

Uncoated fabric for manufacturing air bags

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Description:

5 The invention relates to an uncoated tightly woven synthetic filament yarn fabric for manufacturing an air bag.

 Fabrics used for manufacturing air bags are required to have in particular a low air permeability.
10 Hitherto a low air permeability has been mainly achieved by coating the air bag fabric. However, coated fabrics, besides being more expensive to produce, also have appreciable disadvantages in use, of which the increased space required, compared with uncoated fabrics, for
15 accommodation in the steering wheel must be mentioned in particular.

 For this reason processes for manufacturing uncoated air bag fabrics have been developed. Here the required low air permeability is achieved through a very
20 tight fabric construction and through special measures in finishing such as calendering (e.g. EP-A-314,867) or heat setting (e.g. CA-A-974,745).

 It is true that low air permeability is the most important requirement of an air bag fabric, but a
25 serviceable fabric of this kind must additionally meet a number of other important requirements, of which high strength and good foldability are particularly important. The latter requirement is crucial if the air bag is to be accommodated in the steering wheel of motor vehicles in
30 the least amount of space. However, good foldability also makes possible trouble-free inflation of the air bag for protecting the vehicle occupant in the event of an accident.

 To be able to obtain high strengths, air bags
35 have hitherto been manufactured using in particular yarns having a high filament linear density. For instance, US-A3,842,583 proposes for this purpose yarns having a

filament linear density of 6.0-6.2 den (6.6-6.8 dtex).

CA-A-974,745 proposes a yarn having a filament linear density of 6 den (6.7 dtex).

5 Although US-A-4,977,016 specifies a yarn linear density range of 400-600 den (440-660 dtex) for 100-300 individual filaments, the invention is described in the embodiment examples only in terms of a yarn having a linear density of 440 den and 100 individual filaments, which corresponds to a filament linear density of 4.4 den
10 (4.8 dtex).

It is true that these linear densities give the required strength, but they have the appreciable disadvantage of high stiffness, which has a very adverse effect on foldability. The least-space requirement for
15 accommodating the air bag, for example in the steering wheel of the vehicle, and trouble-free inflation cannot be adequately achieved with linear densities of this order of magnitude.

Similarly, very low filament linear densities
20 have already been proposed for manufacturing air bag fabrics. For instance, JP-A-64-041,438 proposes for this purpose linear densities below 3 den (3.3 dtex) and even prefers linear densities below 2 den (2.2 dtex). It is true that these linear densities are free of the problem
25 of inadequate foldability, but they do have appreciable disadvantages as regards economics. For instance, in man-made fibre spinning, fine linear densities are more expensive to produce than coarse linear densities. Moreover, more filament breakages occur at the drawing
30 stage, resulting in a fluffy material of little suitability for further processing by weaving. This disadvantage is particularly noticeable when weaving a very tight fabric construction as required for air bag fabrics. When processing yarns of such fine filament
35 linear densities it is therefore inevitable that the weaving efficiency will be lower. Finally, very fine linear densities are also more problematical than coarse linear densities in regard to abrasion resistance along the folds of the folded air bag.



It is therefore an object of the present invention to develop a fabric for manufacturing air bags which fully meets the air bag fabric requirements such as low air permeability, high strength and high abrasion resistance at the folds, which makes possible soft cushioning of the vehicle occupants in the event of an accident, and which moreover is inexpensive to manufacture and further process.

It has now been found, surprisingly, that these requirements can be satisfactorily met only with polyamide yarns of precisely selected filament linear densities. This is because only if polyamide yarns having a filament linear density of 3.5-4.5 dtex are used does the fabric obtained fully guarantee the properties required of air bag fabrics in respect of air permeability, strength, abrasion resistance of the folds and in particular foldability. Polyamide yarns having this linear density can be manufactured inexpensively and are free of the lints which in the case of finer filament linear densities customarily impair yarn quality as a consequence of stretch breakages.

