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D E C I S I O N
of 28 June 2001

Case Number: T 0082/97 - 3.3.7

Application Number: 89103639.4

Publication Number: 0331156

IPC: D01F 6/60

Language of the proceedings: EN

Title of invention:
Poly(p-phenyleneterephthalamide) yarns of improved fatigue resistance and process for preparation thereof

Patentee:
E.I. DU PONT DE NEMOURS AND COMPANY

Opponent:
Akzo Nobel N.V.

Headword:
-

Relevant legal provisions:
EPC Art. 56, 123(2)(3)

Keyword:
"Amendments - broadening of claim (no) - added subject-matter (no)"
"Inventive step - (yes) after amendment - closest prior art, problem and solution"

Decisions cited:
-

Catchword:
-

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Case Number: T 0082/97 - 3.3.7

D E C I S I O N
of the Technical Board of Appeal 3.3.7
of 28 June 2001

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 19 November 1996 revoking European patent No. 0 331 156 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: R. E. Teschemacher
Members: G. Santavicca
B. L. ter Laan

Summary of Facts and Submissions

I. The mention of the grant of European patent 0 331 156, in respect of European patent application 89 103 639.4, filed on 2 March 1989 and claiming the priority of US 162967 of 2 March 1988, was published on 1 June 1994. The three granted claims read as follows:

"1. Poly(p-phenylene terephthalamide) yarn of improved fatigue resistance having an apparent crystallite size in the range of 4 to 5 mm (40 to 50 A), an orientation angle in the range of 20 to 30°, an elongation in the range cf 4.5 to 5.6%, a tenacity of at least 15.8 dN/tex (18 grams per denier) and a modulus of at least 176 dN/tex (200 grams per denier), but less than 396 dN/tex (450 grams per denier)."

"2. In a method for preparing poly(p-phenylene terephthalamide) yarn wherein a spin dope containing from 17 to 20% by wt. of said polymer in 98 to 102% sulfuric acid is spun through an air gap into an aqueous coagulating bath maintained at a temperature of from 20°C to 40°C and then washed, neutralized and dried, the improvement comprising washing and neutralizing the fiber while it is under a tension of from 0.18 to 0.36 grams per dtex (0.2 to 0.4 grams per denier) and drying the fiber at a temperature below 200°C while the fiber is maintained under a tension of 0.045 to 0.18 grams per dtex (0.05 to 0.2 grams per denier)."

"3. A method according to Claim 2 wherein the drying temperature is 100 to 200°C."

II. Notice of opposition was filed on 27 February 1995 on the grounds of Article 100(a) EPC that the subject-matter claimed in the patent lacked novelty and inventive step. The opposition was supported, *inter alia*, by the following documents:

D1: EP-A-0 118 088

D2: US-A-4 016 236

D3: GB-A-2 044 668

D7: US-A-3 767 756

III. By a decision announced at the end of the oral proceedings held on 5 November 1996 and issued in writing on 19 November 1996 the patent was revoked.

(a) According to the impugned decision, none of the prior art documents, in particular none of D1 and D2, disclosed all the claimed features in the combination as granted. Therefore, the claimed subject-matter was novel.

(b) As to inventive step, D7 was considered to be the closest prior art document. The patent in suit aimed at a poly(p-phenylene terephthalamide) yarn with a fatigue resistance superior to that attained in D7, produced by a process with only simple modifications to the process in D7.

The process defined in claims 2 and 3 as granted differed from that of D7 in the tension applied to the fibre during washing, neutralising and drying.

The distinctive tensions were however considered to be arbitrary variations within the wider teaching of the closest prior art, since no

surprising technical effect as a consequence of those differences had been demonstrated. Hence, the subject-matter of claims 2 and 3 was obvious.

Claim 1 of the patent-in-suit defined a yarn which was obtainable by the process of claim 2. Therefore, the conclusion regarding claim 2 in respect of inventive step also applied to claim 1.

For those reasons, the claimed subject-matter did not involve an inventive step.

