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D E C I S I O N
of 7 November 2000

Case Number: T 0340/97 - 3.3.5

Application Number: 89310997.5

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Title of invention:
Ceramic bearing components and method of manufacture thereof

Applicant:
KABUSHIKI KAISHA TOSHIBA

Opponent:
Norton Company

Headword:
Bearings/NORTON

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0340/97 - 3.3.5

D E C I S I O N
of the Technical Board of Appeal 3.3.5
of 7 November 2000

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 15 January 1997 revoking European patent No. 0 366 443 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: R. K. Spangenberg
Members: M. M. Eberhard
M. B. Günzel

Summary of Facts and Submissions

I. European patent No. 366 443 based on application No. 89 310 997.0 was granted on the basis of fourteen claims.

The respondent (opponent) filed a notice of opposition requesting revocation of the patent on the grounds that the subject-matter of the patent extended beyond the content of the application as filed and lacked an inventive step. In support of his arguments, the respondent relied inter alia on the following documents:

D1: "Inclusion Effects on the Strength of Hot Pressed Si_3N_4", Fracture Mechanics of Ceramics, vol. 1, 1974, pages 367-385

D2: EP-A-0 231 130

D3: Kirk-Othmer, Encyclopedia of Chemical Technology, 3rd edition, vol. 5, page 254, 1979

D9: 26th Automotive Technology Development Contractors' Coordination Meeting, October 24 to 27, 1988, Dispersion-Toughened Silicon Nitride Composites

II. The opposition division revoked the patent. The decision was based on three sets of amended claims all submitted on 8 November 1996 as a main request and two auxiliary requests. The opposition division held that amended claim 1 according to each of these requests did not meet the requirements of Articles 123(2) and (3) EPC.

III. The appellant lodged an appeal against this decision and submitted new sets of amended claims together with the statement of grounds of appeal. The respondent relied at the appeal stage on an additional document, namely an English translation (16 pages) of NTN Technical Review, No. 54, May 1988, pages 31 to 39, hereinafter D14.

In a communication dated 22 May 2000, the parties were informed of the provisional opinion of the board as regards clarity, allowability of the amendments and inventive step in connection with the amended claims filed with the statement of grounds of appeal. In reply thereto, the appellant filed six sets of amended claims on 9 October 2000, as a main request and five auxiliary requests. Oral proceedings were held on 7 November 2000. In the course of the proceedings the appellant abandoned these requests and submitted four sets of amended claims as a main request and three auxiliary requests. Claim 1 of the main request reads as follows:

"1. A bearing component formed of ceramic material and having a metallic constituent in an amount of 3,500 ppm or less, characterised in that it is a rolling bearing wherein said metallic constituent comprises more than one of the following elements: Fe, Ni, Cr and W, the content of iron being restricted to less than 2000 ppm."

Claim 1 according to the first auxiliary request differs from claim 1 of the main request in that the phrase **"more than one of the following elements:"** has been deleted.

Claim 1 of the second auxiliary request has the following wording:

"1. A method for making a ceramic rolling bearing component comprising: converting raw material ceramic powder into slurry form, then granulating the slurry, forming the slurry to a desired shape, and baking, to obtain the rolling bearing component, the method including a removal step whereby metallic constituent comprising at least one of Fe, Ni, Cr and W is removed to a level of 3,500 ppm or less remaining in the bearing component, Fe being removed to a level of less than 2000 ppm."

Claim 1 of the third auxiliary request differs from claim 1 of the second auxiliary request by the omission of the words **"at least one of"** before the list of metallic elements.

IV. The appellant's arguments in connection with the issue of inventive step can be summarised as follows:

The respondent's statement that the Japanese patent application corresponding to the patent in suit was revoked on the basis of D14 was not correct. The Japanese application was finally granted on September 24, 1998. D14 merely showed that metallic inclusions were considered to be causative of stress concentration upon repeated loading. It was silent on the level of the metallic constituents for unexpectedly improving the stability of a bearing. The comparative examples in the appellant's letter dated 15 May 1997 showed that the total content of impurities was critical. As shown in Table 1 of the patent in suit, the difference between the maximum and minimum values

of rolling fatigue life, ie the statistical "dispersion" of rolling fatigue life, was unexpectedly reduced in the present invention. The statistical dispersion had to be minimized as much as possible because the entire bearing apparatus did not work even if only one of the bearing balls assembled in a bearing apparatus had a low fatigue life. Therefore, reduction of the statistical dispersion of rolling fatigue life was critically important. This important feature concerning the problem to be solved was not taught or suggested in D14. The latter failed to disclose to what level the metallic constituent had to be limited in order to achieve the said advantageous effects. Furthermore, D14 did not focus only on the problem of metallic inclusions as the origin of flaking. A number of other factors were also discussed which had an influence on flaking. The authors of D14 had not planted their flag where the critical factor was. The teaching was missing in D14 that the level of metallic inclusions was the critical factor. The respondent had cited 14 documents to attack the patent in suit and the selection of two or three of them to combine with D14 was based on an ex post facto analysis.