Furthermore, polyamide yarns having a filament linear density of 3.5-4.5 dtex additionally offer the particular advantage of lower air permeability compared with yarns of equal yarn but higher filament linear densities. This means that such polyamide yarns make it possible to use fewer threads in the fabric and yet, through suitable finishing conditions, obtain a fabric having the low air permeability required for air bags. Thus, these polyamide yarns, compared with the yarns of higher filament linear density, yield a distinct cost benefit in fabric manufacture.

Suitable yarn linear densities range from 200 to 600 dtex. Experiments were carried out with polyamide yarns of 235 dtex and 72 filaments (235 f 72 $\hat{=}$ filament linear density 3.3 dtex), 350 f 94 (filament linear density 3.8 dtex) and 470 f 104 (filament linear density 4.5 dtex).

The polyamide yarns to be used for manufacturing air bag fabrics preferably have a tenacity of at least





60 cN/tex and an elongation of 15-30%. This meets specifications issued by the automotive manufacturers in a particularly advantageous manner.

5 Air bag fabrics can be manufactured with any
synthetic filament yarn which meets the abovementioned
tenacity and elongation values. However, polyamide yarns
have been found to be particularly highly suitable.
Compared with for example polyester yarns they have the
10 significant advantage of higher elasticity, which is due
to a flatter course of the load-extension line in the
initial region. Of particular suitability for use in air
bag fabrics are yarns made of nylon 6.6. Particular
preference is given here to yarns made of nylon 6.6 which
contain a heat stabiliser introduced in the course of the
15 polycondensation.

The fabrics are manufactured in a tight construction, preferably in a plain or Panama weave. However, it is also possible to use twill weaves. In the case of a polyamide yarn linear density of 235 dtex,
20 26-30 threads per cm are used in warp and weft. If the
polyamide yarn has a linear density of 350 dtex, 23-27
threads per cm are used. If polyamide yarns having a
linear density of 470 dtex are used, then 19-23 threads
per cm are employed. The numbers quoted here relate to a
25 plain weave. In the case of a Panama weave with a yarn
linear density of 235 dtex the numbers are for example
34-38 threads per cm in warp and weft.

An important requirement is an essentially
30 symmetrical fabric sett; that is, the fabric must have
the same or virtually the same number of threads per cm
in both warp and weft. Only such setts make it possible
to meet the automotive manufacturers' demands for equal
strength in warp and weft.

The desired air permeability is achieved with the
35 aid of a wet process, described in EP-A-436,950. It
involves shrinking in an aqueous bath within the
temperature range between 60-140°C. This is followed by
drying only and no heat setting. The precondition for
this process is that the polyamide yarns used have a hot



air shrinkage of at least 6% (measured at 190°C).

Air bag fabric is required, according to the automotive manufacturers' specifications, to have an air permeability of $< 10 \text{ l/dm}^2 \cdot \text{min}$ at a test pressure difference of 500 Pa. This requirement applies to the contact part of the air bag. The filter part is permitted to have air permeabilities of $20\text{--}80 \text{ l/dm}^2 \cdot \text{min}$. The fabrics manufactured according to the present invention readily meet even the very low air permeability required for the contact part of the air bag.

As shown in the following table, the fabrics manufactured according to the present invention from polyamide yarns having a filament linear density of $3.5\text{--}4.5 \text{ dtex}$ always give a lower air permeability than if polyamide yarns of higher filament linear densities are used:

Yarn type	Filament linear density dtex	Threads per cm warp	Threads per cm weft	Air permeability $\text{l/dm}^2 \cdot \text{min}$ at 500 Pa
235 f 36	6.5	28.8	27.9	7.7
235 f 72	3.3	27.8	27.7	3.1
350 f 72	4.9	25.2	25.7	5.8
350 f 94	3.8	25.0	24.6	4.1
470 f 72	6.5	21.3	21.1	7.5
470 f 104	4.5	20.7	21.1	4.5

The comparative experiments recited in this table were each carried out with the same number of threads for the polyamide yarns having finer and coarser filament linear densities. Further experiments have shown that the number of threads per cm can be reduced on average by 2 in warp and weft if polyamide yarns having a filament linear density of $3.5\text{--}4.5 \text{ dtex}$ are used in place of the hitherto customary polyamide yarns having a filament linear density of $5.0\text{--}6.5 \text{ dtex}$. Even with this fewer number of threads it is still no problem to achieve the required air permeabilities of $< 10 \text{ l/dm}^2 \cdot \text{min}$. Consequently, by using polyamide yarns having a filament



linear density of 3.5-4.5 dtex instead of the hitherto used polyamide yarns having a filament linear density of 5.0-6.5 dtex, it is possible to achieve a cost saving at the fabric manufacturing stage.

