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D E C I S I O N
of 24 April 2003

Case Number: T 1129/01 - 3.2.2

Application Number: 94306632.4

Publication Number: 0648851

IPC: C22C 33/02

Language of the proceedings: EN

Title of invention:

Sulfur-containing powder-metallurgy tool steel article and its method of manufacture

Patentee:

CRUCIBLE MATERIALS CORPORATION

Opponent:

ERASTEEL KLOSTER AKTIEBOLAG
Uddeholm Tooling Aktiebolag
Böhler Edelstahl GmbH

Headword:

-

Relevant legal provisions:

EPC Art. 52(1), 54, 56, 84

Keyword:

"Novelty (yes)"
"Clarity (yes)"
"Inventive step (no)"

Decisions cited:

-

Catchword:

-



Case Number: T 1129/01 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 24 April 2003

Appellant:
(Proprietor of the patent)

CRUCIBLE MATERIALS CORPORATION
P.O. Box 977
State Fair Boulevard
Syracuse,
New York 13201-0977 (US)

Representative:

Powell, Timothy John
Eric Potter Clarkson
Park View House
58 The Ropewalk
Nottingham NG1 5DD (GB)

Respondents:

(Opponent 01)

ERASTEEL KLOSTER AKTIEBOLAG
P.O. Box 100
S-815 82 Söderfors (SE)

Representative:

Hynell, Magnus
Hynell Patenttjänst AB
Patron Carls väg 2
S-683 40 Hagfors/Uddeholm (SE)

(Opponent 02)

Uddeholm Tooling Aktiebolag
S-683 85 Hagfors (SE)

Representative:

Hynell, Magnus
Hynell Patenttjänst AB
Patron Carls väg 2
S-683 40 Hagfors/Uddeholm (SE)

(Opponent 03)

Böhler Edelstahl GmbH
Mariazellerstrasse 25
A-8605 Kapfenberg (AT)

Representative:

Barger, Werner, Dipl.-Ing.
Patentanwälte
Barger, Piso & Partner
Postfach 96
A-1015 Wien (AT)

Decision under appeal:

Decision of the Opposition Division of the
European Patent Office posted 7 August 2001
revoking European patent No. 0 648 851 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: W. D. Weiß
Members: S. S. Chowdhury
U. J. Tronser

Summary of Facts and Submissions

I. The appellant (patent proprietor, Crucible Materials Corporation, USA) lodged an appeal against the decision of the opposition division to revoke the European patent No. 0 648 851. The decision was dispatched on 7 August 2001.

The appeal and the fee for the appeal were received on 4 October 2001. The statement setting out the grounds of appeal was received on 5 December 2001.

The opposition was filed against the whole patent and based on Article 100(a) EPC (lack of novelty and inventive step), and on Article 100(b) EPC, that the patent does not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

In response to the opposition the patent proprietor maintained the claims of the patent as granted as the main request, and filed amended claims as first and second auxiliary requests. The opposition division decided that, although the requirement of Article 100(b) EPC was met by the patent, claim 1 of each of the main request and the first auxiliary request did not define novel subject-matter, and claim 1 of the second auxiliary request did not involve an inventive step, and revoked the patent, accordingly.

II. Of the documents considered by the opposition division the following are of importance for the present decision:

D1: Metals Handbook, 10th Edition, Volume 1, pages 780 to 792, "P/M Tool Steels"

D7: Metal Powder Report, June 1992, pages 25 to 29

D8: Paper Entitled: "High Strength PM High Speed Steels and Tool Steels" presented by Per Hellman at the International Conference of Materials by Powder Technology, March 23 to 26 1993 at Dresden, Germany

D10: Metals Handbook, Ninth Edition, Vol. 16, Machining, 1989, pages 60 to 64 and 733 to 735

D18: S. Wilmes, "Pulvermetallurgische Werkzeugstähle - Herstellung, Eigenschaften, Anwendung", Stahl und Eisen, 1990, Heft 1, Seiten 93 to 103.