Concerning the first auxiliary request, D14 just specifically disclosed Fe and Cr as metallic inclusions. D2 failed to mention Ni and W. D9 was silent about W and was not concerned with bearing components. As regards the method claims according to the second and third auxiliary requests, D14 neither disclosed the claimed combination of steps nor the specific level of impurities necessary to get the best statistical dispersion of rolling fatigue life. It had not been shown that the combination of process steps, namely converting the raw material into a slurry,

granulating the slurry and forming to a desired shape, was a conventional combination of steps in the ceramic production. D3 did not disclose that spray drying produced granules.

V. The respondent submitted, inter alia, the following arguments in connection with the issue of inventive step:

D14 correlated the rolling fatigue life of ceramic bearings to metallic inclusions, in particular iron, in the ceramic material. This document clearly suggested removal of these inclusions and taught that acceptable levels of inclusions should be determined. Determining the acceptable level of metallic inclusions was well within the technical skill of the person skilled in the art. The problem of metallic inclusions was extensively discussed in D14 and these inclusions were said to be causative of stress concentration. The solution to this problem was also given in D14 since the latter taught to reduce the content of metallic inclusions, in particular iron, as much as possible. The skilled person would have looked for materials which fulfilled this requirement. D2 and D9 disclosed silicon nitride powders having a very small amount of metallic impurities. The skilled person would have arrived at the low level of metallic impurities by using the starting material disclosed in D9. The content of tungsten was not given in D9 but it was normally very low. Furthermore, D1 disclosed in the chapter "Results of Observations" that the iron was usually found in conjunction with one or more of the common steel alloying elements Cr, Mn, and Ni and that W was found to be associated with Co or occurred concurrently with Fe in the same inclusion. Regarding the method of

preparation of the bearing component, the process steps indicated in claim 1 of the second and third auxiliary requests were conventional steps for manufacturing ceramic articles as shown by D3 and D14 taught to remove as much metallic inclusions as possible.

VI. The appellant requested that the decision under appeal be set aside and that the patent be maintained with the claims according to the main request submitted at the oral proceedings before the board. As auxiliary requests 1 to 3 the appellant requested that the patent be maintained with the claims of any of the auxiliary requests 1 to 3 submitted at the oral proceedings, taken in their consecutive order. The respondent requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. The board is satisfied that the amended claims according to all four requests meet the requirements of Articles 123(2) and (3) EPC. Taking into account that the subject-matter of claim 1 of each of these requests lacks an inventive step (see the reasons given hereinafter), further considerations regarding the allowability of the amendments are not necessary.

The subject-matter of claim 1 of each of the four requests is new with respect to the disclosure of the cited documents. No reasons need be given since novelty was not disputed.

Main request

3. Concerning the issue of inventive step, the board considers in agreement with the parties that D14 represents the closest prior art.

3.1 D14 relates to bearing components mainly formed of silicon nitride, such as silicon nitride balls and rollers. This document deals with the problem of spalling and discloses various factors of manufacturing processes, which affect the rolling contact fatigue life of silicon nitride bearing components. It teaches in particular that metallic inclusions such as Fe, Cr, W and Co inclusions are often found in silicon nitride balls having a short rolling fatigue life and that metallic inclusions are considered to be causative of stress concentration upon repeated loading. Fe inclusions are cited as an example of metallic inclusion initiating flaking. According to D14 the metallic inclusions are included during the production of a powder, during blending of a sintering aid, or during other steps and removal of these inclusions by more careful screening is necessary to avoid short rolling fatigue life (see page 1, abstract; page 2, point 2; page 5, point 2.3; whole page 6; page 11, point 3; Photographs 1-2, 1-3, 2-2, 2-3, 3-1 to 3-3 showing Fe, Cr, W, Co inclusions).

3.2 Starting from this prior art, the technical problem underlying the claimed product can be seen in the provision of bearing components which have a stable quality minimising potential defects such as spalling (see page 2, lines 23 to 26, of the patent in suit), or expressed in other words, which have a reduced statistical dispersion of rolling fatigue life.