IV. On 21 January 1997 the Proprietor (Appellant) lodged an appeal against the decision and paid the prescribed fee on the same day. With the statement of grounds filed on 21 March 1997, a further document (D8: US-A-4 466 935), as well as further test results were filed.

During the oral proceedings held on 28 June 2001, the Appellant filed, in support of its arguments, a comparison of the coagulation bath temperatures in the prior art. As a result of the discussion in respect of the claims as granted, the Appellant also filed a new request as its sole request consisting of two method claims, reading:

"1. A method for preparing poly(p-phenylene terephthalamide) yarn of improved fatigue resistance having an apparent crystallite size in the range of 4 to 5 nm (40 to 50 A), an orientation angle in the range of 20 to 30°, an elongation in the range cf 4.5 to 5.6%, a tenacity of at least 15.8 dN/tex (18 grams per denier) and a modulus of at least 176 dN/tex (200 grams per denier), but less than 396 dN/tex (450 grams per denier) wherein a spin dope containing from 17 to 20% by wt. of said polymer in 98 to 102% sulfuric acid is spun through an air gap into an aqueous coagulating

bath maintained at a temperature of from 20°C to 40°C and then washed, neutralized and dried, the method comprising washing and neutralizing the fiber while it is under a tension of from 0.18 to 0.36 grams per dtex (0.2 to 0.4 grams per denier) and drying the fiber at a temperature below 200°C while the fiber is maintained under a tension of 0.045 to 0.18 grams per dtex (0.05 to 0.2 grams per denier)."

"2. A method according to Claim 1 wherein the drying temperature is 100 to 200°C."

V. The Appellant's arguments in support of inventive step of the new claims can be summarised as follows:

D1 to D3 were considered to be the closest prior art rather than D7, since the latter did not address improving the fatigue resistance of the fibres. D1 to D3 described washing, neutralising and drying of the fibres on a conveyor belt, which involved no application of any substantial tension to the fibres.

However, that process was not suited for commercial production which had to run at higher speeds. The technical problem vis-à-vis D1 to D3 was thus to modify the process described in those documents so as to make it suitable for the speeds desirable for commercial processes, without deterioration of the physical properties, in particular of the fatigue resistance, of the resulting fibres. That problem was effectively solved by the claimed process.

The process conditions essential for the process in dispute were the temperature of the coagulating bath and the tension applied to the fibres during washing, neutralising and drying. The relevant prior art that also considered fatigue resistance of the fibres

recommended washing and drying them without application of any substantial tension. All prior art documents mentioned the use of a low temperature for the coagulation bath and thus taught away from using higher temperatures, as now claimed. There was no pointer to the combination of the process conditions and the product parameters as claimed. Since the process conditions alone did not always automatically give rise to the properties of the fibres as claimed, the latter should also be taken into account for assessing the presence of an inventive step. The prior art did not suggest the present combination of process and product features, so that the claimed subject-matter was inventive.

VI. The arguments of the Respondent (Opponent) against the inventive step of the new claims can be summarised as follows:

The Respondent, who in the written arguments had regarded D7 as closest prior art since it disclosed tensions which encompassed the claimed ones, now considered D2 as the appropriate starting point.

D2 was the closest prior art because it mentioned improving fatigue resistance. Contrary to D1, it disclosed fibres with almost all of the product features as now claimed and it also was the starting point for the further improvement disclosed by D3.

The problem of providing a commercially more attractive process, apart from whether such a problem definition actually involved any technical problem, was not mentioned at all in the patent in suit. Vis-à-vis D2, the fatigue resistance of the fibres resulting from the process as claimed was not improved either.

From the comparative examples of D3 it appeared that the fibres according to the patent in suit only possessed a slightly lower elongation compared to D2, so that this might be seen as the problem to be solved, although it had not been specifically mentioned either in the patent in suit.

However, the difference in elongation and the relevant effect thereof were marginal and actually could not result in an inventive step. Moreover, in order to provide a commercially more attractive process, it was unavoidable to use rollers instead of a conveyor belt and this would inevitably lead to tensions being applied to the fibres during washing, neutralising and drying. In line with the teaching of D2 the tension should however be kept as low as possible, hence the ranges of tension as now claimed were not an inventive part of the process.