The respondents cited four new documents in response to the grounds of appeal. The appellant cited three new documents during the appeal procedure, of which the following two have some bearing on the present decision:

D24: "Influence of Slag Particles on the Mechanical Properties of a P/M High Speed Steel", Arnberg and Karlsson, The International Journal of Powder Metallurgy, Vol. 24 No. 3, 1988.

D26: "Commercial Gas Atomisation of High Speed Steel", Hellman & Billgren, Metal Powder Report, 40 (1985) pages 38 to 40.

III. Oral proceedings before the Board took place on 24 April 2003, at the end of which the following requests forming the basis of the decision were put forward:

The appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of claims 1 to 6 of the main request or claims 1

to 6 of the first or second auxiliary requests, respectively, submitted at the oral proceedings, or claims 1 to 4 according to the third, fourth, or fifth auxiliary requests filed with the letter dated 24 March 2003.

The respondents (opponents Erasteel Kloster AB (OI), Uddeholm Tooling AB (OII), and Böhler Edelstahl GmbH (OIII)) requested that the appeal be dismissed.

IV. The independent claims 1, 2, 4, and 5 of the main request read as follows: -

"1. A machinable powder metallurgy produced sulfur containing tool steel article comprising a fully dense, consolidated mass of nitrogen gas atomized, prealloyed particles of a tool steel alloy the said mass having been hot worked and the said tool steel alloy comprising in weight percent 0.80 to 3.00 carbon, 0.20 to 2.00 manganese, 0.10 to 0.30 sulfur, up to 0.04 phosphorus, 0.20 to 1.50 silicon, 3.0 to 12.00 chromium, 0.25 to 10.00 vanadium, up to 11.00 molybdenum, up to 18.00 tungsten, up to 10.00 cobalt, up to 0.10 nitrogen, up to 0.025 oxygen, balance iron and incidental impurities, characterised in that said article has a maximum sulfide size controlled to be less than about 15 μm .

2. A machinable powder metallurgy produced sulfur containing tool steel article having a minimum transverse bend fracture strength of 3450 MPa (500 ksi) when heat treated to hardness of 64 to 66 HRC, said article comprising a fully dense, consolidated mass of nitrogen gas atomized, prealloyed particles of a tool steel alloy the said mass having been hot worked and the said tool steel alloy comprising, in weight percent, 1.25 to 1.50 carbon, 0.20 to 1.00 manganese, 0.10 to 0.26 sulfur, up to 0.04 phosphorus, up to 1.00

silicon, 3.0 to 6.00 chromium, 4.0 to 6.0 molybdenum, 3.50 to 4.50 vanadium, 4.0 to 6.5 tungsten, up to 0.025 oxygen, up to 0.10 nitrogen, balance iron and incidental impurities, characterised in that said article has a maximum sulfide size controlled to be less than about 15 μm .

4. A method for manufacturing a powder metallurgy sulfur containing tool steel article comprising a hot worked, fully dense, consolidated mass of nitrogen atomized, prealloyed particles of a tool steel alloy comprising, in weight percent 0.80 to 3.00 carbon, 0.20 to 2.00 manganese, 0.10 to 0.30 sulfur, up to 0.04 phosphorus, 0.20 to 1.50 silicon, 3 to 12.00 chromium, 0.25 to 10.00 vanadium, up to 11.00 molybdenum, up to 18.00 tungsten, up to 10.00 cobalt, up to 0.10 nitrogen, up to 0.025 oxygen, balance iron and incidental impurities, said article having a maximum sulfide size controlled to be less than about 15 μm , said method comprising producing said prealloyed particles by nitrogen gas atomization, hot isostatically compacting the prealloyed particles to full density at a temperature of 1185°C (2165°F) and a pressure of 103.5 MPa (15 ksi), hot working the resulting compact to a desired shape of the article at a temperature of 1121°C (2050°F), and annealing said article.

