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(54) **SYSTEM FOR INDUSTRIAL YARN PRODUCTION FROM COMPOSITE POLYETHYLENE NAPHTHALATE MATERIAL**

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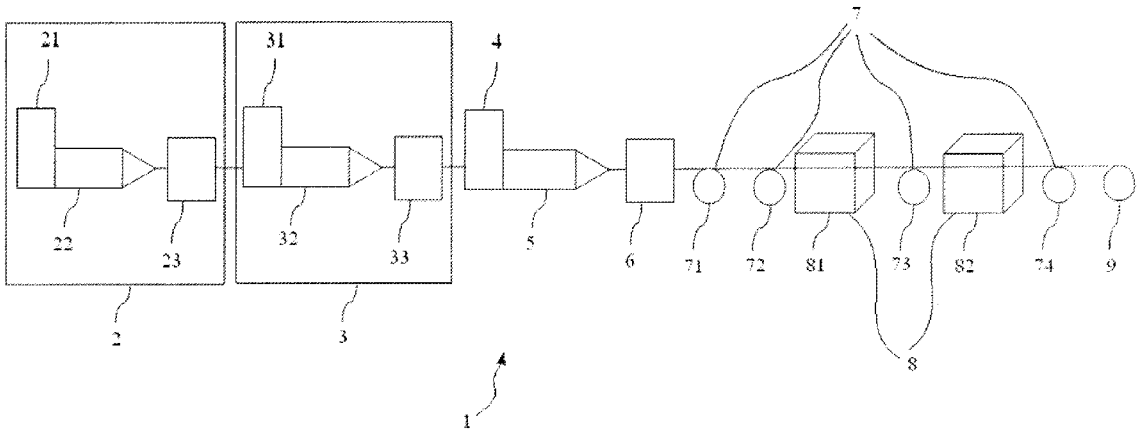
(57) **ABSTRACT**

The present invention relates to a system for industrial polyester yarn production in order to be used in industrial fabric production wherein polyethylene naphthalate (PEN) material is used mixing with liquid crystal polymer material and thus the tenacity, elastic modulus and dimensional stability of the obtained material is improved.