As regards the higher temperature of the coagulating bath, temperatures falling in the claimed range were known from D2. D3 stated that the coagulating bath temperature was not critical.

In summary, according to the Respondent, the direct application of the teaching of D2 to an existing, commercially attractive process with rollers would lead to the present process, which therefore lacked an inventive step. In support of these arguments, during the oral proceedings, the Respondent submitted a declaration by Dr Ir. H. Boerstoel.

VII. The Appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of the main request, claims 1 and 2, submitted at the oral proceedings.

The Respondent requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 Claim 1 corresponds to claim 2 as originally filed with the inclusion of the mechanical and structural features of the yarn according to original claim 1 as well as of the preferred range of temperatures for the coagulating bath as defined in original claim 4, and with the following further modification:

The unit of measure defining the lower and upper limits of the apparent crystallite size (ACS) range, initially only indicated in Ångstrom, which had been erroneously converted into the SI unit "mm" additionally indicated in the granted claims, was corrected into "nm".

2.2 Hence, the modifications meet the requirements of Article 123(2) EPC.

2.3 Since claim 1 now concerns a process of manufacture of a yarn with all limitations of claims 1 and 2 as granted, the requirements of Article 123(3) EPC are also fulfilled.

2.4 The Respondent did not challenge the above conclusions.

3. *Novelty*

Novelty was no longer contested by the Respondent and the Board sees no reason to take a different view.

4. *Closest prior art*

The patent as defended concerns a process for preparation of poly(p-phenylene-terephthalamide) yarns of improved fatigue resistance. Poly(p-phenylene-terephthalamide) yarns and a process for preparation thereof are described in D7 as well as in D1 to D3. Whereas the Appellant mentioned D1 to D3 as the closest prior art, the Opposition Division and initially the Respondent, too, regarded D7 as the starting point.

4.1 D7 discloses a method comprising extruding a spin dope from an orifice through a layer of inert noncoagulating fluid into a coagulating bath, said dope comprising a certain specified polyamide and a solvent essentially consisting of sulfuric acid of at least 98% concentration, chlorosulfuric acid or fluorosulfuric acid and mixtures thereof at certain specified concentrations (claim 1). The polyamide may be poly(p-phenylene-terephthalamide) (claim 13).

Spin dopes are made of poly(p-phenylene-terephthalamide) at concentrations varying from about 18 to 23.4 weight percent (column 6, lines 12 to 13). The preference for using as high a dope concentration as possible derived from the discovery that the tenacity of the spun fibres increased with the concentration of the dope used (column 6, lines 39 to 42).

The dope is extruded from a spinneret through air into an aqueous coagulating bath (examples). Preferably, the temperature of the coagulating bath is below 50°C, more preferably 28°C or lower (claims 7 and 8). Satisfactory temperatures may range from -25 to 28°C; temperatures as high as 50 °C or more are possible, depending on the coagulants (column 9, lines 2 to 6). To obtain the highest tenacity in the filaments, the temperature

should be below 10°C (column 9, lines 6 to 9). In the examples, the coagulating bath temperatures actually vary between 0 to 4°C (examples I to III) and 27°C (example VI b).

The washing and neutralising steps may be carried out in a continuous way, at the same speed as the thread line, preferably on rolls with overhead sprays (column 9, lines 27 to 33). D7 is silent as to the amount of tension which is actually applied to the fibres during washing and neutralising.

The drying step is conveniently carried out on heated rolls (column 9, lines 35 to 39), under tensions of less than about 0.3 gpd, to prevent any significant change in the properties of the fibres. Higher tensions reduce the elongation and increase the modulus compared to that obtained under tensionless drying (column 9, lines 39 to 41).

The preparation of poly(p-phenylene-terephthalamide) fibres is described in several examples in D7. However, only examples I and II also give the properties of the resulting fibres in the form of a yarn. These yarns as-spun have tenacities varying from 21.2 (example IIa) to 24.8 g/d (example IIc), elongations from 2.8 (examples Ia and IIc) to 3.9% (example IIa) and moduli from 547 (example IIa) to 948 g/d (example IIc).