5. A method for manufacturing a powder metallurgy sulfur containing tool steel article having a minimum transverse bend fracture strength of 3450 MPa (500 ksi) when heat treated to hardness of 64 to 66 HRC, said article comprising a hot worked, fully dense, consolidated mass of nitrogen atomized, prealloyed particles of a tool steel alloy comprising, in weight percent, 1.25 to 1.50 carbon, 0.20 to 1.00 manganese, 0.10 to 0.26 sulfur, up to 0.04 phosphorus, up to 1.00 silicon, 3.0 to 6.0 chromium, 4.0 to 6.0 molybdenum,

3.5 to 4.50 vanadium, 4.0 to 6.5 tungsten, up to 0.025 oxygen, up to 0.10 nitrogen, balance iron and incidental impurities, said article having a maximum sulfide size controlled to be less than about 15 μm , said method comprising producing said prealloyed particles by nitrogen gas atomization, compacting the prealloyed particles to full density at 1185°C (2165°F) and at a pressure of 103.5 MPa (15 ksi), hot working the compact to a desired shape of the article at a temperature of 1121°C (2050°F), and annealing said article."

Claim 3 is dependent on claims 1 or 2 and claim 6 is dependent on claims 4 or 5.

Auxiliary requests

The claims of the first auxiliary request stress that the hot working step is separate from and follows the hot isostatic pressing (HIPing) step.

The claims of the second auxiliary request additionally stress that the maximum sulfide size is 15 μm after elongation from the as-HIPed condition.

The claims of the third to fifth auxiliary requests are the same as the claims of the main, first and second auxiliary requests, respectively, save for the deletion of claims 2 and 5.

V. The parties argued as follows:

Appellant

The opposition procedure was very old, but the documents D19 to D23 were cited very late to support an objection under Article 56 EPC, which was an abuse of procedure. The publication date of D22 was not proven.

In any case various isolated disclosures from these documents were taken to attack the claims. D7 and D8 taught against the combination of hot working and a HIPing process since adequate strength was achieved in the as-HIPed condition and hot working was not necessary and merely increased production costs.

The opponents initially did not substantiate their novelty objections, and all the written submissions concerned inventive step. Lack of novelty as a ground of opposition should not be admitted, accordingly. Moreover, although D24 was cited a month before the oral proceedings, the respondents OI/OII did not give prior warning of a novelty attack based on this document, and the appellant was surprised by and not prepared to answer this new attack at the oral proceedings. In any case, D24 did not clearly disclose a HIPed and hot rolled article having a maximum sulfide size of 15 μm , and an attempt at hot rolling the only article with a high sulfur content failed, so this could not be cited against the article of claim 1.

Sulfides formed during the rapid solidification of powder particles were small and uniformly distributed, and these intra-particle sulfides did not elongate during a post HIP hot working. On the other hand, sulfides at the inter-particle boundaries might grow during HIPing in the presence of oxygen, and these would elongate during hot working and degrade the strength with increasing size and elongation.

The statement in D7 that all sulfides were small should not be taken literally. D7 stated that the steel was isotropic, but D7 was updated by D8 which clearly showed a non-isotropic steel (Figure 2(a)). Therefore,

D8 contradicted D7, whose teaching was questionable, accordingly. D10 also did not disclose small sulfides since the chain of roughly collinear stringers in Figure 2(b) should be considered as a single sulfide, according to the prevailing norm.

Normally, there would be a distribution of sulfide sizes, with the vast majority of sulfides having a small size, but there would be a significant number of sulfides having a size greater than 15 μm , at the tail of the distribution curve, which would impair mechanical properties. Figure 1(b) of D8 was a snapshot of a very small part of the article, it was not representative of the whole article, in which there would be some large sulfides which would form the weak link. The patent in suit recognised this and taught that it was important to ensure that the maximum particle size was restricted to 15 μm . This was not taught by D7 or D8, which latter was the closest prior art document.

When one looked at the historic evolution of PM steels, starting from 1970 and up to the dates of D7 and D8 (1992 and 1993, respectively), there was no discernable trend pertaining to hot working or particle size, or to a technical effect relating these to the maximum size of 15 μm . The patent in suit was the first to teach that the maximum sulfide size must be 15 μm and the steel **must** be hot worked in order to improve the transverse bend fracture strength (BFS). To extract this teaching from the previous muddle involved an inventive step.