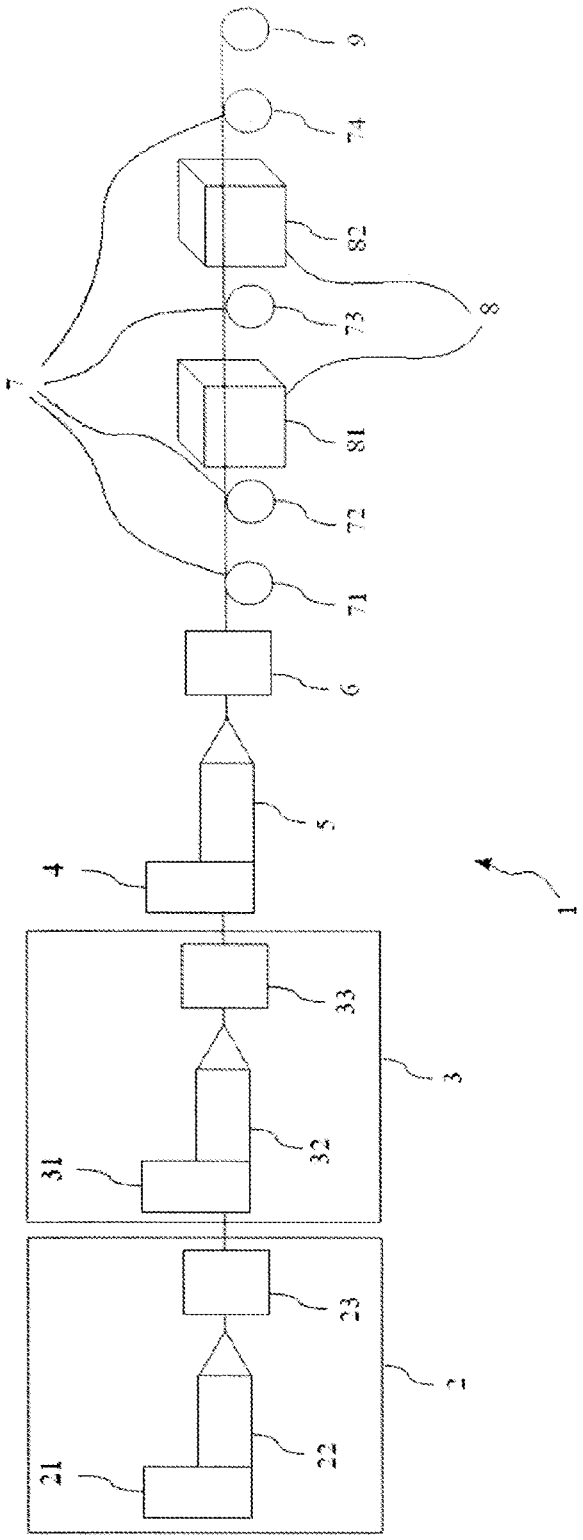


Figure 1

SYSTEM FOR INDUSTRIAL YARN PRODUCTION FROM COMPOSITE POLYETHYLENE NAPHTHALATE MATERIAL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the national phase entry of International Application No PCT/TR2015/000117, filed on Mar. 25, 2015, which is based upon and claims priority to TR2014/03779, filed on Apr. 1, 2014, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates a system for industrial polyester yarn production, in which the mechanical properties of the yarn (tenacity, modulus, dimensional stability) are improved with additive, in order to be used in industrial fabric production.

BACKGROUND OF THE INVENTION

[0003] Improved mechanical properties and a strong structure are required in conveyor band chafer, membrane and coating fabrics. For such embodiments, processes should be improved without increasing the cost that much, and the resultant fiber should provide. high modulus and better dimensional stability compared to the reference. For this reason, studies have been carried out to produce self-reinforced composite PEN yarns.

[0004] Liquid Crystal Polymers (LCP), which can be used as reinforcing phase in different polymeric materials, are high performance resins with a unique structure comprising long, hard, rod like high oriented molecules. Rod-like molecules orient themselves in the flow direction during injection or extrusion molding.

[0005] The parts molded in LCP exhibit very high dimensional stability even if they are heated up to 200-250° C. Melting temperature of some LCP classes can reach up to 300° C. LCP can generally be used as an additive in many fields depending on its properties. Electronic and electrical components, fuel and gas barrier structures and sensors can be given as example for these fields.

SUMMARY OF THE INVENTION

[0006] The objective of the present invention is to provide a system for liquid crystal polymer added industrial polyester yarn production.

[0007] Another objective of the present invention is to provide a system for industrial yarn production wherein polyethylene naphthalate is used as polymer.

[0008] A further objective of the present invention is to provide a system for industrial yarn production with improved tensile strength and elastic modulus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A system for industrial yarn production with LCP added polyethylene naphthalate developed to fulfill the objectives of the present invention is illustrated in the accompanying figure, wherein

[0010] FIG. **1** is the schematic view of the inventive system for yarn production.

[0011] The components shown in FIG. **1** are each given with reference numerals as follows:

- [0012] **10**. System for industrial yarn production
- [0013] **11**. Raw mixture forming unit
  - [0014] **21**. Raw particle loading unit
  - [0015] **22**. Raw molten extruder
    - [0016] **23**. Raw molten cooling unit
  - [0017] **12**. Primary mixture forming unit
  - [0018] **31**. Particle loading and diluting unit
  - [0019] **32**. Primary molten extruder
    - [0020] **33**. Primary molten cooling unit
- [0021] **13**. Primary particle loading unit
- [0022] **14**. Extruder
- [0023] **15**. Cooling unit
- [0024] **16**. Roller
  - [0025] **71** Primary roller
  - [0026] **72**. Secondary roller
  - [0027] **73**. Tertiary roller
  - [0028] **74**. Quaternary roller
- [0029] **17**. Hot chamber
  - [0030] **81** First hot chamber
  - [0031] **82**. Second hot chamber
- [0032] **18**. Winding unit

DETAILED DESCRIPTION OF THE INVENTION

[0033] The inventive system for composite polyethylene naphthalate industrial yarn production system (**1**) essentially comprises

- [0034] at least one raw mixture forming unit (**2**) wherein the raw polymer particles. are prepared,
- [0035] at least one primary mixture forming unit (**3**) wherein the primary polymer mixture is obtained diluting the raw polymer mixture with the main polymer ,
- [0036] at least one primary particle loading unit (**4**) wherein the polymer particles forming the primary mixture are filled and heated,
- [0037] at least one extruder (**5**) wherein the primary polymer mixture obtained in primary particle loading unit (**4**) is melted and spun as filaments with the help of the spinneret located at the exit,
- [0038] at least one cooling unit (**6**) wherein the material coming from ext (**5**) is cooled,
- [0039] at least one roller (**7**) wherein the material is drawn and oriented.
- [0040] at least one hot chamber (**8**) wherein the material is annealed,
- [0041] at least one winding unit (**9**) wherein the material is drawn via rollers (**7**) by cooling and heating is wound as yarn.

[0042] Raw mixture forming unit (**1**) present in inventive system (**1**) comprises

- [0043] at least one raw particle loading unit (**21**) wherein polyethylene naphthalate (PEN) and liquid crystal polymer (LCP) are mixed,
- [0044] at least one raw molten extruder (**22**) wherein the raw molten mixture is extruded,
- [0045] at least one raw molten cooling unit (**23**) wherein the material going out of raw molten extruder (**22**) is cooled.

