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Effect of bio-friendly conditioning agents on jute fibre spinning

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ARTICLE INFO

Article history:
Received 11 April 2008
Received in revised form
24 May 2008
Accepted 25 May 2008

Keywords:
Aminosilicone
Enzyme
Jute
Fibre conditioning agent
Mineral oil
Process performance
Vegetable oil
Yarn properties

ABSTRACT

From early times, jute fibre has been generally conditioned for easy spinning by adding oil and water in the form of an emulsion. The commonly used oil consists of C_{12}–C_{31} fractions of mineral oil that sometimes impart different intensities of oily (kerosene) or fishy smell to the end product. In the present work, efforts have been made to find a suitable sustainable substitute of mineral oil based conditioning agent for spinning of jute yarn and for this, three types of vegetable oil (rice bran oil, palmolein oil and castor oil), a silicone emulsion, a mixed enzyme system and glycerine have been used separately or in combinations as conditioning agents for jute fibre before its mechanical processing for making yarn in jute spinning machines. Considering comparable mechanical process performance for spinning of jute fibre (*viz.*, fibre loss as droppings during processing, moisture retention prior to spinning stage and spinning end breakage rate), tensile properties of yarn, and lower yarn hairiness, it may be suggested to use 2.5% castor oil alone, or 2% castor oil in combination with 0.1–0.5% glycerine in the form of oil-in-water emulsion as the most suitable alternatives to conventional mineral oil-based jute conditioning agent to spin ordinary jute yarn.

1. Introduction

Jute fibre, a natural composite of cellulose, hemicellulose and lignin, occupies second place to cotton in economic importance. Jute is abundantly grown in Indian sub-continent, China and Thailand. The global production of jute, kenaf and allied fibres is presently around 3.3 million tonnes per year (2003–2004) (FAO, 2005). It is widely used for the manufacture of flexible packaging fabrics besides its prospective use as carpet backing, decorative fabrics and in some other fields. Some major plus points about jute are its agro-based, annually renewable and biodegradable nature and availability at a low cost. Reusability of bag/sack is another major advantage of jute. There is hardly any major use of chemical fertilizer and pesticides in jute cultivation, which ensures freedom of finished jute products from any residues of pesticides and heavy toxic metal. The jute fibre shows prominent stiffness and harshness properties, which offer hindrance to its smooth, trouble-free spinning for yarn making. The spinning problem is minimized partly by applying water and oil. So, jute fibre is essentially conditioned for easy spinning by adding oil and water in emulsion form. The water softens or plasticizes the fibre to some extent and increases its extensibility thus, making it easier for the fibre to bend round the pins and rollers of different machinery, reducing fibre breakages and losses. Oil serves as a good lubricant (Atkinson, 1965; Stout, 1988) and it also helps in partial retention of the added moisture (Chakrabarty and Sinha, 2001). In earlier days, whale oil and

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doi:10.1016/j.indcrop.2008.05.008

spermaceti oil (Bannerjee, 2003) were used but at the later days these oils have been replaced by petroleum. At present, commonly used oil is C_{12}–C_{31} fractions of mineral oil that sometimes impart different intensities of oily (kerosene) or fishy smell to the end product. The jute yarns are spun using up to 3% oil (Rahman, 2001; IS 13188, 2002). The main problem associated with use of mineral oil is that it may affect the taste and odour of items such as food grains, sugar, flour or tea, coffee/cocoa-beans, and tobacco packed in jute bags/sacks. Probability of some degree of contamination of residual oil with the packed items is also there. These problems may be reduced by finding out a suitable substitute for the relevant mineral oil as softening/lubricating agent. The dwindling fossil fuel sources, its tremendous price hike at regular intervals and the increasing dependency on imported crude have also led to a major interest in using vegetable (i.e., agro-renewable) and/or any bio-friendly substitute of conventional mineral oil. There are some reports in the literature on use of selected vegetable oils in place of mineral oil for conditioning of jute fibre before spinning (Basak et al., 1992; Ghosh et al., 1995; Basu and Sarkar, 1998), and on simultaneous application of a much lesser proportions of mineral oil along with a suitable softener during conditioning of the fibre (Chatterjee et al., 1961, 1966; Chakraborty et al., 1998; Ghosh et al., 1998) are available. Enzyme treatment is also known to improve the spinning quality of jute fibre (Ghosh and Dutta, 1980, 1983; Dutta et al., 2000; Chakrabarty and Sinha, 2001). But integrated study in the search of suitable alternative of hydrocarbon based conditioning agent for processing of jute fibre is rather scanty.