Respondents OI/OII

Claim 1: D24 described experiments done with variations of the commercial alloy ASP23, which had a composition falling within the terms of claim 1 and one alloy D had a high sulfur content. This HIPed article of this material was also hot worked, and though it fractured it nevertheless had all the features of claim 1.

The composition of the ASP grade steel in Table 1 of D10-I and the M3 and M4 steels in Table 3 of D10-I had the compositions of the steel defined in claim 1. D10-II pointed out the advantages of a high-S PM steel and of small size of the sulfides. By "small size" was meant about 8 μm and this size would not be appreciably altered by hot working, which step was also disclosed.

Claim 2: The composition of the steel of claim 2 was also disclosed in D10 or was obvious. The BFS value was an inherent property of the steel satisfying the other limitations of the claim.

Claims 4, 5: D10 taught hot working after HIPing and also the temperature and pressure used for HIPing. D19 to D22 gave more precise compositions of the steels used in D10, and also the HIPing pressure and temperature close to those of claims 4 and 5.

Respondent OIII

The appellant's argument that D7 provided a technical prejudice against hot working after HIPing was wrong, D7 simply said that hot working was superfluous, not that it was harmful. Hot working was normally done for different reasons, for example to improve mechanical properties or simply to change shape or dimensions.

The second auxiliary request was unclear for the reasons given by the opposition division.

The closest prior art was D7 whose aim was to produce articles from APM 23 steel with a S content of 0.26% and sulfide size of $< 2 \mu\text{m}$, whose mechanical properties were good enough after HIPing and without the need for hot working. This was to save costs and not because of any technical considerations. No inventive step was required to further hot work the article since this was necessary for example to bring it to a required geometrical form.

The BFS defined in claim 2 was an inherent property of the material and also was obvious in view of D23. The same arguments applied to claims 4 to 6.

Reasons for the Decision

1. The appeal is admissible.
2. *The newly filed documents*

While the respondents did not object to the late filed documents introduced by the appellant, the converse was not true. The Board admitted the newly filed documents into the discussion at the oral proceedings since they contribute to the understanding of the relevant background art. The Board considered it too formalistic an approach to disregard these documents at the outset of the oral proceedings, considering the contribution they could make. In the end, however, it turned out that only the documents D24 and D26 cited by the appellant had some bearing on the present decision.

3. Main request, first and second auxiliary requests

The second auxiliary request will be dealt with first. If claim 1 of this request is demonstrated to lack patentability, then the main request and the first auxiliary request will also fall since they are broader in scope than the second auxiliary request. Claim 1 of the third to fifth auxiliary request, being the same as claim 1 of the main request and the first and second auxiliary requests, respectively, will also not be patentable.

The feature "the maximum sulfide size is 15 μm after elongation from the as-HIPed condition" in claim 1 of the second auxiliary request is supported by Table IV and page 8, lines 22 to 24 of the patent. It is understood by the Board to mean that even after hot working the maximum sulfide size is 15 μm , but it does not exclude that hot working could result in no elongation of the sulfides. However, it is not taken to mean that there must be some elongation due to hot working or that there is some beneficial effect in this elongation, since there is no support for such an interpretation in the patent.

4. *Background of the patent*

Claim 1 relates to a machinable powder metallurgy (PM) produced sulfur containing tool steel article comprising a hot worked, fully dense, consolidated mass of nitrogen gas atomized, prealloyed particles of a tool steel alloy. Tool steels are used in both cutting and non-cutting tooling applications, for which strength, toughness, and wear resistance, in addition to adequate machinability and grindability are necessary properties of the steel. It was known that the presence of sulfur in tool steels improved machinability and grindability, but sulfur in amounts

over about 0.10% was known to reduce the hot workability of conventional ingot-cast tool steels and adversely affect their toughness.

An object of the invention is to provide a tool steel article made from a hot worked high sulfur containing powder metallurgy produced tool steel wherein the presence of sulfur and the resulting sulfides does not significantly degrade toughness, as exhibited by the bend fracture strength (EP-B-648 851, page 2, lines 46 to 48). In other words it is desired to improve the transverse bend fracture strength of resulfurised PM produced high speed and cold worked tool steel articles.

