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(54) Title: A METHOD FOR THE PRODUCTION OF QUALITY COTTON YARNS INVOLVING A LOW-COST PROCESS, FREE OF ENVIRONMENTAL POLLUTION		
(57) Abstract A method for cotton purification is described, where the cotton is subject to a purification process in water, at a ratio of 1/10-20 volumes of water/weight cotton, at temperatures in the 60-150 °C range. The process solution contains calcium hydroxide at a ratio of 2-4 % w/w calcium/cotton and a non-ionic detergent wetting agent at a ratio of 0.3-4 gr. agent/lt. water. Following this processing the cotton is rendered hydrophilic, having water absorptivity in the order of 5-20 gr. water/gr. cotton and a rate of water absorption of 0.2-1.2 gr. water/gr. cotton/minute. The cotton is carried in a net, it is compressed in a horizontal press by applying a pressure of 20 at. with simultaneous removal of the adsorbed processing solution, it is then washed and bleached with H2O2 or ClONa in a two-stages process, leading to a product of a lovibond grade of 85-90. The effluent water is processed by anaerobic digestion in the thermophilic region for the production of biogas containing 85 % methane at a rate of 0.45-0.5 kg biogas/kg COD reduced. The effluent water from the anaerobic digestion process is further processed by aerobic biological treatment until it reaches an environmental load of 100 BOD>. It can then be either recycled or rejected. The biogas is used for steam production or electricity generation for covering the plant's needs. The whole process operates with energy self-sufficiency without resulting in environmental pollution. Finally, a high purity cotton is produced with high water absorptivity which is suitable for spinning for the production of quality cotton yarns suitable for weaving quality fabrics or dyeing.		

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**A METHOD FOR THE PRODUCTION OF QUALITY COTTON YARNS INVOLVING
A LOW-COST PROCESS, FREE OF ENVIRONMENTAL POLLUTION**

5 This invention refers to an original method for the processing of cotton yarns: By this method, the traditional mechanical spinning process is substituted by a wet process which involves complete purification of the cotton by rendering it hydrophilic. This process is self-sufficient in terms of energy consumption and does not lead to environmental pollution.

10 The textiles industry is a field of technical and industrial activity since the Renaissance period. The first industrial installations and specialised industrial equipment have been developed for textiles processing. The textiles industry consumes mainly cotton, which is not being produced in Central Europe, where industrial
15 equipment and installations were first developed. Hence, large capital intensive developments were necessary in the cotton-producing countries for the exploitation of the said raw material. Greece is among the cotton producers, indeed the major European producer. Among the European
20 Union countries, Greece is the country most depending on the cotton and yarn manufacturing industry, an industry requiring highly expensive industrial installations, often becoming problematic and economically unsound. With a production of 700,000 tons/year the problems in the industrial exploitation of this industrial agricultural product may reflect badly on the overall economic performance of the Country.

25 The exploitation of cotton for yarn production is developed along the following series of processes:

- a) Mechanical purification and arrangement of yarns, where in more than 10 different equipment of a high capital and operating cost are used.

b) Chemical purification by mercerising and scouring, where highly expensive installations are used, and where an alkaline effluent, difficult to handle, is released.

5 c) Yarn dyeing, where large volumes of water are consumed, and where coloured effluents are released.

Thus, the cotton yarn production and the cotton fabric production involve complex processes involving high production costs, a high consumption of water and the release of toxic and other harmful pollutants.

10 The inventor has been intensively involved in Research and Development work aiming at the reduction of production costs and of water consumption and at the elimination of environmental pollution, for the reduction of the overall cost of yarn and fabric production from cotton.

15 It was observed that the utilisation of devices for cotton accommodation by lap and yarn formation is not possible, as wet processes follow the yarn production process.

20 It was also observed that cotton can be directly introduced into a wet process, as its presence in an aqueous environment will induce fibre orientation. Should this be combined with cotton purification by rendering it hydrophilic to some desirable extent, the process will be complete and cotton will assume a form convenient for spinning, which will not be prone to agglomeration.