The fibres resulting from the process of manufacture according to D7 are said to be useful in tire cords (column 1, lines 56 to 57). As desired fibre properties high filament tenacity and modulus are mentioned (column 2, lines 13 to 17). Fatigue resistance is however not addressed, nor are the structural features orientation angle (OA) and apparent crystallite size (ACS) of the fibres.

4.2 D1, D2 and D3 stem from the same applicant and share the use of a conveyor belt system for processing the fibres after spinning.

4.2.1 Although D1 mentions "wet spinning", it actually concerns dry-jet, wet spinning. This was not challenged any longer by the Respondent during the oral proceedings.

D1 describes a process for the preparation of poly(p-phenylene-terephthalamide) fibres comprising passing an optically anisotropic solution of a poly(p-phenylene-terephthalamide) type polymer through a non-coagulating fluid layer and guiding the solution to a coagulating bath, characterized in that (a) filaments are taken out together with a stream of a coagulating solution from a fine tube or fine hole arranged in the lower portion of the coagulating bath and the filaments are travelled through a second fine tube or fine hole arranged below said fine tube or fine hole through a space, and (b) in the fine tube or fine hole arranged in the lower portion of the coagulating bath, the stream of the coagulating solution flowing out together with the filaments is accelerated and in the second fine tube or fine hole, the speed of the stream of the coagulating solution accompanying the filaments is decreased (claim 1).

For the spinning dope, sulfuric acid of at least 95%, especially at least 99% is used as the solvent (page 7, lines 1 to 6). The concentration of polymer varies from 13 to 22 wt.% (page 7, lines 10 to 17).

Regarding the tensions applied during the neutralising, washing and drying steps, no values are given, but explicit reference is made to D2 as describing a method suitable for obtaining fibres having a high quality on an industrial scale (page 21, lines 9 to 19). Figure 4

shows the practical implementation of the application of the belt conveyor system according to D2 to the spinning system according to D1, whereby examples 2 to 5 and 8 to 10 give the properties of the fibres obtained therefrom. The fibres produced in the examples have tensile strengths varying from 23.5 to 24.7 g/d, elongations varying from 4.5 to 4.9% and initial moduli between 347 and 379 gpd (tables 2 and 6). The fatigue resistance, in minutes, varies from 940 and 1250 (tables 3 and 7). The other examples do not mention the use of the belt conveyor system of D2 or actually specify that the filaments as spun are actually wound on a bobbin and then, in this state, washed, neutralised and dried, without however indicating any tensions (example 1, page 28, lines 20 to 25).

D1 aims at a low tension during spinning in order to improve the mechanical properties of the fibres, in particular the strength and elongation, without losing the industrial significance of the process (page 2, lines 2 to 9; page 4, lines 7 to 16).

The combination of high strength and high elongation is particularly important for the fatigue resistance when the fibres are used for tire cords (page 4, lines 1 to 5). The general teaching of D1 is, that, in order to prepare the desired fibres, the tension of the filaments in the incomplete coagulation state should be reduced in order to prevent fracture of the fibre structure (page 10, lines 12 to 20).

The spinning tension for forming the filaments and the coagulation state determined by the removal of sulfuric acid should satisfy certain specific conditions, which can be achieved by the arrangement of fine holes or

tubes through which the filaments are made to travel and by regulation of the speed of the coagulating solution accompanying the filaments (page 4, lines 16 to 36).

4.2.2 D2 describes a process for the manufacturing of fibres by wet-spinning an anisotropic dope of certain specified aromatic polymers, the process comprising the steps of a) dissolving the polymer in at least one solvent selected from a specified group of solvents, b) forming filaments by extruding the dope into a coagulation bath, c) removing the filaments from the bath, d) depositing them onto a conveyor at a rate greater than the linear speed of the conveyor, e) washing the filaments on the conveyor, and f) drying the resulting filaments, the steps of the process being conducted in a manner such that the filaments are formed in the substantial absence of any tension being applied to the filaments (claim 1).

