Title: MANUFACTURING METHOD OF HIGH STRENGTH PART AND THE HIGH STRENGTH PART THEREBY

Abstract: The goal of the present invention is to improve productivity and workability and simultaneously to achieve high strength by processing a part made of steel and by increasing its strength. To this end, the present invention provides a method of manufacturing a high strength part, including processing a steel material having a first tensile strength as a first member having a predetermined form of a finished part, and nitriding the first member in a salt bath including a non cyan group nitrate to form a second member having a second tensile strength that is greater than the first tensile strength, and a high strength part manufactured using the method.

FIG. 1

- PROCESS FIRST MEMBER
- FORM SECOND MEMBER
- FORM THIRD MEMBER
- WELD AND/OR PAINT

- S1
- S2
- S3
- S4
MANUFACTURING METHOD OF HIGH STRENGTH PART AND THE HIGH STRENGTH PART THEREBY

TECHNICAL FIELD

The present invention relates to a method of manufacturing a high strength part and a high strength part manufactured using the method, and more particularly, to a method of manufacturing a high strength part by which workability and high strength are obtained simultaneously, and a high strength part manufactured using the method.

BACKGROUND ART

Recently, demand for high strength, lightweight parts formed of steel, such as car parts, has increased. In accordance with demand for high strength, high strength parts are manufactured by forming parts in a desired form by using a high strength steel sheet having tensile strength that is equal to or greater than 400 MPa by performing a variety of forming processes, such as pressing, etc. High strength steel includes Dual Phase (DP) steel, Complex Phase (CP) steel, TRansformation Induced Plasticity (TRIP) steel, Twinning Induced Plasticity (TWIP) steel etc.

However, in order to process parts in a desired form by using such a high strength steel sheet, a forming method that is suitable for tensile strength of a corresponding steel sheet must be selected. In addition, a metallic mold for forming the high strength steel sheet must be formed at higher strength than that of the steel sheet so as to be suitable for tensile strength of a steel sheet. As tensile strength increases, a forming method, in particular, a plastic working is greatly restricted.

Deterioration of workability of such a high strength steel sheet causes a reduction in productivity of parts and an increase in costs.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flowchart illustrating a method of manufacturing a high strength part, according to an embodiment of the present invention.

FIG. 2 is a stress-strain graph according to an embodiment of the present invention.
FIG. 3 is a stress-strain graph according to another embodiment of the present invention.

FIG. 4 is a graph illustrating the relationship between nitriding time and tensile strength according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

The present invention provides a method of manufacturing a high strength part by which a part made of steel is processed and its strength is increased so that productivity and workability are improved and simultaneously, high strength is obtained, and a high strength part manufactured using the method.

TECHNICAL SOLUTION

According to an aspect of the present invention, there is provided a method of manufacturing a high strength part, the method including: processing a steel material having a first tensile strength as a first member having a predetermined form of a finished part; and nitriding the first member in a salt bath comprising a non cyan group nitrate to form a second member having a second tensile strength that is greater than the first tensile strength.

The processing of the first member may include forming the steel material.

The forming of the steel material may include press forming, hydroforming, bending, cutting or polishing.

The steel material may be steel comprising carbon in an amount of 0.2 wt% or less and may include low carbon steel, ultra low carbon steel or Interstitial Free (IF) steel.

The steel material may include a steel material having elongation that is equal to or greater than 15%.

The first tensile strength may be equal to or less than 500 MPa, and more particularly, the first tensile strength may be equal to or less than 400 MPa.

The second tensile strength may be 400 to 1100 MPa.

The forming of the second member may include maintaining the non cyan group nitrate at a temperature of 400-700°C.
The forming of the second member may include immersing the first member in the salt bath for 1 minute to 24 hours.

The non cyan group nitrate may include at least one salt selected from the group consisting of KNO₃, KNO₂, Ca(NO₃)₂, NaNO₃, and NaNO₂.

The method may further include forming a third member by removing a surface oxidation scale formed on the second member.

The method may further include welding or painting the third member.