25 It was also observed that this production process leads to yarn and fabric production at a reduced cost, involving a smaller water consumption and the elimination of environmental pollution problems. This production process will also lead to higher quality - lower cost cotton yarn and fabrics.

This invention refers to and describes a method for yarn and fabric production featuring the above advantages leading to cotton yarn production (and subsequently cotton fabric production) in an overall production process free of environmental pollution, which involves
5 generation of heat in the form of biogas produced by the anaerobic digestion in the thermophilic region of the waste material and refuse produced. Thus, this production process constitutes a clean production technology which is self-sufficient in terms of its energy requirements.

According to this invention, the cotton which is received in
10 packages is passed to a tank filled with water containing calcium oxide at a ratio of 2-4% by weight of cotton. It also contains an ionic detergent at a quantity of 2-5 gr./ litre of process water. The cotton is suspended in excess water in the order 1-10 or 1-20 weight/volume. The cotton is carried in a polypropylene net and heated to a temperature
15 of 60 to 150 °C, (preferably 60-80 °C) with raw heating steam and being continuous agitated for a time period of 1-3 hours. Following its heating, it is lifted by a crane and is carried to a unit comprising of a series of horizontal presses where it is compressed to 20 atm. with simultaneous water removal. The compressed cotton is washed in water
20 which originates from the decoloration unit downstream and is then conveyed to the decoloration unit, where it is bleached in the presence of 10% ClO₂, or 10% hydrogen peroxide or 5% ozone solution. Following a two-stage processing, the cotton is received at a high degree of whiteness, in the order of 85-90 degrees lovipont. The effluent water
25 from the bleaching process is used for washing the cotton in the presses.

Thus a high purity cotton of 80-90 degrees lovipont and of controlled hydrophilic properties (absorptivity of 5-20 gr. water/ gr. cotton) is produced, featuring a water absorption rate of 0.5 - 1.5 gr.
30 water/ gr. cotton/ minute. The hydrophilic nature of the final product depends on the duration and conditions of processing with calcium and detergent. The results of this process are summarised in Tables 1 and 2.

Table 1 Processing Conditions

		Ca(OH) ₂ gr./ $\frac{1}{2}$	Levapon gr./lit	Temperature °C	Time mins
5	1	0.00	0.4	75	120
	2	0.00	3.8	75	120
	3	4.00	0.4	75	120
	4	4.00	0.8	75	120
	5	4.00	1.1	75	120
10	6	4.00	1.6	75	120
	7	4.00	2.5	75	120
	8	4.00	3.8	75	120
	9	4.00	0.4	60	120
	10	4.00	2.5	60	120
15	11	4.00	2.5	60	360
	12	4.00	0.4	75	360
	13	4.00	3.8	75	360
	14	4.00	0.4	135	360
	15	4.00	3.8	135	360
20	16	2.00	2.1	60	240
	17	2.00	2.1	105	240
	18	2.00	2.1	105	240
	19	2.00	2.1	75	240
	20	2.00	2.1	105	120

Table 2

Results

		Hydrophilic properties	Absorption Ratio	Yield %
5	1	6.53	0.02	88.3
	2	8.10	0.20	86.4
	3	10.48	0.55	87.8
	4	13.5	0.6	86.6
	5	15.5	0.72	85.8
10	6	17.5	0.81	85.2
	7	19.5	0.9	84.8
	8	17.32	0.94	85.2
	9	13.20	1.08	87.3
	10	18.14	1.12	84.2
15	11	16.31	1.29	83.3
	12	11.26	0.7	85.5
	13	12.00	1.8	84.8
	14	10.05	0.71	85.7
	15	17.84	1.71	83.7
20	16	17.20	1.45	87.4
	17	17.99	0.96	86.8
	18	17.53	0.91	87.1
	19	17.28	0.98	86.3
	20	17.84	0.91	84.11