Concentrated sulfuric acid having a concentration of more than 98% is one of the two most preferred solvents for the spinning dope (column 6, lines 63 to 68). The higher the concentration of polymer in a dope, the higher the tenacity of the resulting fibres (column 7, lines 40 to 41). The concentration of polymer in the spinning dope is preferred to be at least 15 wt.% and up to 50 wt.% (column 7, lines 22 to 51).

The dope is extruded and may be passed through air into a coagulating bath (column 7, lines 53 to 60). The latter procedure is preferred since no substantial tension is applied to the fibres while they are coagulated (column 7, lines 60 to 64).

The absence of any substantial tension during further processing is emphasized (column 7, lines 64 to 68). To that end, the spun fibres are put onto a conveyor at a rate greater than the linear speed of the conveyor (column 9, lines 44 to 53).

According to D2, no substantial tension should be applied to the filaments while they are being taken from the coagulation bath and fall onto the conveyor. However, it is not possible to avoid all tension completely, since the coagulated filaments are taken out of the coagulation bath and made to fall onto the conveyor belt by a roller. Hence, the expression "in the substantial absence of any tension" should be interpreted as tensions of less than 0.5 g/d, preferably less than 0.2 g/d (column 8, lines 41 to 58, in particular lines 54 to 58).

The temperature of the coagulating bath may be maintained at any desired temperature and is usually selected between -5°C to 70°C (column 8, lines 33 to 35).

The fibres, after drying, may be submitted to an additional heat treatment for preparing thermally set fibres stabilised in dimensional and mechanical properties at high temperatures. This heat treatment step is also carried out without applying any substantial tension to the filaments (column 10, lines 64 to 68).

Regarding the filament properties, in column 11, lines 54 to 56, it is disclosed that the lower limit for the elongation should be at least 4%, preferably at least 5%. The initial modulus is usually below 600 g/d, preferably below 450 g/d, and more preferably below

350 g/d. According to column 12, lines 12 to 14, there is no substantial inequality in mechanical properties between individual filaments or between bundles of filaments.

In the examples of D2 filaments are prepared by dry-jet, wet-spinning. Some of them are heat-treated. According to examples 1 and 2, the filaments of poly(p-phenylene-terephthalamide) which had not been heat-treated have, respectively, tenacities of 21.3 (example 1) and 21.5 to 22.8 g/d (example 2), elongations of 6.8 (example 1) and 6.4 to 7.0% (example 2) and initial moduli of 330 (example 1) and 425 to 465 g/d (example 2). The filaments which had been heat-treated have, respectively, tenacities of 21.5 (example 1) and 21.4 to 22.5 g/d (example 2), elongation of 6.4 (example 1) and 5.8 to 6.5% (example 2), initial moduli of 355 (example 1) and 345 to 380 g/d (example 2). The other examples do not concern dopes of poly(p-phenylene-terephthalamide) or concern applications of the filaments obtained in example 1. Orientation angle and apparent crystallite size of the fibres is not given. The filaments prepared according to D2 exhibit, amongst other advantages, a good compression-extension fatigue property (column 12, lines 8 to 9).

The object of D2 is to provide fibres possessing high tenacity, controlled, not too high initial modulus and not too low elongation as well as a process for manufacturing such fibres (column 2, lines 3 to 7).

That object is achieved by avoiding the application of any substantial tension to the filaments while they are being taken from the coagulation bath and fall onto the conveyor, where the filaments are washed, neutralised and dried.

Although good fatigue resistance is not specifically mentioned as an object of the invention, it is stated that the known filaments were poor in flexural fatigue-resistance (column 1, line 43), whereas the filaments of D2, amongst other advantages, also express a good compression-extension fatigue property (column 12, lines 8 to 9).

4.2.3 D3 discloses a fibre consisting essentially of poly(p-phenylene-terephthalamide), wherein the tangential refractive indices, the apparent crystallite size and the orientation angle of the fibre satisfy certain specified conditions (claim 1).

