ADAPTATION OF RING SPINNING IN THE FLYER SPINNING MACHINE FOR MAKING FINE JUTE YARN

By

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RECOMMENDATION OF THE BOARD OF EXAMINERS

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ABSTRACT

The existing Apron Draft Flyer spinning machine has been modified by adapting ring system at its delivery end for making fine jute yarn. In the experiment, the flyer system of the machine has been removed by introducing rings and travellers. Fine jute yarn upto 3 count (103.5 tex) can be produced by the modified machine. The speed of the spindles has been increased upto 8000 rpm from its original flyer speed 4250 rpm. Fine yarn of 3 count was spun by this modified machine. Bangla Tossa B (BTB) and Bangla White C (BWC) jute fibre were used for making this fine yarn. Spinning performance of the machine was satisfactory. The properties of produced fine yarn, such as elongation, strain, tenacity, textile modulus, quality ratio, spinning breakage and load at break were determined by a computerized Universal Testing Machine. It was compared with the yarn produced by spin gard (gardella) spinning machine which produces fine jute yarn. From the comparison it was observed that fine yarn produced from modified machine is comparable to the yarns produced by standard spin gard machine. The different jute mills of jute growing countries will be able to produce fine jute yarn by making similar modification.

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GLOSSARY

Bobbin	A piece of wood cylindrical shape, whose centre is hollow and where yarn winding on.
Bobbin Carrier	Who carries the bobbin in proper position in flyer spinning system.
BTB	Bangla Tossa B (Jute Grade)
BWC	Bangla White C (Jute Grade)
Count	$\frac{\text{Weight in lbs}}{\text{14400 Yards of Yarn}}$
Draft	$\frac{\text{Weight of input sliver per unit length}}{\text{Weight of output yarn per unit length}}$
Draft Constant	Number of teeth in draft pinion x draft
Flyer	Rotate at high speed and insert twist in the yarn.
Gauge Length	The length of sampe yarn for test purpose.
Linear Density	Weight of yarn per unit length (normally expressed as Tex)
Load at Break	The amount of applied load when yarn breaks
Load Cell	A transducer which assess the load applied on yarns by load frame. It passes the message of amount of load to the computer.
Load Frame	The frame where load is applied on the yarn.
Quality Ratio	$\frac{\text{Load at break in lb}}{\text{Count of yarn}}$
Ring	Round in shape and made of steel, traveller rotates on the ring.
Spindle	Who carried the bobbin in ring spinning system.
Spinning Tension	Tension developed in the yarn during spinning between the bobbin surface and the drafting nip
Strain	$\frac{\text{Elongation}}{\text{Initial length}}$
Tenacity	The tenacity of a material is the mass stress at break. where, mass stress = Force applied/Linear density
Tex	$\frac{\text{Weight in Grams}}{\text{1000 meters of Yarn}}$

Textile Modulus	A number of quantities related to the shape of the tensile stress-strain curve is the Textile modulus, which is equal to the slope of the stress-strain curve. Slope at the origin called initial modulus. An easily extensible fibre will have a low modulus.
Traveller	Made of steel and rotates on the ring at high speed.
Twist	Twist is the measure of the spiral turns given to a yarn in order to hold the constituent fibres or threads together

CHAPTER - 1
INTRODUCTION

Jute is a natural cellulosic bast fibre. It is bio-degradable and friendly to environment. Due to its spinnable characteristics it may be used as textile fibre. There are two different types of textile fibres. These are classified into two main groups: synthetic and natural. Presently production of synthetic fibres are increasing sharply due to its favourable characterisitcs. At the moment fine yarn of jute can partially replace the use of synthetics. In this regard it is essential to modify the existing flyer spinning machine which can be able to produce fine jute yarn.

Now-a-days main competitor of Jute fibres is artificial fibres. Jute growing countries are trying to use the jute fibre in various diversified ways. So the country is trying to find out the various possibilities of its uses. Bangladesh Jute Research Institute (BJRI) is engaged to carryout the research activities on jute and its products. At present technological research on jute is very essential. In this regard production of fine yarn ($\leq$ 3 count) of jute is very much important for its diversified usages. Presently conventional jute processing system is able to produces yarn of $\geq$ 5 count but some sophisticated machine are able to produce (Gardella spinning machine) fine yarn like 2 or 3 count but the price of this is exorbitantly high (price of a single machine is about Tk. 3 crore).