From the results of the above Tables it is shown that the principal parameters of cotton purification and of rendering the material hydrophilic is the quantities of detergent and calcium hydroxide added. Rising the temperature has a small effect on the technological characteristics of the product and leads to a decrease of the yield. The detergent particularly, is of a non ionic nature (Levapon was found to be the most suitable material as it has a high activity). Calcium addition is also important. Optimum conditions hence are: a temperature in the order of 60 - 80 °C, a ratio of cotton to process water in the order of 1/15 to 1/20, an addition of calcium hydroxide at a ratio of 2-4 % w/w and of Levapon at a ratio of 0.2 - 4 gr./ lt. of process solution.

Then, the cotton is dried by conventional methods, i.e. in drying towers with rising hot air, whereas the cotton is mercerised to the desired degree of purification. It is then subject to spinning processes resulting in higher quality yarns for dyeing or weaving.

The process and cleaning water streams which carry chemicals and heat, as well as the resulting solid waste stream, are continuously recycled with a substitution of 10-20% of the quantity of the process water. The waste stream removed has a constant BOD load of 20,000 - 40,000 and COD of 50,000 - 100,000. It is passed to the installations for anaerobic digestion which operate in the thermophilic region in a BIOMET PROCESS unit (invented and demonstrated by the inventor) with a yield in biogas (containing methane in the order of 85%) of 0.5 cu.meters / kg of organic matter degraded. The effluent water produced, following the anaerobic digestion, can be used as process water and is finally subject to aerobic biological treatment to effluent water of BOD 100.

The above method constitutes an original approach towards cotton processing for yarn production, introducing an innovation both in terms of the process used and of the results obtained. It offers innovative operation, it constitutes a clean technology and it operates with energy self-sufficiency without causing environmental pollution.

In general the invention introduces maximum economy in the processing of cotton for yarn production, reducing the cost of installations, as the cotton can be sorted in terms of quality and length of fibre and as it will be subject to a simple treatment which will not lead to the reduction of the strength of the cellulosic mass. The cotton will be delivered at an advanced degree of processing. Finally, following treatment by the method proposed by this invention, high quality yarns will be produced, as the cotton will have been purified and rendered hydrophilic, according to the exploitation requirements. This process results in a high quality product and substitutes the mercerising process. All these quality and economy - related features are combined with the need for simple and low- cost installations operating free of environmental pollution.

EXAMPLE NO 1

10 kg of cotton carried in a polypropylene net are brought into an 1 cu.m. capacity tank containing 200 lt. of water, 0.4 kg calcium hydroxide and 2.5 gr./lt. Levapon. The contents of the tank are heated
5 to a temperature of 75°C. Heating with continuous agitation of cotton lasts for three hours. Then, the net is lifted by a crane and passed to a horizontal press where it is compressed by the application of a pressure of 20 atm. with simultaneous water removal. The resulting cotton product contains moisture at 20%. It is then washed with water
10 from the bleaching process and then transferred, always in the net, to a decolorisation unit containing a 20% H₂O₂ or a 20% ClO₂ solution. It is then subject to two - stage bleaching at installations similar to those for bleaching paper - pulp. Finally, a degree of bleaching (whitening) of 86 degrees lovipont is achieved with a yield of 86.4%. The product
15 did not show any difference in its mechanical properties, it has hydrophilic properties expressed as absopitivity of 17.10 gr. water / gr. cotton and a rate of water absorption of 0.81 gr. water / gr. cotton / minute.

The process water was recycled by substituting 20% of it by fresh
20 processing solution. The pollutant load was stabilised at 22,000 BOD and 48,000 COD. Thus, the steady state consumption of chemicals can be reduced to 20% of the chemicals originally present in the tank per unit cotton produced, i.e. 0.8 kg calcium hydroxide / 100 kg cotton and 0.5 gr. detergent / lt. water.