The weak link in the microstructure of an as-HIPed PM tool steel is the quality of the inter-particle bonding, which is negatively influenced, *inter alia*, by the presence of oxides and sulfides. These negative effects can be offset, to some extent, by hot working, which causes grain refinement and an increase in the BFS value.

5. *Novelty*

5.1 The appellant argued that, although the notices of opposition by all three opponents asserted lack of novelty of the claimed subject-matter, this allegation was not supported by any of the documents filed, and this ground of opposition was, therefore, inadmissible. Moreover, document D24 had been cited by the appellant one month before the oral proceedings before the Board, yet the respondents OI/OII did not forewarn the appellant of an impending novelty attack based on this document, so this attack took the appellant by surprise. Therefore, this ground should not be admitted.

The Board does not accept these arguments. The opposition division has the power, under Article 114(1) EPC, to consider a ground of opposition of its own motion, which it did by considering novelty of the claimed subject-matter, and its decision was in fact based on this ground of opposition. Therefore, this ground of opposition was already in the procedure when the appeal was filed.

Moreover, document D24 was cited by the appellant itself, so it must be assumed to know it intimately and not be surprised by its contents or by the fact that the other parties may have a different interpretation thereof. Since this document was cited by the appellant rather late in the day it is understandable that no response to it was submitted before the oral proceedings. Finally, since this document was admitted into the procedure (point 2), it must be considered fully and for all those grounds already in the appeal procedure. Therefore, the Board allows the novelty attack based on this document.

5.2 D24 describes a series of high speed steels based on the commercial composition ASP 23, which have a composition falling within the terms of claim 1, and which were produced by nitrogen atomisation and HIPing, with controlled added amounts of slag particles and sulfur and nitrogen, in order to study the influence of the slags on the microstructure, impact and bend fracture strength, fatigue properties and cutting performance. A correlation was found between the inclusion size and the BFS values, and subsequent forging of the HIPed material improved mechanical properties.

The only steel with a high sulfur content is the alloy D with S=0.29 wt%, but this fractured during forging and could not be worked to final dimensions. A

destroyed article cannot be cited against a claimed tool steel article since this is a waste product of no further use. For this reason alone the novelty attack based on D24 fails. However, other reasons for the failure of the novelty attack are that the sulfide size is not unambiguously derivable from this document. The sulfide size mentioned on page 204 under "Results" refers to the powder and not the HIPed article, and Figure 9 throws doubt on the actual sulfide size in the article since the respondent's representative himself said that the defects in Figure 9 could have been sulfides, whose size of about 50 μm could have been the cause of fracture of the high sulfur article during hot working.

- 5.3 Claim 1 defines a powder metallurgy produced tool steel article comprising a fully dense, consolidated mass of nitrogen gas atomized, prealloyed particles of a tool steel alloy the said mass having been hot worked subsequent to the consolidation.

D7 and D8 describe the super sulfurised high speed steel designated commercially as APM 23, which has a composition falling within the terms of claim 1, a fact not disputed by the appellant. A high speed steel article is produced by nitrogen atomisation and HIPing. In D7 the only disclosure relating to hot working is that this step is not necessary since the as-HIPed article already has the required strength. This is not the same as saying that the article was actually hot worked.

However, Figure 1(b) of D8 shows a HIPed and hot worked article. In D8, however, there is doubt as to whether the sulfide size was less than 15 μm throughout the article. The appellant explained that in practice there would be a distribution of sulfide sizes, with the great majority (tens of thousands) of sulfides being of

the order of 1 or 2 μm in size, and at the other end of the distribution, a few hundred inclusions having a size of 15 to 30 μm , and it was crucial for the patent in suit to completely suppress formation of the latter. Figure 1(b) of D8 is in fact a photomicrograph of a relatively small area of about 90 microns square, which is hardly representative of the whole article. This Figure was selected to show typical sulfides, which are small, but it cannot be said to also truly represent other areas of the article which could well have a few sulfides of much larger size and which would impair the mechanical properties.