At first a British company James & Mackie, Ireland introduce jute machinery at their own interest when they ruled the indo-pak subcontinent. They are not trying to develop its processing system because jute is not grown in their country, on the other hand western Europe has been carrying an extensive research on synthetic fibres. So scientists of jute producing countries are trying to develop or modify the existing conventional machines for producing fine yarn. In this regard this investigation will be done and expected its suitability to produce fine yarn.

1.1 JUTE FIBRE

The commercial jute fibre is obtained from two kinds of jute plant known as Corchorus Capsularis and Corchorus Olitorius respectively.

<u>Corchorus Capsularis:</u> The Jute plant of this variety is annual and grown from seeds. The stem is straight, smooth and cylindrical it branches near the top, is about 2 m to 4 m long and 1 cm to 2 cm in diameter. The leaves are thin and light green in colour with serrated edges. The plant flowers in the monsoon season and the fruits ripen in September and October. Fibres from this variety are known as white jute in the grade.[20]

Corchorus Olitorius: The jute plant of this variety is also annual, grows from seed and is similar to capsularis variety. The leaves are lovely green in colour and not so bitter to taste. The bark of the stem tends to be purple in colour. The flowers are larger and deeper yellow in colour than those of the Capsularis variety. The seed pot are long and cucumber like in shape, about 6 cm in diameter and 5 cm to 8 cm in length. Seed when matured are gray in colour with a bluish tinge. The plants flower in the monsoon season and fruits ripen during October and November. Fibre from this variety are known as tossa in the trade. The Tossa jute is classified according to their quality from A to E. In this experiment BTB (Bangla Tossa B) and BWC (Bangla White C) Jute fibre have been used, it is shown from the literature Tossa is suitable for making fine yarn.

1.2 STRUCTURE OF JUTE FIBRE

In each plant, the rings of fibre cell bundles from a tubular mesh that encase the entire stem from top to bottom. Two layers can usually be distinguished, connected together by lateral fibre bundles, so that the whole sheath is really a lattices in three dimension. The cell bundles from the links of the mesh, but each link only extended for a few centimeters before it itself devides, or joins up with another link. After extraction from the plant, the fibre sheath form a flat ribbon in three dimensions.

The commercial jute fibre refers to the sheath extracted from the plant stem, where as a single fibre is a cell bundle forming one of the links of the mesh, staple length, as applied to cotton and wool fibres has no counterpart in the bast fibre, and has a preliminary to spinning. It is necessary to break up the sheath by a carding process. The fragments so produces are the equivalent of the staple fibre of the cotton and wool industries.

When a traverse fibre section of a single jute fibre is examined under the microscope, the cell structure is seen clearly. Each cell is roughly polygonal in shape, with a central hole or lumen, comprising about 10% of the cell area of cross section. The cells are firmly attached to one another laterally, and the region at the interface of two cells is termed the middle lamella. Separation of cells can be effected by chemical means, and they are then seen to be thread like bodies ranging from 0.75 to 5 mm in length, with an average of 2.3mm. The cells are some 200 times longer than they are broad, and in common terminology are referred to as ultimate cells. A single fibre thus comprises a bundle of ultimates [23].

Traverse sections of single fibres shows that the number of ultimate cells in a bundle ranges from a minimum of 8 or 9 to a maximum of 20-25. Bundles containing upto 50 ultimates cells are sometimes reported but it is then questionable whether the fibre is truly single in the botanical sense, or whether it is two fibres adhering together. A minimum number of cells in the cross section is evidently necessary to provide a coherent and continuous overlapping structure.

1.3 JUTE SPINNING

For thousands of years hand spinning was the only method of producing yarns. The onset of the industrial revolution led to the introduction of mechanical system of spinning. These were later followed by ring spinning which was dominant for so many years, and which is still the technique used for producing the bulk of the worlds staple yarns. [24]

Spinning in the process where jute yarns are spun from finisher drawing sliver with the help of spinning machine. Spinning is undeniably the most important phase in the process of any textile fibre. In the case of jute and allied fibres this phase becomes also the most delicate one as the success of all the subsequent processes will always depend mainly on the characteristics of the yarn produced by the spinning frames. In spite of such circumstances, jute spinning is far from having received the same attention in terms of research and development as paid to other spinning technologies.