25

EXAMPLE NO 2

10 kg of cotton carried in a polypropylene net are brought into a tank containing 150 lt. of water, calcium hydroxide at a ratio of 2% by weight of cotton and 2.1 gr. of Levapon / litre of solution. The contents of the tank are heated by raw steam to a temperature of 60°C for three hours. The material is then compressed and bleached as in Example No 1. The product did not show any difference in its mechanical properties, it has hydrophilic properties expressed as an absorptivity of 18.280 gr. water / gr. cotton and a rate of water absorption of 0.98 gr. water / gr. cotton / minute. The process water was recycled by substituting 20% of it by fresh processing solution. Thus, actual chemicals consumption is 0.4 kg calcium hydroxide / 100 kg cotton and 0.41 gr. Levapon / lt. water.

EXAMPLE No 3

In an enclosure of a capacity of 1 cubic meter, 20 kg of cotton in a polypropylene net and 300 lit. of water containing 0.8 kg calcium hydroxide and 2.5 gr. Levapon / litre are placed. The total enclosure is heated at 135°C for two hours. The cotton is removed and compressed in a horizontal press by the exertion of a pressure of 20 atm., reaching a moisture content of 20%. It is then washed and bleached in a two - stage process as per the Examples No 1 and 2. The following product is finally collected:

10 Experiment a:

Yield 85.7%; hydrophilic properties expressed as an absorptivity of 15.04 gr. water / gr. cotton; rate of water absorption 0.71 gr. water / gr. cotton / minute

Experiment b:

15 Yield 85.2%; hydrophilic properties expressed as an absorptivity of 15.82 gr. water / gr. cotton; rate of water absorption 0.82 gr. water / gr. cotton / minute

The process water was recycled by substituting 20% of it by fresh processing solution. Thus, actual chemicals consumption is 0.8 kg calcium hydroxide / 100 kg cotton and 0.5 gr. Levapon / lt. water.

EXAMPLE No 4

In an enclosure of a capacity of 0.5 cubic meter, 15 kg of cotton in a polypropylene net and 300 lit. water containing 0.3 kg calcium hydroxide and 2.1 gr. Levapon / litre are placed. The total enclosure is
5 heated at 105°C for four hours. Following the cleaning and bleaching processes explained in examples 1 - 3, the cotton is received at a yield of 86.8% and has the following properties: hydrophilic properties expressed as an absortivity of 17.99 gr. water / gr. cotton; rate of water absorpion 0.96 gr. water / gr. cotton / minute

10

EXAMPLE No 5

The effluent water replaced by fresh processing solution has an environmental load of 30,000 BOD and 50,000 COD. It is fed to an installation of anaerobic digestion, operating in the thermophilic region and producing 0.47 kg of biogas (containing 85% methane) / COD
15 reduced. This is equivalent to a degree of pollution reduction of 85 - 88%. Part of the effluent water stream from the anaerobic digestion treatment is recycled into the process water, the rest being further processed at aerobic biological treatment installations for the production of water stream of BOD 100 which can be safely rejected to
20 the environment.

The biogas produced is used for the production of the steam used for the processing of cotton. Indeed, in the same as for the process water which is recycled to a degree of 60-80%, the energy requirements for heating the cotton are also reduced. 60 - 70% of the biogas produced
25 can be used for electricity generation for the needs of the plant. This will depend on the size and the design of the plant.

CLAIMS

1. A method for cotton spinning where the cotton is subject to a purification process in water, by rendering it hydrophilic in a controlled manner in industrial installations operating with energy self sufficiency and without any environmental pollution.
- 5
2. A method according to claim 1, where the cotton is rendered hydrophilic in a controlled manner following treatment by heating at 60 - 150 OC, in the presence of an aqueous solution at a ratio of 15 - 20 w/w solution/cotton, containing calcium hydroxide at a ratio of 2-4 % w/w calcium / cotton and a non ionic detergent acting as wetting agent at a ratio of 0.4 - 4 gr. detergent / lit. water. Following this treatment, cotton has a water absorptivity of 10 - 20 gr. water / gr. cotton.
- 10
3. A method according to claims 1 and 2, where, apart from being rendered hydrophilic in a controlled manner, the cotton also achieves a controlled rate of water absorption in the order of 0.3 - 1.4 gr. water. gr. cotton / minute.
- 15
4. A method according to claim 1, where the processing solution is recycled by substituting 20 - 40% of it with fresh processing solution. Thus, the water effluent stream has a uniform environmental load and maximum savings in chemicals and energy is achieved. The effluent water stream has an environmental load of 20,000 - 40,00 BOD and 50,000 - 100,000 COD, depending on the design of the unit.
- 20
- 25