5 The air permeability of the fabrics according to the present invention was tested on the lines of DIN 53887. However, in departure from this DIN standard the test pressure difference was raised to 500 Pa in order that a discernible test signal was still obtainable
10 with the fabrics manufactured according to the present invention.

 A linear density of 3.5-4.5 dtex has a particularly advantageous effect on the foldability of air bag fabrics. This lower filament linear density compared with
15 the polyamide yarn hitherto predominantly used (filament linear density > 5 dtex) brings about a reduction in the stiffness of the air bag fabric, thereby distinctly improving the foldability. Consequently, less space is required to accommodate the air bag in the motor vehicle,
20 for example in the steering wheel. Moreover, however, a low stiffness and hence better foldability of the air bag fabric also brings about trouble-free inflation of the air bag in the event of the air bag function being triggered, thereby improving in a particularly advantageous manner the protective effect of the air bag on
25 the vehicle occupants in the event of an impact. This is of particular importance in the event of out-of-position contact when the seat position of the vehicle occupant differs from the standard position. If the air bag function is triggered in this situation, air bags manufactured with polyamide yarns having filament linear densities > 5 dtex give rise to a sudden impact of the inflated air bag on the vehicle occupant with an attendant risk of injury, while, if air bag fabrics made of
30 polyamide yarns having filament linear densities of 3.5-4.5 dtex are used, the higher flexibility of the fabric and hence the better adaptability to the body shape of the vehicle occupant makes a softer cushioning possible. Very particular advantages have been found to
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be possessed here by fabrics made of polyamide yarns having a filament linear density of 3.5-4.5 dtex, since, compared with polyester for example, polyamide has a higher flexibility and thus the positive effect of yarns having a filament linear density of 3.5-4.5 dtex is additionally enhanced by the high flexibility of the polyamide.

The lower stiffness and hence better foldability of fabrics made of polyamide yarns having a filament linear density of 3.5-4.5 dtex compared with fabrics made of the hitherto used polyamide yarns having a filament linear density > 5 dtex is shown in the following table:

	Yarn type	Filament linear density dtex	Specific stiffness
15	235 f 36	6.5	$1.35 \cdot 10^{-2}$
	235 f 72	3.3	$0.68 \cdot 10^{-2}$
	350 f 72	4.9	$0.95 \cdot 10^{-2}$
	350 f 94	3.8	$0.80 \cdot 10^{-2}$
20	470 f 72	6.5	$1.32 \cdot 10^{-2}$
	470 f 104	4.5	$0.88 \cdot 10^{-2}$

The test fabrics were manufactured in a plain weave with the numbers of threads per cm in accordance with the above-stated particulars.

The bending stiffness was tested with a Taber stiffness tester, Model 150 B, from Taber Instruments. This instrument determines the moment needed to deflect the end of a sample 38 mm in width and 50 mm in length, clamped at one end, through an angle of 15°. The unit of measurement is the stiffness unit (SU). 1 SU is the bending moment (in cN·cm) of a sheetlike test specimen of the stated width which is being deflected through 15°. Contrary to the customary clamped length of 50 mm, however, the abovementioned experiments were carried out with a clamped length of 10 mm.

To enable an objective comparison to be made



between different fabrics, the specific stiffness was calculated according to the following formula:

$$\text{Specific stiffness} = \frac{\text{Bending stiffness} \times \text{air permeability}}{\text{Linear density}}$$

In addition to the stiffness unit SU determined by the abovementioned method, the specific stiffness is affected by the yarn linear density and the air permeability as an indirect measure of the fabric density.