The essential feature of the spinning process arc drafting, twisting and winding on. Spinning frames are made in several different sizes, designed by the distance between adjacent spindles, i.e. the pitch. Only a small part of the entire count range is produced on a given pitch of frame. But, no matter what the size of the frame, the mechanism for twisting and winding on function in the same manner although same differences exist in the methods adopted for controlling fibre motion during drafting.

The different types of spinning, both in the conventional area e.g. Cap spinning, Mule spinning, Flyer spinning, Ring spinning etc. and in the non-conventional area e.g. Rotor spinning, self twist spinning, Siro spun spinning, wrap spinning, Friction spinning, Twistless spinning, Cerifil spinning. Jet spinning, Disc spinning etc. The conventional methods are still the most popular and universal way of spinning short and long staple fibres of both natural and man-made types. Most of the above systems are not suitable for jute spinning. Flyer spinning system is widely used in the jute mill for spinning of jute fibre for producing yarn more than 5 count.

1.4 OBJECTIVES OF THE PRESENT INVESTIGATION

The objectives of the present investigation are listed below:

(i) To study the performance characteristics of present spinning machine and modify its design so it can produce fine yarns with competitive cost in respect of production, operation and maintenance.

(ii) To study the properties of the produced fine jute yarn and compare with those produced by standard (Gardella Spinning) machine.

CHAPTER - 2
LITERATURE REVIEW

In the recent years, various research work on jute is undertaken but most of them are physical and chemical analysis of jute fibre. Bangladesh Jute Research Institute (BJRI) carried the research programme on development/modification of jute machinary through their engineering and maintenance division. The Indian Jute Industries Research Association (IJIRA) and Jute Technological Research Laboratories (JTRL) of India and China Zhejiang Jute Research Institute (CZJRI) are working for the development of jute but their research activity on jute machinery are very little compare to other field on jute. International Jute Organization (IJO) also working for the development of jute and jute good but their project are mainly on market promotion and new products oriented. Some attempts have been done by IJO for improvement of existing jute spinning system for production of fine yarn.[4]

2.1 WORLD JUTE SITUATION

Jute is mainly using as sacking, hessian and carpet backing cloth in the world textile market. Fine yarn can be used as decorative and tailoring fabrics. Presently due to presence of synthetic its uses are affected partially. But it is expected that in near future its uses will be increase for its environment friendly nature.

2.1.1 Acreage, Production and Supply of Raw Jute [4]

Total acreage under jute cultivation in the five major producing countries (Bangladesh, China, India, Nepal and Thailand) is estimated to increase by 7.3% to 4,506,300 acres in 1993/94 from the 1992/93 level of 4,201,000 acres indicating a recovery of the decline from the 1991/92 level of 4,993,000 acres.

World production of raw jute in 1993/94 have been estimated at 2.98 million tons, 5.4% lower than the 1992/93 production level of 3.15 million tons, indicating a fall in production for the third consecutive year since 1990/91. The production in Bangladesh is estimated to be 783,000 tons, 11.6% lower than the 1992-93 production of 885,400 tons, while that of India to be 1,224,000 tons which is 8.1% lower than the 1992/93 of 1,332,000 tons. Production in China shows an upward trend from 619,000 tons to 650,000 tons (an increase of 5%) and also in Thailand from 130,400 tons in 134,000 tons (an increase of 2.8%). The declines in production in Bangladesh and India in 1993/94 would much more offset the increases in China and Thailand. (Table 15)

The decline in production in Bangladesh was due to frequent rainfall, unfavourable weather conditions and early flood leading to lower yields per acre and that in India was due mainly to the late arrival of the monsoon and unremunerative prices compared to the alternative crops.

Due to the lower production in 1993/94 the total availability of raw jute in both Bangladesh and India in 1993-94 would also be lower, despite reasonable stocks were carried forward from 1992/93. The total supply of raw kenaf in Thailand is also estimated to be lower than in 1992/93. Overall mill consumption of raw jute is expected to be stable during 1993/94. The year ending (end-June 1994) stocks of fibre in Bangladesh, India and Thailand are estimated to be lower after meeting the requirements of the mills and exports.

2.1.2 Prices of Raw Jute [4]

Internal Prices: During the first three months of 1993/94 (July-September 1993), the declining trend of prices (since 1990/91) continued in Bangladesh while in India that showed an upward trend. However, sharp rises in prices occured in Bangladesh since October 1993 and in India since December 1993, and prices continued to be at high levels in the subsequent months.