It is proposed that this problem be solved by the

bearing component as defined in claim 1, which differs from the silicon nitride ball bearings or roller bearings of D14 by the specific amounts of metallic inclusions and iron. According to the examples of the patent in suit a reduction in variation of the rolling fatigue life was achieved, which means an improvement in quality, and spalling could be effectively prevented, thereby obtaining an improved stability of product quality (see page 3, lines 33 to35 and page 4, lines 14 to 16). These results were obtained with 10 tests for each examples. The comparative examples in the applicant's letter dated 15 May 1997 further illustrate the reduction of the statistical dispersion of the rolling fatigue life when the total amount of metallic inclusions is decreased to less than 3,500 ppm. It is credible in view of these results and in the absence of evidence to the contrary that the technical problem has actually been solved by the claimed bearing component. This was not disputed by the respondent.

3.3 As pointed out by the appellant, D14 does not focus only on the problem of metallic inclusions as the origin of flaking. A number of other factors having an influence on flaking, and thus, on the rolling fatigue life of the ball or roller bearings are also discussed. D14 discloses that flaking occurs in an early stage with silicon nitride balls which had been subjected to a normal sintering while products prepared by hot pressing and hot isostatic pressing (HIP) have a service life equivalent or superior to that of steel bearings. HIP is considered necessary for achieving a long service life. Heterogeneous blending of the silicon nitride powder with sintering aids and inappropriate sintering conditions are said to result

in the creation of vacancies which remain even after HIP and which also initiate flaking. Segregation of the sintering aid due to unsatisfactory blending or a surface defect such as a crack on the surface of the ball are also disclosed as inducing flaking. As already indicated above in point 3.1 the presence of metallic inclusions is an additional factor causing flaking, metallic inclusions being causative of stress concentration upon repeated loading. D14 teaches that these inclusions are introduced during the production of a powder, during blending of a sintering aid or during other steps and that it is necessary to remove these inclusions by more careful screening. According to D14, although metallic inclusions cannot be fully removed, the acceptable level thereof should be determined taking into consideration the balance between the rolling fatigue life and the cost. As a conclusion, D14 teaches that the factors which adversely affect the rolling contact fatigue life of ceramics are classified roughly into factors associated with the production of materials for the ceramics and factors associated with finishing and that the quality control in each step is important for avoiding harmful defects attributable to these factors (see page 4, first paragraph; pages 5 to 8; page 15, first paragraph; conclusion on page 16).

It can be inferred from this teaching that the defects disclosed in D14 as inducing flaking have an influence on the stability of the product quality since they lead to bearing balls or rollers having a short rolling fatigue life compared to those containing no (or less) defects. The skilled person would have realised that the defects such as vacancies, metallic inclusions or cracks mentioned in D14, should be avoided (or their

frequency reduced) in order to reduce the statistical dispersion of rolling fatigue life, since those ceramic balls or rollers which contain these defects would be expected to have a short rolling fatigue life. Therefore, he would have contemplated following the recommendations given in D14 for avoiding these defects, such as homogeneously blending the silicon nitride powder with the sintering aids, using hot-pressing or HIP, and/or removing the metallic inclusions included during the production of the powder or during further steps by careful screening. As according to D14 removal of the metallic inclusions, such as Fe, Cr, W and Co, is necessary for avoiding flaking, the skilled person faced with the problem stated above would have removed as much of the metallic impurities as possible in order to avoid that some of the ceramic balls or rollers have a short rolling fatigue life. The fact that, according to D14, the acceptable level of inclusions should be determined by taking into consideration the balance between the service life and the cost, would have not deterred the skilled person from removing as much of the metallic impurities as possible since the problem he had to solve was to achieve a stable quality (see point 3.2 above) and the economical aspect was not decisive. Thus, by applying the recommendations of D14 and carrying out routine experimentation the skilled person would have arrived in an obvious manner at the claimed bearing component.

3.4 For these reasons the subject-matter of claim 1 is considered not to involve an inventive step over the disclosure of D14. As claim 1 does not meet the requirement of inventive step set out in Articles 52(1) and 56, the main request cannot be granted.

First auxiliary request

4. The subject-matter of claim 1 of this request differs from that of claim 1 according to the main request by the presence of all four metallic elements Fe, Ni, Cr and W. This additional feature taken in combination with the remaining features of claim 1 is also considered to lack an inventive step over the cited prior art for the following reasons:

The technical problem underlying the subject-matter of this claim with respect to the closest prior art D14 is identical to that indicated in point 3.2 above. It is also credible in view of the examples of the patent in suit and in the absence of evidence to the contrary that this problem has actually been solved by the claimed bearing component.