D3 also discloses a process for the preparation of fibres consisting essentially of poly(p-phenylene-terephthalamide), which comprises extruding an anisotropic dope of a polymer consisting essentially of poly(p-phenylene-terephthalamide) in concentrated sulfuric acid having a concentration of at least 98% by weight, in a non-coagulating layer, passing the extrudate through a coagulating layer, depositing the resulting coagulated fibres on a net conveyor, and in the absence of substantial tension sequentially washing the fibres to remove sulfuric acid, holding the fibres in saturated steam maintained at at least 100°C, and drying the fibres at a temperature in the range of from 120°C to 450°C for a time which fulfills certain specified conditions (claim 10).

In order to prepare the fibre, the polymer is dissolved in concentrated sulfuric acid of at least about 98 wt.% and the resulting spinning dope is passed through a non-coagulating layer, eg air, then into a coagulating bath (page 8, lines 24 to 56). The temperature of the coagulating bath is not considered to be critical, but usually lies in the range of from room temperature to the freezing point of the coagulating layer (page 9,

lines 28 to 31). The necessity of the absence of substantial tension during preparation of the fibre in relation to fatigue resistance is emphasized (page 5, lines 43 to 45; page 9, lines 46 to 48, 56 to 57 and 63 to 64).

In example 1, poly(p-phenylene-terephthalamide) is dissolved in sulfuric acid with a concentration of 99.4% to a polymer concentration of 18%. The dope is extruded through an air gap and then coagulated in diluted sulfuric acid at a temperature of 5°C, washed and neutralised and steam treated at 120°C before being dried at 200°C. The other examples differ in details from that method. The fibres so obtained have apparent crystallite sizes varying from 52 to 75Å (Examples 2-3 and 2-6), orientation angles varying from 19 to 26° (Examples 2-3 and 3-1), tenacities of 17.8 to 22.6 g/d (Examples 3-1 and 1), elongations of 6.0 to 6.9 g/d (Examples 2-8 and 3-1) and tube fatigue resistant lives of 840 to 1320 minutes (Examples 2-3 and 2-1).

Comparative examples 1, 2 and 3 in D3 specifically refer to the methods used in D7 and D2, respectively.

In comparative example 1 of D3, which follows D7, basically the same process is used as in example 1 of D3, with the omission of the conveyor belt system. Instead, the filament is wound up on a bobbin, neutralised and washed, and then dried at 160°C. The filament has an apparent crystallite size of 43Å, an orientation angle of 15°, a tenacity of 19.5 g/d , an elongation of 3.9% and a tube fatigue resistant life of 280 minutes.

In comparative example 2 of D3, which follows D2 without heat-treatment, the same process as in example 1 of D3 is applied; however, during the passage through the steam treatment chamber the supply of steam

is completely stopped. The filament is then dried at 170°C. It has a an apparent crystallite size of 49Å, an orientation angle of 27°, a tenacity of 21.6 g/d, an elongation of 6.4% and a tube fatigue resistant life of 610 minutes.

In comparative example 3 of D3, poly(p-phenylene-terephthalamide) fibres are produced following D2 but with a heat treatment after drying the fibre. As in the previous examples, no substantial tension is applied while washing, neutralising and drying the fibres. The fibre thus obtained has an apparent crystallite size of 50Å, an orientation angle of 25°, a tenacity of 22.5 g/d, an elongation of 5.9% and a tube fatigue resistant life of 620 minutes.

The object of D3 is to find a process for manufacturing poly(p-phenylene-terephthalamide) fibres which have a high tenacity, high Young's modulus and excellent fatigue resistance, and which are excellent in stability against heat or tension (page 2, lines 20 to 24). That is achieved by applying a steam treatment before drying the fibres and by then carrying out the drying under specific conditions (page 2, lines 24 to 25).

4.3 As can be seen from the above analysis of D7 and D1 to D3, these documents have a number of features in common with the subject-matter now being claimed. According to the present patent specification, the object of the invention is to improve the fatigue resistance of fibres made by the process of D7, preferably by a simple modification of that process (page 2, lines 5 to 10), which is a clear invitation to start from D7.