In **Bangladesh**, despite the declining trends of price in the initial three months of 1993/94, the average internal price of raw jute in 1993/94 (average of 9 months: July 1993 - March 1994) was significantly higher at Tk. 291.76 per maund (Tk. 781.7 or US$ 19.6 per 100 kg) than that in the corresponding period of 1992/93. The average price, however, during the first three months of the year (July-September 1993) was Tk. 213.1 per maund (Tk. 570.9 or US$ 14.3 per 100 kg); in rose to Tk. 266 per maund (Tk. 712.7 or US$ 17.9 per 100 kg) in October and rose sharply to Tk. 380 per maund (Tk. 1018 or US$ 25.5 per 100 kg) in December 1993 and the rise continued in the subsequent months.

In **India**, on the contrary, the increasing trend was observed in the beginning of 1993/94 and average price recorded during July-October 1993 was Rs. 213.8 per maund (Rs. 572.9 or US$ 18.26 per 100 kg) as against Rs. 173.6 per maund (Rs. 465.0 or US$ 16.74 per 100 kg) in 1992/93. The price, however, reportedly rose to Rs. 317.2 per maund (Rs. 850 per 100 kg) in December 1993. Prices in Thailand also showed a downward trend during 1992/93 and in the first four months (July-October 1993) of 1993/94.

Export Prices: The average export price of raw jute (BWD grade, the representative export grade) fell further during 1992/93 to US$ 277.5 (the lowest price being US$ 260 during January-June 1993) as against US$ 355.5 during 1991/92, a fall by 22 percent. In the beginning of 1993/94 (July-October 1993) the price remained at US$ 260; it increased to US$ 300 in November 1993 and further increased to US$ 338 (approx.) in December 1993 and that rate still continues. The level was far below the indicative price range of US$ 400±$30 set by the FAO Inter-Governmental Group on Jute, Kenaf and Allied Fibres at its 29th Session during December 1993. Similar trend has been observed in respect of the price of the BWC grade, the lowest price being recorded at US$ 310.

Export prices of Kenaf, however, remained stable at relatively high levels, because of the tight supply position. The f.o.b. price at US$ 364 per ton for Thai "A" grade for 1992/93 remained within the FAO Indicative range of US$ 350±$20.

2.1.3 Exports/Imports of Raw Jute [4]

Exports: World exports of raw jute declined slightly in 1992/93 to 347,800 tons as against 350,300 tons in 1991/92, a decline for the third consecutive year since the last high level of over 500,000 tons in 1989-90. While exports from Bangladesh, the largest exporter, rose marginally by 2.3% during the period (from 275,900 tons to 282,200 tons), from China those fell by 12.4% (from 36,300 tons to 32,100 tons) and from India those remained stable at 9,000 tons. The export target of raw jute from Bangladesh was set at 324,000 tons for 1993/94 and actual export till March 1994 has been 183,060 tons. (Table 16)

Imports: World imports of raw fibres also declined to 361,500 tons in 1993 from the 1991 level of 373,200 tons. Imports of the developed countries declined sharply to 81,100 tons in 1992 from 105,900 tons in 1991 (a decline for the fourth consecutive year since the 1989 level of 155,000 tons). However, while imports by the developing countries increased to 280,400 tons in 1992 from the 1991 level of 267,300 tons, those could not offset the decline in imports by the developed countries, leading to the overall decline in imports.

2.1.4 Production of Jute Goods [4]

Production of jute products decreased further in China, India, Thailand, Nepal and Pakistan in 1992, while in Bangladesh it increased. Bangladesh produced 600,500 tons in 1992 as against 530,600 tons produced during 1991, an increase by 13.2%. The target of jute goods production of Bangladesh for the year 1993/94 is 535,200 tons. In India, on the contrary, the production during 1992 fell by 19.2%, from 1,546,100 tons to 1,248,600 tons. China produced 588,500 tons in 1992 as against 608,400 tons in 1991, while Thailand 141,000 tons as against 146,100 tons. In 1992 the production in Pakistan decreased to 106,500 tons from 108,600 tons in 1991. (Table 17)