According to another aspect of the present invention, there is provided a high strength part manufactured by using the method.

ADVANTAGEOUS EFFECTS

According to the present invention, a first member made of steel, in the form of a finished part and having a first tensile strength is manufactured and then, a second member having a second tensile strength that is greater than the first tensile strength is formed by using non cyan group nitriding method so that forming workability can be improved in the forming of the finished part, a conventional processing method suitable for a raw material can be used without changes and a part having sufficiently high strength can be manufactured without the need of additional facilities. In addition, when a raw material having good workability, low strength and high elongation is used, the durability and life span of a processing facility, such as a mold, etc., can be further increased. In addition, desired tensile strength can be easily obtained with respect to a product having a finished form so that demand for various parts can be easily satisfied.

BEST MODE

Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the attached drawings.

FIG. 1 is a flowchart illustrating a method of manufacturing a high strength part, according to an embodiment of the present invention.

The method of manufacturing a high strength part according to the present embodiment of the present invention comprises an operation S1 of processing a steel material having a first tensile strength into a first member having a predetermined, finished part form by a forming method, which is suitable for processing the steel material. In this case, the processing of the steel material may be performed using only a single operation. However, the present invention is not limited to only one operation and the
processing of the steel material may comprise two or more than operations. For example, when a steel sheet is used as the steel material, the steel sheet may be processed into an intermediate member by using a first pressing process and then a final part may be formed in a desired form by applying a second pressing process to the intermediate member. In addition, when a coil is used as the steel material, the coil may be processed into a pipe and then the pipe is processed into a part having a desired form. The method of processing the first member may be press forming, hydroforming, bending, cutting, polishing or the like. The first member manufactured by using operation S1 may have the form of a finished part and may not be processed to form a shape in a subsequent operation.

Meanwhile, tensile strength, i.e., the first tensile strength of the steel material may be low so as to improve workability. The first tensile strength may be generally lower than tensile strength required for a high strength part. As such, the steel material can be easily processed by using a conventional processing method without using a specific processing method. Due to an improvement in workability, a facility for manufacturing a high strength part is not separately required and an existing facility can be used without changes and thus the present invention is more economical.

In order to improve workability, low carbon steel having low tensile strength and high elongation due to carbon content of 0.2 wt% or less may be used as the steel material. The steel material may include material that is manufactured for a deep-hole drilling process, such as low carbon steel, ultra low carbon steel, Interstitial Free (IF) steel, or the like. The elongation of the steel material may be equal to or greater than 15%. In addition, the first tensile strength may be equal to or less than 500 MPa, and more preferably, the first tensile strength may be equal to or less than 400 MPa. Interstitial Free (IF) steel and ultra low carbon steel having tensile strength that is equal to or less than 500 MPa may have maximum elongation that is equal to or greater than 50%. Thus, it is easy to form a part. The time required for a process of manufacturing such a steel material having low strength is shorter than the time required for a process of manufacturing high strength steel such as Dual Phase (DP) steel, Complex Phase (CP) steel, Transformation Induced Plasticity (TRIP) steel, or Twinning Induced Plasticity (TWIP) steel, and the amount of alloy addition is low. Thus, a low strength steel material can be manufactured relatively inexpensively. When high strength steel, such as DP steel, CP steel, TRIP steel, or TWIP steel, is directly used in operation S1, due to the characteristic of a product design, parts having various tensile strengths must be
produced according to grades. However, in the present invention, the strength of a steel material having a tensile strength condition of one grade is increased by using a post-processing process in various grades and thus, productivity is further improved.

A material having excellent elongation unlike high strength steel is used in operation S1. Thus, press forming in a complicated shape can be performed and products can be formed in a variety of shapes. In addition, hydroforming processing can be performed as described above and thus, a pipe or a tube etc. can be freely formed.

Contrary to this, when high strength steel is formed, due to low elongation with respect to high strength, press forming in a complicated shape cannot be performed, and if necessary, a process of forming a material by heating the material during the press forming must be additionally performed. In addition, due to the limitation of forming, structure strength cannot be increased and must depend on strength of a steel material. Thus, when part forming is performed by using steel having high strength that is equal to or greater than 800 MPa, a process other than a simple process, such as bending, cannot be performed.