[0046] In the preferred embodiment of inventive system (**1**), PEN:LCP ratio of the mixture prepared in raw particle loading unit (**21**) is 60:40 by weight. The raw material which

is prepared in this ratio and solidified in cooling unit (**23** melted and blended in twin screw extruder (**22**) is become as particles.

[0047] Primary mixture forming unit (**3**) comprises

[0048] at least one particle loading and diluting unit (**31**) wherein the polymer particles coining from raw mixture forming unit (**2**) are melted and diluted with PEN,

[0049] at least one primary molten extruder (**32**) wherein the primary raw molten mixture is extruded,

[0050] at least one primary molten cooling unit (**33**) wherein the material going out of main molten extruder (**32**) is cooled.

[0051] The raw mixture particles prepared in raw mixture forming unit (**2**) are sent to primary molten forming unit (**3**), and the polymer particles diluted with pure PEN are produced here. The PEN:LCP raw mixture is mixed with PEN till the LCP ratio becomes 1-3% by weight in particle loading and diluting unit (**31**). At the process is preferably carried out at 260-300° C.

[0052] In one embodiment of the invention, the molecular weight of the blended polymer particles that are obtained are increased at the outlet of primary mixture forming unit (**3**), and their internal viscosity (IV) is increased above 1 dL/g at 240-250° C. with solid state polymerization, which takes 12-24 hours. The purpose here is to increase molecular weight to obtain a polymer suitable for yarn drawing by decreasing the degradation and chain movement dining extrusion. %Clystallinity increase is above 100% with solid state polymerization.

[0053] In one embodiment of the invention, the particles obtained at primary mixture forming unit (**3**) with increased IV via solid state polymerization are dried in vacuum furnace for at least 24 hours at 120-140° C., and loaded to primary particle loading unit (**4**) under nitrogen atmosphere at 120° C. In order to prevent hydrolytic degradation, the humidity value of the blended and solid state polymerized particles should be under 60 ppm before loading to extruder (**32**).

[0054] The primary polymer mixture coming out of primary mixture forming unit (**3**) is transferred to primary particle loading unit (**4**), and dried here at 100-120° C. and sent to extruder (**5**) which is heated to 290-320° C. PEN-LCP polymer mixture comprising 1-3% LCP by weight is become filaments via spinneret at the exit of extruder (**5**). In the preferred embodiment of the invention, the length/diameter ratio of the spinneret used at extruder exit (**5**) is 2-5, the hole diameter is 1 mm. The jet velocity of the material from extruder (**5**) is 6-7 m/min, the residence time of the material in the extruder is 11-12 minutes. The throughput here is adjusted as 6-7 g/min.

[0055] The PEN-LCP filament coining out of extruder (**5**) is transferred to cooling unit (**6**) preferably treated with cooling water. In one embodiment of the invention, the length of the cooling unit is 70 cm and its temperature is 80-95° C. In the same embodiment of the invention, the distance between extruder (**5**) and cooling unit (**6**) is adjusted as maximum 10 cm. The yarn coining out of cooling unit (**6**) first comes to primary roller (**71**) and it is sent to secondary roller (**72**) from here. In the preferred embodiment of the invention the temperature of primary roller (**71**) is between 100-140° C., and the temperature of secondary roller (**72**) is between 140-160° C. Cold drawing process is applied on the yarn between these rollers (**7**).

[0056] The yarn coming out of secondary roller (**72**) is transferred to first hot chamber (**81**) and heated with hot air to 200-250° C. here and then transferred to tertiary roller (**73**). The temperature of tertiary roller (**73**) may vary between 200-250° C. Therefore, hot drawing is performed between secondary roller (**72**) and tertiary roller (**73**).

[0057] The yarn coming out of tertiary roller (**73**) enters into second hot chamber (**82**) at temperature of 120-180° C. It comes to quaternary roller (**74**) which is the last roller without heating, at room temperature; here it is relaxed in ratio of 1-2% and sent to winding unit (**9**) in order to be wound.

[0058] In the preferred embodiment of the invention, the ratio of primary roller (**71**) speed to extruder (**5**) exiting speed is between 4-6. The ratio of tertiary roller (**73**) speed to—primary roller (**71**) speed may vary between 5-6,5.

[0059] When the tenacity and elastic modulus of LCP added PEN yarn in ratio of 1-3% obtained using inventive system (**1**) and the yarn manufactured from. pure PEN material with the total draw ratio of 6 are compared; the tenacity of the composite yarn produced in the inventive system has increased by 40-45%, and its elastic modulus has increased by 5-10%. When the total draw ratio is more than 6 the tenacity increase is between 25-30%, the elastic modulus improves by 2-5%. When the dimensional stability is considered, the dimensional stability of the 1-3% LCP added PEN yarn is 15-25% better than the pure PEN yarn in 6 drawing ratio.