2.1.5 Export Prices of Jute Goods [4]

Export prices of different jute products fluctuated in Bangladesh and India during 1992/93 and declining trends were observed in respect of almost all the jute products in the beginning of 1993/94. Price of hessian (40″/10 oz) was quoted at US$ 15 per 100 yards in Bangladesh indicating a decline from US$ 17 in 1991/92, while in the beginning of 1993/94 (July-October 1993) it fell further to US$ 14. In India hessian price fell to US$ 15 in 1992/93 from US$ 18 in 1991/92. The average sacking price in Bangladesh fell from US$ 29 to US$ 38 per 100 bags and in India from US$ 45 to 44 during 1992/93. In the beginning of 1993/94 (July-October 1993) the sacking price rose back to US$ 39 in Bangladesh, but further reduced to US$ 44 in India. Prices of carpet backing decreased in Bangladesh (from US$ 658 to 633 per ton) and increased in India (from US$ 675 to 747 per ton) during 1992/93; however, a fall in carpet backing price was observed in both Bangladesh and India in the beginning of 1993/94 (July-October 1993). In Thailand, price of yarn showed an increase to US$ 730 per ton in 1992/93 compared to US$ 687 in 1991/92, while in the beginning of 1993/94 it registered a further increase to US$ 764. (Table 18)

2.1.6 Trade in Jute Goods [4]

Exports: During 1992/93, world exports of jute products, increased by 1.3% (to 924,600 tons from 912,400 tons) during 1991/92. While exports from Bangladesh, India and China increased, exports from Nepal, Thailand, etc. declined. Exports from Bangladesh, which increased by 26% (from 386,700 tons to 487,000 tons) during 1991/92, further slightly increased by 1% (from 487,000 tons to 491,700 tons) during 1992/93. Exports of jute goods in India reached at 215,400 tons in 1992/93 as against 186,200 tons exported in 1991/92, an increase of 15.7%. India's export of jute products to the general currency areas recorded a remarkable growth while it continued to decline in the East European Market, particularly in the former USSR where trade in jute had been mostly on barter and Rupee trade basis. (Table 19)

Imports: World imports of jute products increased by 4.8% during 1992 to 923,400 tons from the 1991 level of 881,300 tons. However, volume of imports into the developed countries declined by 4.2% to 576,00 tons in 1992 from the previous year level of 601,200 tons. Except the EEC countries, where import increased to 277,300 tons from the previous year level of 266,500 tons, in all other developed countries/regions (North America, other Europe, former USSR, Oceania and other developed countries) imports of jute products have declined. In the developing countries/regions (Asia, Africa and Latin America), on the contrary, the volume of imports has increased to 347,400 tons from the 1991 level of 280,100 tons, an increase much offsetting the decline of imports into the developed countries.

2.2 METHODS OF JUTE SPINNING

There are various methods of jute spinning both in the conventional area and in the nonconventional area. Under the conventional area the following methods have been used. They are Cap spinning, Mule spinning, Flyer spinning, Ring spinning etc. and in the nonconventional area they are Rotor spinning, Self-Twist spinning, Siro-Spun spinning, Wrap spinning, Friction spinning, Twistless spinning etc. The conventional methods are still the most popular and universal way of spinning short and staple fibres of both natural and man-made types. However, there are limits to spindle speed e.g. at high spindle speed the spindle vibrates, the traveller gets hotter due to increased friction between ring and traveller, as the traveller slides over the ring. Again the high spindle speed the tension in the yarn also increase with a greater chance of yarn breakage. Thus the cost of production increase rapidly with spindle speed.

2.2.1 Flyer Spinning System [20]

This is the most popular and widely used for jute spinning system. Here jute spinning frame insert the twist means of overhung flyers suspended above the bobbin. Fig. 3 shows the twisting arrangement adopted in the system. The flyers are carried on ball bearing whereas mounted on the front of the frame at about warst-weight. The part of the wharf projecting above the mounting assembly called the cap and plays an important part in the actual operation of the frame. The wharf is driven by a cotton or nylon flat belt from the main cylinder of the machine.

The yarns comes down from the drafting tip to the top of the wharf cap where it enters a central hole and continues down through the wharf. At the exist of the hole a ceramic disc is cemented to project the metal from the abrasive action of the yarn. The flyer legs is screwed on to the whraf so that they may be replaced if necessary. The flyer legs have a small eye at the foot through which the yarn passes on to the bobbin in the system, flyers are designed to run at high speeds they must be dynamically balanced otherwise any eccentricity would ultimately damage the whole assembly and could cause a serious accident.