Next, the first member having such construction is immersed in a salt bath containing non cyan group nitrate, to form a second member having a second tensile strength in operation S2.

Salt bath nitriding using non cyan group nitrate used in operation S2 is not a carbonitriding method in which both nitrogen and carbon are infiltrated into metal by using molten salt, such as KCN or NaCN etc. in which conventional cyanide (CN), i.e., cyan group is contained, but is a nitriding method by which only nitrogen is infiltrated into metal by using non cyan group molten salt. In this case, the non cyan group nitrate includes at least one salt selected from the group consisting of KNO₃, KNO₂, Ca(NO₃)₂, NaNO₃, and NaNO₂.

In the nitriding method performed in operation S2, at least one salt selected from the group consisting of KNO₃, KNO₂, Ca(NO₃)₂, NaNO₃, and NaNO₂ is put into a salt bath and then, the salt is molten and is maintained at a temperature of 400-700 °C, preferably, at a temperature of 550-680 °C. After that, the first member is immersed in the salt bath for a predetermined amount of time, for example, 1 minute or 24 hours and is thereby nitrided. For example, when a car part formed of IF steel having tensile strength of 300 MPa is immersed in nitrate KNO₃/NaNO₃ at 600 °C for 2 to 4 hours, a car part having tensile strength of 400-700 MPa is manufactured.
The nitrate begins to be melted at nearly 300°C and is slowly decomposed at 400°C or higher to generate nitrogen and nitrogen oxide as shown in the following formulas. Thus, there is no reaction of the nitrate at 400°C or less, nitrogen is not diffused into the first member, and a decomposition reaction occurs excessively briskly so that the amount of nitrogen dissipated to the air is larger than the amount of nitrogen diffused into the first member, which is non-efficient. Thus, a temperature of 550-680°C in which decomposition of nitrate occurs and nitrogen is efficiently diffused into the first member, may be most preferable.

Formula 1 shows a nitrogen generation reaction in a salt bath, such as NaNO₃ or NaNO₂.

[Formula 1]
\[
\text{NaNO}_3 \rightarrow \text{NaNO}_2 + 1/2\text{O}_2
\]
\[
2\text{NaNO}_2 \rightarrow \text{Na}_2\text{O} + \text{NO}_2 + \text{NO}
\]
\[
2\text{NaNO}_2 + 2\text{NO} \rightarrow 2\text{NaNO}_3 + \text{N}_2
\]

Formula 2 shows a nitrogen generation reaction in a salt bath, such as KNO₃ or KNO₂.

[Formula 2]
\[
\text{KNO}_3 \rightarrow \text{KNO}_2 + 1/2\text{O}_2
\]
\[
2\text{KNO}_2 \rightarrow \text{K}_2\text{O} + \text{NO}_2 + \text{NO}
\]
\[
2\text{KNO}_2 + 2\text{NO} \rightarrow 2\text{KNO}_3 + \text{N}_2
\]

Formula 3 shows a nitrogen generation reaction in a salt bath, such as Ca(NO₃)₂.

[Formula 3]
\[
\text{Ca(NO}_3)_2 \rightarrow \text{CaO} + 2\text{NO}_2 + 1/2\text{O}_2
\]
\[
2\text{NO}_2 \rightarrow 2\text{O}_2 + \text{N}_2
\]

By using the salt bath nitriding method using a non cyan group salt, a nitrogen solid solution layer in which nitrogen is contained is formed in the first member, thereby forming the second member.

By using nitriding, the tensile strength of the second member is significantly increased. The second tensile strength of the second member nitried in this manner is
about 400-1100 MPa and may be appropriately selected according to a nitriding temperature and nitriding time.

According to the present invention, after the first member is formed in the shape of a final part by using a steel material having good workability, the strength of the first member is increased by nitriding, thereby producing a high strength part. Thus, the high strength part can be manufactured without limitation in workability.