The considerations in point 3.3 above apply likewise to the subject-matter of claim 1 according to this request. D14 discloses Fe, Cr, W and Co as examples of metallic inclusions. Although D14 does not specifically mention Ni inclusions, the teaching of this document that metallic inclusions are causative of stress upon repeated loading is not limited to the four metallic elements stated above. Furthermore, as pointed out by the respondent, it was known from D1 that the most common general type of inclusion found in hot-pressed silicon nitride consists of large silicon rich grains which are associated with additional metallic elements, the most predominant of which is iron. According to D1, the iron is usually found in conjunction with one or more common steel alloying elements: chromium, manganese and nickel. D1 also discloses the presence of W associated with a small amount of Co or the presence

of Fe and W in the same inclusion (see page 370 paragraph headed "Results of Observations"; page 373, first and second paragraphs). D1 concerns hot pressed silicon nitride for such applications as gas turbine engine components, bearings and a variety of high temperature structural components (see page 367, first paragraph). Therefore the skilled person was also aware of the fact that Fe, Ni, Cr, Co, Mn and/or W could be present as metallic inclusions in hot-pressed silicon nitride material for bearings. Under these circumstances, the skilled person faced with the problem stated above would have contemplated removing not only the metallic elements specifically indicated in D14 but also Ni which is usually found in conjunction with iron since according to D14 metallic inclusions should be removed for avoiding a short rolling fatigue life.

It follows from the above that the subject-matter of claim 1 according to the first auxiliary request does not meet the requirement of inventive step. Therefore, this request must also fail.

Second auxiliary request

5. D14 is also considered to represent the closest prior art with respect to the method as defined in claim 1 of this request. The technical problem to be solved by the claimed process can be seen in the provision of a process for manufacturing bearing components having a reduced statistical dispersion of rolling fatigue life.

It is proposed that this problem be solved by the process comprising the combination of steps defined in claim 1. This process differs from the process of D14

by (i) the amounts of Fe and metallic constituent remaining in the bearing component and (ii) the following steps: converting the raw material ceramic powder into slurry form, granulating the slurry and forming the resulting granules to a desired shape. In view of Examples 1 and 2 of the patent in suit, it is plausible that this problem has actually been solved by the claimed process.

5.1 For the reasons indicated above in connection with the main request, no inventive step can be seen in feature (i) in view of the teaching of D14. Concerning feature (ii), the respondent has argued that the three steps indicated above are well-known manufacturing steps in the ceramic industry. This was contested by the appellant at the oral proceedings; however, in view of D3 which illustrates the common general knowledge in ceramics, the board cannot accept the appellant's arguments. D3 discloses a process for manufacturing ceramic articles, which comprises grinding the raw materials, mixing the ingredients in water and thereby forming a slip, removing water on filter presses or drum filters or spray drying the slip, optionally removing iron contaminants, forming to a desired shape and firing (see page 254, second and third paragraphs). The appellant's arguments that D3 did not disclose the granulating step as it was not taught therein that spray drying produced granules are not convincing for the following reasons. It is well-known that spray drying produces powders, the dimensions of which depend on different parameters of the spray drying process. According to the patent in suit the slurry is granulated by the spray drying method, but no dimension is given for the resulting granules. Claim 1 also contains no indication as to the size of the granulated

product. Under these circumstances, it cannot be considered that the "granules" formed by spray drying of the slurry are different from the "powder" produced by spay-drying of a slip. Therefore, the board considers that the combination of process steps indicated in claim 1 of the second auxiliary request was well-known for the manufacture of ceramic articles before the priority date of the patent in suit. Using these steps for the manufacture of the bearing components in combination with the step of removing the metallic inclusions disclosed in D14 was, therefore, obvious to the skilled person confronted with the problem stated above.

5.2 It follows from the above that the process as defined in claim 1 of the second auxiliary request does not involve an inventive step.

Third auxiliary request

6. The technical problem to be solved with respect to D14 is the same as for the second auxiliary request (see point 5). The solution proposed in claim 1 to solve this problem differs from the process of D14 by (i) the amounts of Fe and metallic constituent remaining in the bearing component, (ii) the following steps: converting the raw ceramic material into slurry form, granulating the slurry and forming the resulting granules to a desired shape, and (iii) the fact that the metallic constituent comprises Fe, Ni, Cr and W. In the absence of evidence to the contrary, it is credible in view of the examples of the patent in suit that this problem has actually been solved by the claimed process.

Regarding features (i) and (iii), the reasons indicated

above in connection with claim 1 of the first auxiliary request apply likewise to claim 1 of the present request (see point 4 above). Therefore, removing Fe inclusions and the metallic constituent comprising Fe, Ni, Cr and Ni to the levels defined in claim 1 is not considered to involve an inventive step in view of the teaching of D14 and D1. Furthermore, the combination of process steps stated in claim 1 was well-known for the manufacture of ceramic articles (see point 5.1 above). Therefore, it would have been obvious to the skilled person confronted with the problem stated above to use these steps in combination with the step of removing the metallic inclusions recommended in D14.

It follows from the above that the process according to claim 1 of this request also lacks an inventive step. Therefore the third request must also fail.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Hue R. Spangenberg