According to the patent in suit it is crucial to maintain the sizes of all sulfides to below 15 μm , so that the Figures shown in the patent may be considered to represent this feature. On the other hand, in D7 and D8 there is no importance given to the maximum sulfide size, so the Figures therein cannot be considered to fairly disclose this feature, despite the statement in D7, page 28, last paragraph of the right hand column, that all magnesium sulfides are very small.

Similar considerations apply to D10. While Figure 2(b) does indeed show an area of the article where the sulfide size would appear to be less than 15 μm , it is not clear that this is representative of the entire article and that there are, indeed, no areas with impermissibly large sulfides.

- 5.4 Since none of documents D7, D8, or D24, each of which was used by the respondents to question the novelty of the article of claim 1, clearly and unambiguously discloses all the features of the claim, lack of novelty has not been proven.

6. *Inventive step*

6.1 Claim 1 claims protection for a product which is defined by a certain combination of features. There exist two options which would warrant the patentability of such a product *per se*. The first option is that the combination of features defining the product is patentable, ie it is novel and involves an inventive step, on its own merits. The second option is that a product exhibiting the said combination of features could be envisaged as such or had even constituted a desideratum which the skilled community had striven to achieve but for which no known method of manufacture had existed. Such an otherwise obvious entity might nevertheless become non-obvious and claimable as such if there had been no known method in the art to make it and the methods described in the patent for its preparation were the first to produce it and do so in an inventive manner (see Case Law BoA, 4th edition 2001, page 132, chapter 6.19).

The proprietor has never denied that the specific working parameters of the method disclosed in the patent are common in the art and, in response to arguments on grounds of Article 100(b) EPC, has reiterated that the skilled practitioner operating a powder metallurgical production line would know the measures to be taken to control the maximum sulphide size in the article to be less than about 15 μm .

Therefore, the second option is not applicable in the present case and the allowability of the product claims will depend on the combination of features defining them being novel and inventive on their own merits.

6.2 D7 and D8 describe the super sulfurised high speed steel designated commercially as APM 23, which has a composition falling within the terms of claim 1, and

which is produced by nitrogen atomisation and HIPing prealloyed particles. These documents state that with a cold loaded HIP unit it is possible to produce an as-HIPed PM high speed steel with the same achievable strength as for hot worked materials. Thus, economic costs associated with hot working can be avoided. However, Figure 1(b) of D8 shows a hot worked article, presumably to demonstrate that the sulfides are elongated during the hot working (page 289, end of third paragraph), but the true teaching of these documents is that hot working is not necessary.

- 6.3 The patent in suit aims at producing a powder metallurgy produced sulfur containing tool steel article comprising a fully dense, consolidated mass of nitrogen gas atomized, prealloyed particles of a tool steel alloy, with an improved transverse BFS value. An object of the invention is defined in paragraph [0007] on page 2 as follows: "A more specific object of the invention is to provide a tool steel article made from a hot worked high sulfur containing powder metallurgy produced tool steel wherein the presence of sulfur and resulting sulfides does not significantly degrade toughness, as exhibited by the bend fracture strength."
- 6.4 The solution is to hot work the high speed steel of D7 or D8 while ensuring that the maximum sulfide size is controlled to be less than about 15 μm .
- 6.5 The question then is: would it be obvious for the person skilled in the art to consider hot working the high speed steel of D7 or D8 while ensuring that the maximum sulfide size is controlled to be less than about 15 μm , with a view to improving the BFS value?