5. A method according to claims 1, 2 and 4, where the effluent water with the uniform environmental load is subject to an anaerobic digestion treatment in the thermophilic region releasing biogas (containing 85% methane) at a rate of 0.47 - 0.47 kg biogas / kg COD reduced. The biogas generated is used for covering the needs in thermal and electric energy of the industrial unit. Following further processing by aerobic biological treatment, the effluent water from the anaerobic digestion process reaches an environmental load of 100 BOD and can be safely rejected.
6. A method according to claims 1,2 and 3, where the complex installations and devices for the accommodation of cotton and lap and yarn production, as well as the mercerising equipment are not needed as the complete purification of cotton by mercerising is achieved by a simple treatment in water.
7. A method according to claims 1,2 and 3, where high quality yarns at different levels of purity and mercerising quality are achieved. The other mechanical and physical properties of the cellulosic mass of the cotton are not adversely affected in any way.
8. A method according to claims 1,2 and 3, where the cotton is processed in the water solution enclosed in a polypropylene (or other suitable fibre) net. The cotton remains in net throughout the process involving pressing for removal of the adsorbed water, washing, two - stage bleaching for decolorisation. Following this process cotton is received at a high degree of whiteness of about 85 - 90 degrees lovipont.

9. A method according to claims 1,2 and 3, where the purified, mercerised and bleached cotton is spinned to produced high quality yarns for weaving or dyeing.
10. A method according to claims 1 - 9 where the cotton is subject to a purification and mercerisation process in water, at a ratio of 10-20 volumes of water / weight cotton, at temperatures in the range of 60 - 150 °C. The process solution contains calcium hydroxide at a ratio of 2 - 4 % w/w calcium / cotton and a non-ionic detergent wetting agent at a ratio of 0.3 - 4 gr. agent / lt. water. Following wet treatment, the cotton is compressed in a horizontal press by applying a pressure of 20 at. with simultaneous removal of the adsorbed processing solution. It is then washed and bleached with hydrogen peroxide or ClO₂ in a two - stages process, leading to a product of a lovipont grade of 85 - 90. It is then dried according to specifications. The process water is recycled at a ratio of 60-80%, achieving savings in chemicals and thermal energy. The effluent water has a uniform environmental load of 20,000 - 40,000 BOD and 40,000 - 100,000 COD, according to the design. The effluent water stream is processed by anaerobic digestion in the thermophilic region for the production of biogas containing 85% methane at a rate of 0.45 - 0.5 kg biogas / kg COD reduced. The effluent water from the anaerobic digestion process is further processed by aerobic biological treatment until it reaches an environmental load of 100 BOD. It can then be either recycled or rejected. Finally, a high purity cotton is produced with a water absorptivity of 5 - 20 kg water / kg cotton and a rate of water adsorption of 0.3 - 1.2 kg water / kg cotton / minute. This cotton can be dried according to specifications and be spinned for the production of quality cotton yarns suitable for weaving quality fabrics or for dyeing. The overall process achieves energy self - sufficiency and does not cause any environmental damage.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 D01C D06M

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	BE-A-434 058 (A. FURTH) 31 May 1939 see the whole document ---	1-10
Y	EP-A-0 474 895 (WABAG WASSERTECHNISCHE ANLAGEN) 18 March 1992 see the whole document -----	1-10

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 NL - 2280 HV Rijswijk
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Authorized officer

Tarrida Torrell, J

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