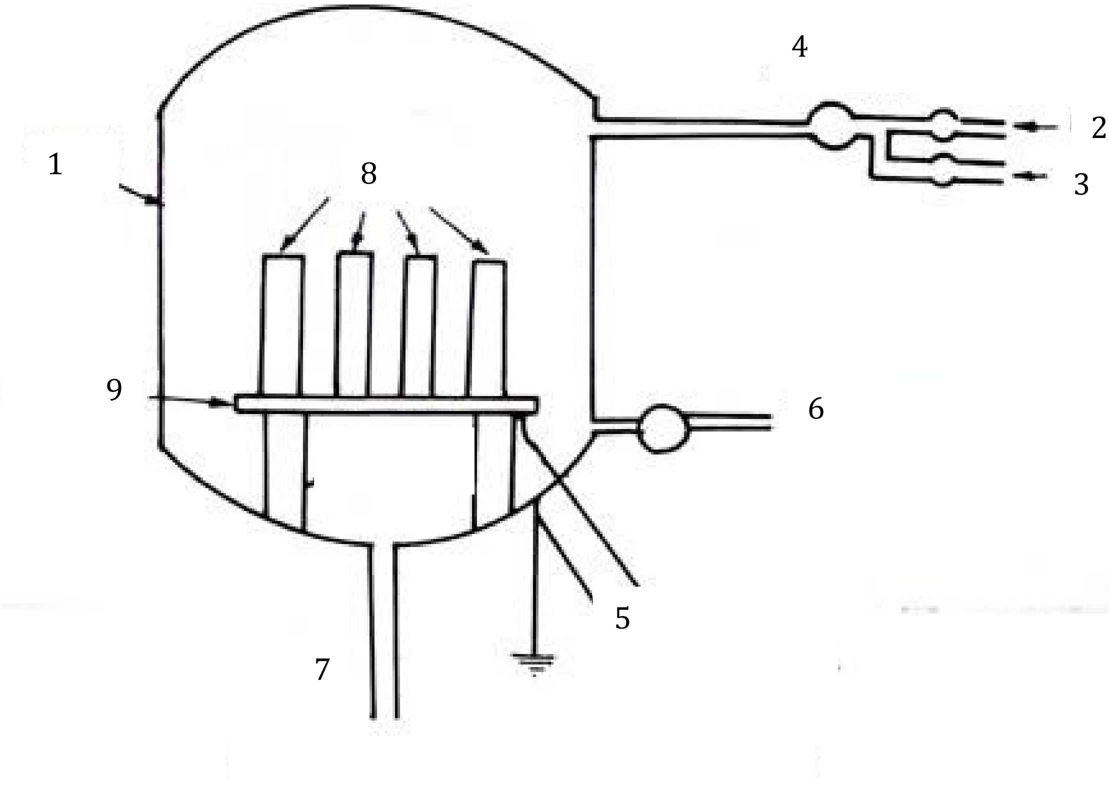

Fig. 1

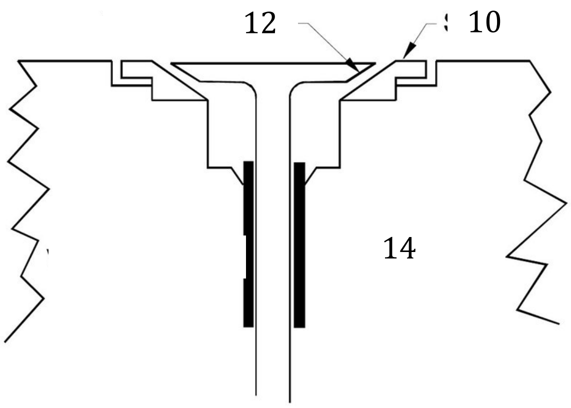

Fig. 2

Automotive Engineering Trade Monthly, March 2022

FERROCASE UNVEILS IMPROVED NITRIDING FURNACE

Ferrocase Ltd has recently introduced a new steel nitriding furnace that allows it to provide case hardening in much shorter times than its standard nitriding process. They have added an endothermic gas generator to the standard ammonia tank and have modified the gas supply so that both ammonia and endothermic gas can be added to the furnace at the same time to provide the treatment atmosphere.

The control process of the improved furnace has been configured to have two modes: Nitriding ('Gastride') and Nitrocarburising ('Gastride Plus').

Nitriding mode corresponds to Ferrocase's standard Gastride process with an ammonia feed at 490–560°C for treatment times ranging up to 90 hours, and involves the diffusion of nitrogen into the surface to produce a controlled depth ('diffusion zone') of hard alloy-nitrides. Hardening is achieved without the need for quenching (rapid cooling in oil to retain the modified surface properties).

This delivers the standard case depth of about 0.45mm.

The Gastride Plus Nitrocarburising mode is a new process with both ammonia and endothermic gas feed, generally of shorter duration (30 minutes–5 hours), and involves enrichment of the surface with both nitrogen and carbon to impart a thin carbonitride layer on a nitride 'diffusion zone'. The furnace temperature control can be set to 560°C–720°C depending on the particular modification required. The process may be completed by quenching in oil.