The simplest relationship between flyer speed, delivery speed and twist is $t = n/v$
where t is the turns of twist per unit length, n flyer speed, and v the delivery speed.

2.2.2 Ring Spinning

The system is suitable for producting fine jute yarn in the system rings and travellers are used instead of flyers. Flyer spinning either slip draft or apron draft is used to produce jute yarn for conventional products like Hessian Cloth, Carpet Backing Cloth (CBC), Sacks etc. Spinning system like ring spinning is able to spin yarn less than three count. The description of following types of ring spinning system are given below.

a. **The Weller Ring Spinning Frame:** The machine is of rigid construction and vibration free but noise level is higher than that of the conventional frames and that is due to pneumatic system of the machine. There is no on-winding tension but a pull by the traveller in the yarn and thus fine spinning is possible with the machine. The yarn spun with the machine is hairy which is claimed to be minimise by applying moisture into the yarn duing spinning. Suppressed balloon spindle tops are employed to achieve high production rates with few end breakages. Twist reversal from S to Z twist is achieved by means of a hand lever. stopping of the spindle on yarn breakage is done by a pedal brake. A pneumatic system of broken-end removal and collection is incorporated with the machine. The range of draft is from 10 to 100 and the frame runs with 6,500 rpm.[1]

b. **The Bolleli Ring Spinning Frame:** The Ring Spinning Frame can be supplied with single draft field or double draft field, being able to draft long fibres from 40 mm upto 350 mm. The speed of the frame can be varied by moving a knob clockwise or anti-clockwise. Twist reversal of the spindles may be obtained by means of a gear translation. The spindle tops of the machine were serrated for suppressed ballooning. The spindle is stopped by a pedal brake when mending the yarn breakage. The yarn spun were hairy which can be minimised by applying moisture into the yarn during spinning by a device attached to the machine. The range of the draft is from 4 to 120.[1]

2.2.3 Centrifugal Spinning (Gardella Spinning Frame):

The Spingard is a centrifugal type dry spinning system (Fig. 10). The Machine which is demonstrated is of 40 spindle running at 9,000 rpm. The yarn can be spun from 71.90 tex (2.08 lbs/spy) to 266.56 tex (7.74 lbs/spy). As there is no on-winding tension during spinning there is no question of yarn breakage.[1]

Apart the case of the "Spingard" innovating principle, all existing spinning frames, although gradually improved in search of the ultimate performances, belong to models and technologies developed last century when certain jute machines took shape from the existing Flax processing ones. The "Spingard" operative principle, on the contrary is something completely different and new. The idea was developed in late 50's and brought soon to the realisation of a jute spinning frame offering performances and advantages never reached before. The machine, named "spingard" after the combination of the words "Spinning" and "Gardella" obtained full success on industrial utilisation since the beginning of the 60's in its previous versions "3rd Series" and "4th Series". This continued in the 70's with the latest version "15 M". Contrary to any existing spinning system, the "spingard" doesn't employ any flyer or ring. The fibre sliver after having been reduced to the due weight by the high draft unit is guided by a tube inside the spinning pot. Since this rotates at high speed (6,000 to 9,500 rpm), the sliver coming out of the tube is pushed by the centrifugal force against the wall of the pot and compelled to rotate with it. In this way any revolution of the pot creates one turn of twist in the yarn. Varying the ratio between the spinning pot speed and the delivery speed of sliver from the high draft unit, yarns with any desired grade ot twist are obtained. The tube guiding sliver inside the pot has an up-and-down motion for the regular distribution of the yarn inside the pot in progressive coils.

It is not at all necessary for the machine to apply extra moisture into the yarn as there is no question of minimisation of hairiness as that of other ring spinning yarns. The cutting of the yarn is carried out automatically. The same machine is capable of spinning fine, medium and heavy counts.

2.2.3.1 Main Mechanical Features

The machine main framing comprises three strong basement cast iron rails where a number of modular heads and two side gables are fitted. The standard model has 12 heads with 8 spindles each, thus making 96 spindles per machine. However models with 80 or 56 spindles are available on request. The drive gable, fitted on the right side of the machine, incorporates the operative push buttons panel, the control instruments, the main drive with relevant spindle speed and twist change assemblies. The end gable, on the left side of the machine, accomodates devices controlling the draft change, the drive and speed change for the automatic restarting of spinning, the slivers feeding, the drive of the yarn distributing tubes. From the top of the machine the main features are as follows:

- Feeding/retaining rollers:

Purpose of these rollers, all driven by one electro-magnetic clutch is to activate the sliver feeding to all high draft units when the correct spindle speed is achieved after the start up of the machine.The rollers, however, perform also the important task of stopping the sliver feeding to any individual high draft unit in case of lappings or cloggins in the draft zone. The occurrence of such inconveniences is detected by suitable feelers.