4.3.1 However, D7 does not address the problem of fatigue resistance, which problem was mentioned and apparently solved in D1 to D3. In the Board's opinion, a document

serving as the starting point for evaluating the inventive merits of an invention should relate to the same or a similar technical problem as the patent in suit, requiring the minimum of structural and functional modifications (cf. Case Law of the Boards of Appeal of the European Patent Office, 3rd edition 1998, I.D.3.1, page 11 of the English version). Therefore, in the Board's view, D7 does not qualify as the closest prior art document.

4.3.2 D1, D2 and D3 all explicitly address the improvement of fatigue resistance.

However, although D1 represents an improvement of D2 and actually describes a dry-jet, wet-spinning process as in the present patent, it only focuses on the control of the spinning part of the process. For control of the tension during the subsequent washing, neutralising and drying steps reference is made to the teaching of D2. Furthermore, D1 teaches the use of temperatures of the coagulating bath below 15°C. Finally, nothing can be learned as to apparent crystallite size (ACS) and orientation angle (OA) of the fibres obtained in D1.

D3 concerns an improvement of D2 as regards the fatigue resistance (examples and comparative examples). From the comparative examples of D3 it appears that the fibres of D2 have properties which are closer to those of the fibres of the patent in suit (see point 4.2.3 above). According to D3 (page 1, lines 37 to 64), the purpose of D2 was to improve the fatigue resistance of the fibres according to D7.

4.3.3 Considering that only D2 discloses fibres having comparable fatigue resistance, it is to be regarded as the closest prior art.

5. *The technical problem*

5.1 The belt conveyor system used in the process of manufacture of D2 (as well as in D1 and D3) has the drawback that its speed must be less than the speed of the filaments falling onto it, namely from 12 to 10 000 times less, preferably from 100 to 2000 less, to prevent the fibres from being subjected to any appreciable tension (D2, column 9, lines 44 to 53). The low speed of the conveyor, exemplified as being from 1 m/min to as low as 0.1 m/min (examples 1 and 3) renders this kind of process commercially uninteresting, which was not in dispute among the parties (Statement of Grounds of the Appeal, paragraph bridging pages 10 and 11; Letter of the Respondent dated 4 September 1997, page 2, second last sentence of the first paragraph).

5.2 Hence, the problem addressed by the claimed invention in view of the disclosure of D2 may be seen as to provide a process for making poly(p-phenylene-terephthalamide) fibres suitable for running at higher speed, without deterioration of the favourable properties of the fibres, in particular the fatigue resistance, as stated by the Appellant.

5.3 The Respondent did not agree with that definition of the problem to be solved, arguing that it was an entirely new problem which had not been addressed in the application as originally filed and also questioning its validity as a technical problem.

5.3.1 The Board considers that the technical problem may be restated, as a consequence of new prior art cited during the proceedings, provided that the reformulated problem could be deduced by the skilled person in the

light of the closest prior art (cf. Case Law of the Boards of Appeal of the European Patent Office, 3rd edition 1998, I.D.4.2, page 116 of the English version).

In the present case, a comparison of the velocities of spinning and transporting the spun yarns as well as of the properties of the fibres of D2 with those of the patent in suit (cf. the table on page 4 in the patent in suit) makes it clear that the above-defined problem was derivable from the patent specification. In this respect, the parties agreed that the yarn speeds given in the table on page 4 correspond to the speeds of the thread line.

5.3.2 Regarding the nature of the problem, the object of increasing production speed refers to industrial production and is therefore of a technical nature.

Also, the measures to solve the above-defined problem are of an entirely technical character, which was not contested by the Respondent. Therefore, the Respondent's objection in this respect is without merits.

6. *The solution*

6.1 According to the patent in suit that problem is solved by applying a certain tension to the spun fibres during washing, neutralising and drying them and to apply certain temperatures during coagulation and drying so as to arrive at a fibre having certain specific properties, as defined in claim 1.

6.2 The examples in the patent in suit as well as the comparative examples filed on 2 October 1996 and on 21 March 1997 show that the above-defined problem is effectively solved.