There are two standard gas mixtures available for use as treatment atmospheres in Gastride Plus Nitrocarburising mode:

Endothermic gas 50% vol., Ammonia 50% vol.

Endothermic gas 40% vol., Ammonia 50% vol., Air 10% vol. (mixed into the Endothermic gas feed before entry into the furnace to partially combust any residual hydrocarbon in the gas mixture from the endothermic gas generator).

The process can be adjusted to give case depths of 0.075–0.75mm.

With the modifications Ferrocase has made, the control system allows complete control of gases and temperature. Therefore, customised treatments can be developed for particular applications.

Ferrocase's MD told *AET Monthly* that one of their clients, a UK engine manufacturer, approached them in early 2019 and told them that it needed to be able to turbocharge its standard four-cylinder 50 HP diesel engine so as to be able to deliver up to 70 HP and to be sure that the crankshaft could handle the almost 50% increase in power. They wanted to avoid a completely new crankshaft design and wanted to see if the existing crankshaft could be made much stronger.

Ferrocase determined that the base steel of the strengthened crankshaft could remain unchanged but the existing surface treatment needed to be improved so that a hard diffusion layer of more than 0.55mm in depth would be needed. They felt that their standard Gastride gas nitriding process, which they have been using for over 10 years, would not be able to address this need and began to develop a modified process, Gastride Plus.

Use of the Gastride Plus process with either of the standard gas mixtures achieved an increase in the strength of the crankshaft of over 150% and Ferrocase's client entered into a long-term contract for Ferrocase to provide Gastride Plus treatment for its crankshafts for at least the next five years.

The new nitriding furnace allows Ferrocase to be able to provide both Gastride and Gastride Plus services using the same furnace.

Journal of Steel Processing, vol 53, June 1980, Stahl, C.

CARBONITRIDING: THE FUTURE OF HEAT TREATMENT

Carbonitriding is a modified form of gas carburizing, a process that has been used for many years to case harden steel. The modification consists of introducing ammonia into the gas carburizing atmosphere to add nitrogen to the carburized surface case layer as it is being produced. Nitrogen forms at the work surface by the dissociation of ammonia in the furnace atmosphere; the nitrogen diffuses into the steel simultaneously with carbon. Typically, carbonitriding can be carried out at a lower temperature and for a shorter time than regular gas carburizing, producing a shallower but harder case than is usual in production carburizing.

In terms of case layer characteristics, carbonitriding differs from carburizing in that carburized case layers normally do not contain nitrogen, whereas a carbonitrided case layer contains both.

Carbonitriding is used primarily to impart a hard, wear-resistant case layer, generally from 0.08 to 0.8 mm deep. A carbonitrided case layer has better hardenability than a carburized case. Consequently, by carbonitriding and quenching, a hardened case layer can be produced at less expense within the depth range indicated. Full hardness with less distortion can be achieved with oil quenching, or, in some instances, even gas quenching, employing a protective atmosphere as the quenching medium.

Steels with a carbon range of 0.30 to 0.50% can be carbonitrided to case depths up to about 0.3 mm when a combination of a reasonably tough, through-hardened core and a hard, long-wearing surface is required (crankshafts and transmission gears are typical examples).

One major advantage of carbonitriding is that the nitrogen absorbed during processing lowers the critical cooling rate of the steel. That is, the hardenability of the case layer is significantly greater when nitrogen is added by carbonitriding than when the same steel is only carburized. This permits the use of steels on which uniform case layer hardness ordinarily could not be obtained if they were only carburized and quenched. Where core properties are not important, carbonitriding permits the use of low-carbon steels, which cost less and may have better machinability or formability.

Because of lower processing temperatures and/or the use of less severe quenches, carbonitriding may produce less part distortion and better control of dimensions than carburizing, and thus may eliminate the need for straightening or final grinding operations.

Spare Set of Claims

CLAIMS

1. A method of heat treating a steel component, comprising:

heating the steel component in a treatment atmosphere to an elevated temperature for a period of time sufficient to form a modified layer on the surface of the steel component;

wherein the treatment atmosphere comprises:

a carbon-containing gas suitable for creating a carbon-enriched layer on the surface of the steel component; and

a nitrogen-containing gas suitable for creating a nitrogen-enriched layer on the surface of the steel component.

2. A method as claimed in claim 1, wherein the elevated temperature is no more than 900 Celsius.

3. A method as claimed in claim 1 or 2, wherein the carbon-containing gas is endothermic gas, and the nitrogen-containing gas is ammonia.

4. A method as claimed in claim 3, wherein the treatment atmosphere contains up to 11% by volume ammonia, the balance being endothermic gas.

5. A method as claimed in any preceding claim comprising:

heating the steel component in the carbon-containing gas at a temperature of 900–955 Celsius for a first period;

introducing the nitrogen-containing gas; and

heating the steel component in the treatment atmosphere including the nitrogen-containing gas at a temperature of about 850 Celsius for a second period.