[0060] The conversion ratio is in range of 80-90% when the monofilament yarn which is produced with the inventive system is twisted as 2 layers with 50 twists.

What is claimed is:

1. A system for industrial yarn production from composite polyethylene naphthalate material comprising:

at least one raw mixture forming unit wherein the raw polymer particles are prepared,

at least one primary mixture forming unit wherein the primary polymer mixture is obtained and become particles by using raw polymer particles,

at least one primary particle loading unit wherein the polymer particles forming the primary mixture are filled and heated,

at least one extruder wherein the primary polymer mixture obtained in primary particle loading unit are melted and become filaments with the help of the spinneret located at the exit,

at least one cooling unit wherein the material coining from the extruder is cooled,

at least one roller wherein the material is drawn and oriented,

at least one hot chamber wherein the material is annealed,

at least one winding unit wherein the material is drawn via the rollers by cooling and heating is wound as yarn, wherein

polyethylene naphthalate (PEN) and the liquid crystal polymer (LCP) are mixed in ratio of 60:40 respectively in raw mixture forming unit, and

The LCP ratio in the mixture is decreased to 1-3% by weight by diluting the raw mixture with PEN in primary mixture forming unit.

2. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein raw mixture forming unit which has at least one raw particle loading unit wherein the polyethylene naphtha-

late (PEN) and the liquid crystal polymer (LCP) is mixed by loading in ratio of 60:40 by weight respectively, at least one raw molten extruder wherein raw mixture is melted and extruded; at least one raw molten cooling unit wherein the material coming out of the raw molten extruder is cooled.

3. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the primary mixture forming unit which has at least one particle loading and diluting unit wherein the polymer particles coming from the raw mixture forming unit are melted and diluted with PEN such that the LCP ratio will be 1-3% by weight; at least one primary molten extruder wherein the primary raw molten mixture is extruded, at least one primary molten cooling unit wherein the material going out of the main molten extruder is cooled.

4. The system for industrial yam production from composite polyethylene naphthalate material according to claim **1**, wherein the particle loading and diluting unit wherein PEN is added until the LCP ratio in the mixture is 1-3% by weight the raw PEN-LCP mixture is extruded at 260-300° C.

5. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the primary particle loading unit wherein the particles obtained at. the primary mixture forming unit outlet are loaded at nitrogen atmosphere at 120° C. after being dried in vacuum furnace for at least 24 hours at 120-140° C.

6. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the extruder (**5**) wherein the primary polymer mixture is become filament, and which has a spinneret with length/diameter ratio of 2-5 and the hole diameter is 1 mm.

7. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the extruder wherein the jet velocity of the polymer mixture as filament is 6-7 m/min.

8. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the extruder wherein the throughput of the polymer mixture as filament is adjusted as 6-7 g/min.

9. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the cooling unit wherein the filament coming out of the extruder is cooled with cooling water at 80-95° C.

10. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the primary roller to which the filament coming out of the cooling unit is transferred, at temperature of 100-140° C.

11. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the secondary roller at temperature of 140-160° C. to which the filament coming out of the primary roller is transferred and wherein cold drawing is applied on the filament,

12. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the first hot chamber to which the filament coining out of the secondary roller is transferred and in which it is used with hot air at temperature of 200-250° C.

13. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the tertiary roller at temperature of 200-250° C. to which the filament coining out of the first hot chamber) is transferred and wherein hot drawing is applied on the filament.

14. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the second hot chamber at temperature of 120-180° C. to which the filament coming out of tertiary roller is transferred.

15. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the quaternary roller without heating to which the filament coining out of the second hot chamber—is transferred and wherein hot drawing is applied on the filament.

16. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **1**, wherein the winding unit wherein the filament coming out of the tertiary cylinder is wound as yarn by relaxing 1-2%.

17. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **2**, wherein the primary mixture forming unit which has at least one particle loading and diluting unit wherein the polymer particles coming from the raw mixture forming unit are melted and diluted with PEN such that the LCP ratio will be 1-3% by weight; at least one primary molten extruder wherein the primary raw molten mixture is extruded, at least one primary molten cooling unit wherein the material going out of the main molten extruder is cooled.

18. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **2**, wherein the particle loading and diluting unit wherein PEN is added until the LCP ratio in the mixture is 1-3% by weight the raw PEN-LCP mixture is extruded at 260-300° C.

19. The system for industrial yarn production from composite polyethylene naphthalate material according to claim **3**, wherein the particle loading and diluting unit wherein PEN is added until the LCP ratio in the mixture is 1-3, by weight the raw PEN-LCP mixture is extruded at 260-300° C.

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