- 6.6 The appellant has argued that D7, D8, and D24 all provide a technical prejudice against hot working a super sulfurised high speed PM steel. The Board does not accept that a clear technical prejudice has been established in this respect. While D24 does state (page 206) that sulfur degrades the impact energy and BFS in such a steel (alloy D), this document was superseded by D7 and D8 since these were published some four years later, and they do not discourage hot working as a technically feasible step. The reason given in D7 and D8 for not hot working is purely economic, no technical arguments against this step are set out.
- 6.7 On the contrary, it is generally acknowledged that hot working improves the mechanical properties of such steels, regardless of the sulfur content. The appellant, in its letter of 24 May 2001 in the opposition procedure, acknowledges (in the paragraph linking pages 4 and 5) "When a PM tool steel is hot worked, the austenitic microstructure present at the hot working temperature is plastically deformed as a sufficient strain rate to cause simultaneous recrystallisation of the microstructure" and "The result of this grain refinement is an increase in the BFS test values with increasing hot working reduction, regardless of the starting powder quality or the HIP parameters employed". Further, it is stated that "This phenomenon has been known for some time, and applies equally to both low and high sulfur tool steels ". The appellant thus admits that hot working was generally acknowledged to improve mechanical properties, including the BFS values, of such steels. This statement is backed up by, for example, D18 (page 95, left column, second paragraph), according to which the toughness of a PM tool steel can be increased considerably by hot working.

Therefore, there is no doubt that the person skilled in the art would consider hot working a PM high speed tool steel, as was conventional in the prior art, with the expectation of improving the BFS value thereof.

- 6.8 As regards the sulfide size, the prior art gives ample indication that inordinate growth of sulfide inclusions is to be avoided, otherwise the mechanical properties will be jeopardised. The following passages of the prior art exemplify the understanding of the person skilled in the art in this respect:

Document D10, see page 734, middle column, states that the machinability advantage of resulfurised PM tool steels largely relates to the uniform distribution of the carbides and sulfides in their microstructures in contrast to the conventional steels made by ingot metallurgy, where the carbides and sulfides are typically segregated in bands and are larger than those of the PM steels.

D7 (page 28, right column, last paragraph) points out that when a cold loaded HIP unit is used then all manganese sulfides are very small even in super sulfurised steels which means that they do not affect the strength of the steel, and Figure 1 illustrates what is meant by "small", ie less than two microns in size. Page 8, third paragraph contains a similar disclosure, and additionally states that in the previous steels the manganese sulfides grow during the heating and are elongated during the hot working.

D1 (page 782, left column) mentions the small size of the sulfides as a distinguishing feature, and D10 shows an example (Figure 2(b)) of a PM steel known commercially as M3, with a sulfur content of 0.28%, containing a uniform distribution of sulfides, the maximum size of which is about 8 μm . It is stated on

page 734, middle paragraph that "Because of the small size and uniform distribution of the sulfides, more sulfur (with a corresponding greater improvement in machinability) can be used in P/M tool steels than in conventional tool steels before hot workability or mechanical properties are degraded".

D26 (page 3, "Inclusions" and Figure 8) also show that there is an inverse relationship between the strength and the inclusion size.

Therefore, the prior art contains ample teaching to hot work a PM tool steel to improve mechanical properties, and to avoid growth of the sulfides. It follows that in order to increase the BFS value of a PM tool steel it is necessary to hot work it and at the same time ensure that the sulfides are not excessively elongated, for why would the person skilled in the art strive for small sulfide size up to the step of hot working and then risk undoing the benefits of small sulfide size while hot working, especially since the method of controlling the maximum sulfide size was known?

6.9 Regarding the maximum sulfide elongation to 15 μm , this figure does not represent some critical value since the amount of elongation tolerable would depend on the required improvement of the mechanical properties during hot working. The figure of 15 μm represents neither a selection from a known range nor a value at which some unexpected effect occurs. Instead, the maximum allowable elongation would depend on the required mechanical properties and be determined by trial and error for a given case.

6.10 Therefore, the tool steel article of claim 1 of the second auxiliary request does not involve an inventive step. As explained in point 3 the other requests also fall with this request.

Order

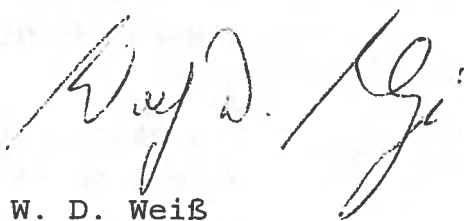
For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:


V. Commare


W. D. Weiß

ML
26.5.03