Nitriding is performed on a conventional car part after several parts are manufactured. However, salt bath nitriding in this case is strictly nitrocarbonizing, and pure nitriding, such as gas and ion nitriding etc., is to improve wear-resistance due to surface hardening on a slide surface of a slide part. In addition, in pure nitriding, such as gas and ion nitriding etc., carbon acts as a lubricant on a slide surface and is differentiated from a method of increasing strength like in the present invention.

In nitriding used as a conventional surface processing method, an alloy element, such as Ti, Al, or the like, contained in steel reacts with nitrogen to form a precipitation product, such as TiN, AlN, or the like, thereby precipitation hardening and increasing surface hardness. However, in the present invention, the first member including low carbon steel having low tensile strength, is nitrided so that nitrogen is contained in steel and solid solution strengthening occurs. Thus, a nitrogen solid solution layer in which nitrogen is contained can be formed to a sufficient thickness.

The thickness of the nitrogen solid solution layer varies according to nitriding time and temperature. As nitriding time increases, the thickness of the nitrogen solid solution layer increases.

For example, when a first member formed of low carbon steel including carbon in an amount of 0.2 wt% is nitrided in a NaNO₃ molten salt of a salt bath at 680°C, the first member is nitrided to a depth of 3.0 mm from the surface thereof, which is about 6 times the nitriding thickness using a conventional nitriding method. Considering that a general car steel sheet part is manufactured from a steel sheet having a thickness that is equal to or less than 1T (1.0 mm), in the present invention, a nitrogen solid solution layer can be formed throughout the entire thickness of the steel sheet in consideration of the depth of nitriding from both surfaces of the steel sheet. Thus, the strength of the first member can be greatly increased unlike a conventional nitriding method forming a nitriding layer only on the surface.

Such a nitriding method is described in Korean Patent Application Publication No.
2006-0049077, which is a prior application of the present applicant, in greater detail.

After the second member is formed in this way, operation S3 of removing an oxidation scale of the surface of the second member is performed to form a third member. The operation S3 of removing an oxidation scale may be performed using a Continuous Pickling Line (CPL) or a sand/short blast method according to characteristics of products.

Next, operation S4 of welding and/or painting the third member is performed to mount the third member on a device such as a car, thereby forming a finished high strength part.

MODE OF THE INVENTION

<Embodiment 1>

First, IF steel having tensile strength of 350 MPa and elongation of 40% was produced or used as a steel material. IF steel was manufactured as coils by hot rolling and cold rolling and then was manufactured as a pipe by using a pipe constituting device. Next, the pipe was bent to have a U-shape by hydroforming, thereby forming a first member in a final form. The first member was the shape of an engine base (a cradle) of a car.

The first member formed in this way was immersed in a salt bath containing non cyan group nitrate maintained at 630°C. The nitrate was formed by mixing NaNO₃ and KNO₃. The first member was immersed in the nitrate for 2 to 12 hours and was heat-treated, thereby forming a second member.

Next, the second member was taken out from the dyebath, and then, an oxidation scale formed on the surface of the second member was removed by using CPL and a sand/short blast method, thereby forming a third member. The third member was welded and painted to form a final product.

FIG. 2 is a stress-strain graph of experimental examples according to the present embodiment of the present invention. Experimental Example 1 shows the case where a first member was immersed in nitrate at 630°C for 2 hours, Experimental Example 2 shows the case where a first member was immersed in nitrate at 630°C for 4 hours, Experimental Example 3 shows the case where a first member was immersed in nitrate at 630°C for 6 hours, and Experimental Example 4 shows the case where a first member was immersed in nitrate at 630°C for 8 hours.

Referring to FIG. 2, all of the first members have high strength that is equal to or
greater than 400 MPa.  

As such, according to the present invention, a part can be manufactured by hydroforming that cannot be easily applied to high strength steel, and a car part having strength of 450-800 MPa can be produced.