In this work, efforts have been made to find out a suitable substitute of mineral oil-based conditioning agent for spinning jute yarn. Selection of an alternative fibre conditioning mix (spinning additive) depends on a number of important factors; (i) it must have no harmful effect on either jute or the machines, (ii) no health hazards must be involved, (iii) there must be no danger of spontaneous combustion, (iv) it should not go rancid or sticky on standing, and (v) it must be cheap and in plentiful supply. At the same time it should have acceptable colour and odour (Atkinson, 1965). Keeping these conditions in mind, some selected additives, *viz.*, three types of vegetable oil (rice bran oil, palmolein oil and castor oil), a silicone emulsion, a mixed enzyme system and glycerine have been used separately, and in combinations as conditioning agents of jute fibre before its mechanical processing for making yarn in the present study. Process performance and yarn property parameters have been evaluated. Mineral oil based conventional oil has been used as control.

2. Materials and methods

2.1. Materials

Jute fibre is obtained from stems of plants (belongs to the botanical genus *Corchorus*) having interconnecting three-dimensional network holding the fibres each other until it is mechanically splitted. The fibre is extracted by a retting process, which involves steeping the stems in water to remove pectins and gummy materials by bacterial action. The fibre is then stripped from the woody core. Such raw jute strands of Tossa Daisee (*Corchorus olitorius Lin.*) variety (grade TD3) (IS 271, 1987) was taken for the present study from a single bale, so that variation in raw fibre quality can be avoided as far as possible.

Commercial grade hydrocarbon based mineral oil commonly referred to as jute batching oil (IS 1758, 1975), rice bran oil, palmolein oil, and castor oil were used separately for preparation of oil-in-water emulsion for application on jute fibre. A polyoxyethylene based non-ionic surfactant, was used as an emulsifier as per recommendation of Bureau of Indian Standards (IS 1758, 1975).

A commercial mixed enzyme preparation (Bio-cellulase, ZK) of cellulase (35 units/ml), xylanase (96 units/ml) and pectinase (136 units/ml) from Biocon India Limited was used. The pH of the solution was 4.8. A textile finish grade silicone emulsion of amino group containing polysiloxane, popularly known as aminosilicone, from L.N. Chemicals, India was used. Aminosilicone content in the emulsion was 32%. Industrial grade glycerine (purity 95%) used was procured from the local market. Trichloroethylene supplied by E. Merck, India, was used as solvent for estimation of residual oil in yarn samples. Some important characteristics of the selected oils, chemical and biochemical are given in Table 1.

Table 1 – Some important characteristics of the spinning additives

Type	Source and quality	Density (g/cm^3)	Colour	Odour
Jute batching oil	Hydrocarbon based mineral oil (C_{12}–C_{31} fraction) conventionally used as conditioning agent for jute fibre	0.82	Light brown	Kerosene
Rice bran oil	Vegetable oil-unpurified	0.90	Dark brown	Typical oily smell
Castor oil	Vegetable oil-industrial quality	0.93	Yellowish	Almost odourless
Palmolein oil	Vegetable oil—edible quality (Olein fraction of crude palm oil-refined, and bleached)	0.90	Yellowish	Light oily smell
Aminosilicone	Available as textile grade aqueous based aminosilicone emulsion (aminosilicone content 32%)	–	Brownish (after dehydration)	Odourless
Enzyme	Mixed enzyme system of cellulase (35 units/ml), xylanase (96 units/ml) and pectinase (136 units/ml)	–	Brown	Odourless
Glycerine	Industrial grade—purity 95%	1.27	Colourless	Odourless