It is true that a further reduction in the filament linear density results in a further reduction in the stiffness of the fabric and further improved foldability, but, if polyamide yarns having a filament linear density < 3.5 dtex are used, the yarn quality deteriorates very considerably, as the following table of lint measurements shows:

Yarn type	Filament linear density dtex	lints per t
235 f 36	6.5	350
235 f 72	3.3	1800
470 f 72	6.5	300
470 f 104	4.5	800

The fact that polyamide yarns having a filament linear density below 3.5 dtex have greatly increased numbers of lints means that such fine-filament yarns cannot be used for manufacturing air bags.

The choice of a filament linear density of 3.5-4.5 dtex for the polyamide yarns envisaged for air bag manufacture results in an air bag system which is safer than that of the prior art. Fabrics manufactured from these polyamide yarns readily meet the automotive manufacturers' demands for high strength and low air permeability. In addition, the higher flexibility and better unfoldability on triggering of the air bag function with the fabrics manufactured according to the present



invention give safer cushioning of the vehicle occupant.

Embodiment examples

Example 1

5 A 235-dtex 72-filament nylon 6.6 yarn, the filament linear density accordingly being 3.3 dtex, was used to manufacture an air bag fabric by plain weaving with 28 threads per cm in warp and weft. The fabric was treated in an aqueous bath on a jigger to shrinking.

10 The treatment was started at 40°C and the treatment temperature was raised to 95°C. The actual shrinking took place at that temperature. The fabric was then dried on a stenter at 150°C. The fabric was found to have an air permeability of 3.1 l/dm²·min and a specific stiffness of 0.68·10⁻².

15 A comparative experiment with a 235-dtex 36-filament yarn, corresponding to a filament linear density of 6.5 dtex, under the same manufacturing conditions in weaving and the same finishing conditions gave an air permeability of 7.7 l/dm²·min and a specific stiffness of 1.35·10⁻².

Example 2:

25 A 350-dtex 94-filament nylon 6.6 yarn, which accordingly had a filament linear density of 3.8 dtex, was used to manufacture an air bag fabric by plain weaving with 25 threads per cm in warp and weft. The wet treatment and drying were carried out as in Example 1. The fabric was found to have an air permeability of 4.1 l/dm²·min and a specific stiffness of 0.80·10⁻².

30 A comparative experiment with a 350-dtex 72-filament yarn, corresponding to a filament linear density of 4.9 dtex, under the same manufacturing conditions in weaving and the same finishing conditions gave an air permeability of 5.8 l/dm²·min and a specific stiffness of 0.95·10⁻².

35 Example 3:

A 470-dtex 104-filament nylon 6.6 yarn, which



accordingly had a filament linear density of 4.5 dtex, was used to manufacture an air bag fabric by plain weaving with 21 threads per cm in warp and weft. The wet treatment and drying were carried out as in Example 1.

5 The fabric was found to have an air permeability of 4.5 l/dm²·min and a specific stiffness of 0.88·10⁻².

10 A comparative experiment with a 470-dtex 72-filament yarn, corresponding to a filament linear density of 6.5 dtex, under the same manufacturing conditions in weaving and the same finishing conditions gave an air permeability of 7.5 l/dm²·min and a specific stiffness of 1.32·10⁻².

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Claims:

- 5 1. Uncoated tightly woven synthetic filament yarn fabric for manufacturing an air bag, characterised in that the yarn used for this purpose is a polyamide yarn and has a filament linear density of 3.5-4.5 dtex.
- 10 2. Fabric according to Claim 1, characterised in that the polyamide yarn used for this purpose has a linear density of 200-600 dtex.
3. Fabric according to Claims 1 to 2, characterised in that the fabric has an at least essentially symmetrical sett.
- 15 4. Fabric according to Claims 1 to 3, characterised in that the required low air permeability is obtained by shrinking in a wet process.
- 20 5. Uncoated tightly woven synthetic filament yarn fabric for manufacturing an air bag, characterised in that it has an air permeability $< 10 \text{ l/dm}^2 \cdot \text{min}$ and a specific stiffness $< 1.0 \cdot 10^{-2}$.
6. Air bag made of a fabric according to at least one of Claims 1 to 5.
- 25 7. Air bag system using an air bag according to Claim 6.

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