<Embodiment 2>

IF steel having tensile strength of 400 MPa and elongation of 30% was produced and used as a steel material. IF steel was produced as a press sheet by hot rolling and cold rolling. The press sheet was formed using a pressing process, thereby forming a first member having the form of a reinforcement member for a car bumper.

The first member was immersed in a salt bath including nitrate NaNO₃ at 670℃ for 24 hours and was heat-treated, thereby forming a second member.

Next, the second member was taken out from the dyebath, and then, an oxidation scale formed on the surface of the second member was removed by using CPL and a sand/short blast method, thereby forming a third member and welding and painting the third member to form a final product.

FIG. 3 is a stress-strain graph of experimental examples according to the present embodiment of the present invention. Experimental Example 5 shows the case where a first member was immersed in nitrate at 670℃ for 12 hours, Experimental Example 6 shows the case where a first member was immersed in nitrate at 670℃ for 8 hours, Experimental Example 7 shows the case where a first member was immersed in nitrate at 670℃ for 5 hours, and Experimental Example 8 shows the case where a first member was immersed in nitrate at 670℃ for 3 hours. Comparative Example shows the case where nitriding was not performed.

Experimental Example 5 has tensile strength of 1066 MPa, Experimental Example 6 has tensile strength of 953 MPa, Experimental Example 7 has tensile strength of 672 MPa, Experimental Example 8 has tensile strength of 577 MPa, and Comparative Example has tensile strength of 405 MPa.

As such, according to the present invention, a part was formed by using a raw material having tensile strength of 400 MPa that can be easily formed by press forming and was heat-treated, thereby producing a car part having strength of about 600-1100 MPa.

<Embodiment 3>
IF steel having tensile strength of 400 MPa and elongation of 30% was produced and used as a steel material. IF steel was formed as a first member having the form of a car part.

The first member was immersed in a salt bath including non cyan group nitrate at 592°C and was nitrided for 26 hours.

FIG. 4 illustrates a change in tensile strength according to nitriding time. As time elapsed, the tensile strength of a product increased gradually.

In addition, when the temperature of a salt bath was 550°C, 600°C, and 650°C under the conditions above and nitriding was respectively performed for 6 hours, tensile strength and elongation values were measured and are shown in Table 1 below.

<table>
<thead>
<tr>
<th>Nitriding temperature (°C)</th>
<th>Tensile strength (MPa)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>550</td>
<td>540</td>
<td>28</td>
</tr>
<tr>
<td>600</td>
<td>720</td>
<td>17</td>
</tr>
<tr>
<td>650</td>
<td>880</td>
<td>12</td>
</tr>
</tbody>
</table>

As can be seen from Table 1, as the temperature of the salt bath increased, tensile strength and elongation increased.

The present invention can be applied to various parts made of steel including car parts.

While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.
CLAIMS

1. A method of manufacturing a high strength part, the method comprising: processing a steel material having a first tensile strength as a first member having a predetermined form of a finished part; and nitriding the first member in a salt bath comprising a non cyan group nitrate to form a second member having a second tensile strength that is greater than the first tensile strength.

2. The method of claim 1, wherein the processing of the first member comprises forming the steel material.

3. The method of claim 2, wherein the forming of the steel material comprises press forming, hydroforming, bending, cutting or polishing.

4. The method of claim 1, wherein the steel material is steel comprising carbon in an amount of 0.2 wt% or less.

5. The method of claim 4, wherein the steel material comprises low carbon steel, ultra low carbon steel or Interstitial Free (IF) steel.

6. The method of claim 1, wherein the steel material comprises a steel material having elongation that is equal to or greater than 15%.

7. The method of claim 1, wherein the first tensile strength is equal to or less than 500 MPa.

8. The method of claim 7, wherein the first tensile strength is equal to or less than 400 MPa.

9. The method of claim 1, wherein the second tensile strength is 400 to 1100 MPa.
10. The method of claim 1, wherein the forming of the second member comprises maintaining the non cyan group nitrate at a temperature of 400-700 °C.

11. The method of claim 1, wherein the forming of the second member comprises immersing the first member in the salt bath for 1 minute to 24 hours.