In particular, it has been demonstrated that a process in which some tension and a relatively high temperature of the coagulation bath are applied to produce a fibre having the characteristics as defined in the patent in suit effectively results in the production of a fibre having a satisfactory fatigue resistance at a higher, commercially more interesting, production speed. As regards the latter, from the examples it can be gathered that the yarn speed (274.3 to 594.3 m/min) is well above the speed of the belt conveyor mentioned in D2 (from 0.1 to 1 m/min).

6.3 The evidence filed during oral proceedings (Declaration of Dr H. Boerstoel) confirms that the values for the tensions as defined in present claim 1 may be implemented in existing plants with rolls which run at higher speeds than according to the process of D2.

6.4 Thus, the Board is satisfied that the technical problem is effectively solved by the claimed solution.

7. *Inventive step*

It remains to be decided whether the claimed subject-matter is obvious having regard to the documents on file.

7.1 The general teaching of D2 is to avoid any tension on the spun fibre, to the extent that the spinning speed is higher than the speed of the conveyor belt that transports the spun fibre through the washing, neutralising and drying zones.

Furthermore, there is no specific teaching as regards the temperature of the coagulation bath, with values in the examples well outside the present range. The one

example (example 3) that mentions a coagulation bath temperature of 40°C does not concern poly(p-phenylene terephthalamide) fibres.

From the comparative examples which concern D2 and which are reproduced in D3, it can be seen that almost all of the structural properties of the fibres obtained therein are within the range now being claimed, apart from the slightly different elongation, which does not fall within the scope of the claimed subject-matter.

However, D2 neither qualifies nor quantifies the influence on the fatigue resistance of the various process features and product properties selected as defined in claim 1 in suit. In particular, D2 neither teaches nor hints at using a higher temperature of the coagulation bath to reduce the loss of fatigue resistance due to the application of the higher, non-preferred tensions for increasing the production speed.

Therefore, D2 does not contain any suggestion about the process or product features necessary to solve the present problem. In fact, by its clear statement that all tension should be avoided, it teaches away from using any tension at all during neutralising, washing and drying. Consequently, D2 by itself cannot render the claimed subject-matter obvious.

7.2 Since D1 and D3 both refer to D2 and contain the same general teaching as D2 that any tension should be avoided during washing, neutralising and drying the fibre, any combination of D2 with D1 and/or D3 cannot lead to the combination of features now being claimed.

7.3 The general teaching of D7 concerns the composition of the dope from which the fibre is spun. Although D7 mentions temperatures of 27 and 28°C for the

coagulating bath, it does not address fatigue resistance and in the examples the temperatures actually used are outside the present range.

Also, there is no indication of a combination of the higher coagulating bath temperatures with specific tensions to which the fibre should be subjected during the various phases of its production, nor of the structural and functional properties of the fibres.

While the tension should be below 0.3 g/d during drying, nothing is said about the tension during washing and neutralising, nor of the effect of a combination of specific tensions with specific coagulation bath temperatures and specific fibre properties.

Therefore, D7 cannot provide the features missing in D2 in order to arrive at the combination of features now being claimed, so that a combination of D7 with D2 also does not lead to the claimed subject-matter.

7.4 Also if one considered D7 as the closest prior art, as the Opposition Division and, at first, the Respondent and also the Appellant, in the original application, did, one would not arrive at any other conclusion. Regardless of the problem to be solved, the combination of D7 with any or all of D1 to D3 would not lead to the present combination of features.

8. Since the description has still to be adapted, the Proprietor may also be given the opportunity to correct the obvious typing error in line 5 of claim 1, namely "of" instead of "cf".

9. *Late filed document*

During the oral proceedings, the late filed document, D8, did not come into consideration in relation to the new claims. Hence, it was not necessary to take any decision on its admissibility pursuant to Article 114(2) EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the patent with claims 1 and 2, according to the main and sole request as submitted during the oral proceedings and a description yet to be adapted.

The Registrar: The Chairman:

E. Eickhoff R. E. Teschemacher

28/9/2001

04.2001