12. The method of claim 1, wherein the non cyan group nitrate comprises at least one salt selected from the group consisting of KNO₃, KNO₂, Ca(NO₃)₂, NaNO₃, and NaNO₂.

13. The method of claim 1, further comprising forming a third member by removing a surface oxidation scale formed on the second member.

14. The method of claim 13, further comprising welding or painting the third member.

15. A high strength part manufactured according to one of claims 1 to 14.
FIG. 1

PROCESS FIRST MEMBER → S1

FORM SECOND MEMBER → S2

FORM THIRD MEMBER → S3

WELD AND/OR PAINT → S4
FIG. 4

Graph showing the relationship between tensile strength (MPa) and nitriding time (h).
**INTERNATIONAL SEARCH REPORT**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

Independent claim 1 is a method of manufacturing a high strength part, the method comprising: processing a steel material having a first tensile strength as a first member having a predetermined form of a finished part, and nitriding the first member in a salt bath comprising a non cyan group nitrate to form a second member having a second tensile strength that is greater than the first tensile strength.

Independent claim 15 is directed to a high strength part manufactured according to the method of one of claims 1 to 14.

(Continued in the Supplemental Box.)

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [X] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- [ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- [ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- [ ] No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2008)
# INTERNATIONAL SEARCH REPORT

**International application No.**
PCT/KR2008/003891

## A. CLASSIFICATION OF SUBJECT MATTER

*C21D 1/46 (2006.01))*

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

- IPC 8: C21D 1/46, C21D 9/48, C21D 8/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

- Korean utility models and applications for utility models since 1975
- Japanese utility models and applications for utility models since 1975

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

- eKIPASS (KIPO internal) & Keywords: Nitriding, Nitrogenation, low carbon steel, ultra low carbon steel, IP steel and similar terms

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 3928087 A (ROLLIN E. HOOK) 23 December 1975 See the abstract; column 4, line 30 - column 6, line 31; examples 1-7; and claims 1-2.</td>
<td>1-15</td>
</tr>
<tr>
<td>X</td>
<td>US 3998666 A (LEE J. CUDEY et al.) 21 December 1976 See the abstract; column 5, line 59 - column 6, line 3; and claims 1-14.</td>
<td>1-15</td>
</tr>
</tbody>
</table>

□ Further documents are listed in the continuation of Box C.  

[ ] See patent family annex.

* Special categories of cited documents:
  * A: document defining the general state of the art which is not considered to be of particular relevance
  * E: earlier application or patent but published on or after the international filing date
  * L: document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
  * O: document referring to an oral disclosure, use, exhibition or other means
  * P: document published prior to the international filing date but later than the priority date claimed

**Date of the actual completion of the international search**
17 OCTOBER 2008 (17.10.2008)

**Date of mailing of the international search report**
17 OCTOBER 2008 (17.10.2008)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office  
Government Complex-Daejeon, 139 Seomsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea

Faesimilie No. 82-42-472-7140

Authorized officer

KIM, Seong Kon

Telephone No. 82-42-481-5526

Form PCT/ISA/210 (second sheet) (July 2008)
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<th>Patent document cited in search report</th>
<th>Publication date</th>
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<td>CA 2250742 A1</td>
<td>02.07.2008</td>
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<td>JP 11-507320 A</td>
<td>29.06.1998</td>
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<td>JP 2001-507060 A</td>
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<td>JP 3970323 B2</td>
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<td>KR 2000010664 A</td>
<td>25.02.2000</td>
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<td></td>
<td></td>
<td>US 5772795 A</td>
<td>30.06.1998</td>
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Continuation of Box III.

The common technical feature between claims 1 and 15 is the method defined in claim 1. This feature lacks an inventive step with respect to the documents US 392087 A, US 3998666 A, and WO 1998/26450 A1 cited in the ISR. Thus, there is no technical relationship left over the prior art among the claimed inventions, leaving the claims without a single general inventive concept.

Hence, there is a lack of unity of invention "a posteriori" (PCT Rules 13.1 and 13.2).