- **High draft unit:**

This unit, of exclusive design, performs the fibres transfer from the feeding to the draft rollers by means of a special belt and a set of 5 metal rollers. These are placed over the drafting zone with the purpose of controlling the draft thus ensuring a regular flow of fibres irrespective of their lengths. This arrangement reduces considerably the nip and therefore it is particularly suitable to process also very short and low grade fibres.

- **Pressing and drawing rollers:**

Right below the high draft units there are the pressing and drawing rollers. The pressing rollers, covered with special long lasting rubber sleeves, are pressed against the drawing rollers by means of a pneumatic system having a centralized precision setting. The drawing rollers, fitted on the drawing shafts, are specially grooved to prevent wearing of pressing rollers and are made of high tension carbon steel for longest life.

- **Self-aligning spindle:**

It has the peculiarity of being a compact unit which, while rotating, can deviate from its normal axis to absorbe unbalancing effects during the formation of the yarn package. The self-aligning spindle comprises:

- The device for the automatic restarting of spinning. This provides a pre-twist to the fibres, while entering the spindle, through a rotating tube having an inner spiral shape.

- The device for the yarn distribution. This guides, through a tube, the yarn inside the spindle with an up-and-down motion assuring a proper distribution of the yarn and a consequent good package.

- The spinning pot. This is made of special alluminium alloy, which rotates upto 9,500 rpm and performs the spinning and collection of the yarn.

- The counter plate. This closes the bottom of the spindle during spinning and it is automatically removed for the doffing operation (ejection of the yarn packages).

- The device for the ejection of the yarn package. This actuates a disk, located inside the spinning pot, which is pneumatically operated to push downwards the yarn package.

- Automatic doffing system:

When the yarn packages are completed the machine stops automatically and the doffing operations take place. The counter plate is removed and replaced by a bobbin holder which collects the yarn package inside the spinning pot. Once the package is doffed the counter plate returns to its normal working position and another spinning cycle can be restarted. All motions are pneumatically actuated and controlled by safety devices.

- Safety devices:

The machine is fully equipped with safety devices to provent injuries to the personnel as well as damages to the machine itself in case of wrong or irregular operations.

2.2.3.2 Technical Specifications

Spindles per machine	: 56, 80, 96
Spindless Speed:	
- maximum mechanical speed	: 10,500 rpm
- operative speed with jute Kenaf and allied fibres	: 6,000 - 9,500 rpm
Spindles speed change	: by pulley change
Type of twist	: "Z"
Twist range	: 1.72 to 6.29 tpi = 67.93 to 247.94 tpm
Draft range	: 5 to 40
Reach	: 14" = 356 mm.
Feeding	: Sliver from cans of 305 mm (12") dia x 1,016 mm (40") high
Yarn package	: Tapered Upper dia: 150 mm (5.9") Lower dia: 181 mm (7.1") Height: 153 mm (6.0") Weight: upto 950 grams
Total maximum installed power	: 56 spindles = 42.5 KW 80 spindles = 42.5 KW 96 spindles = 49.9 KW
Net weight	: 56 spindles = 12,200 Kg. 80 spindles = 16,500 Kg. 96 spindles = 19,000 Kg.

2.2.4 Siro-Spun System

The Siro-spun process, initially developed for worsted yarns, is a means of spinning a two-strand weaving yarn, direct from a single spinning unit. A simple diagram of the system is shown in figure 1. The system has four necessary components- rear roving guide, centre roving guide, front zone condenser, and break out device. In 1975-76 [5], the process was invented in Commonwealth scientific and Industrial Research Organization, Australia. After approximately one year of intense experimentation, CSIRO satisfied themselves and claimed that manufacture of siro-spun yarn was an acceptable industrial process. The current system is a joint development of IWS and CSIRO and in 1980, Zinser took over the development of the Siro-Spun system to its marketability. Within a short period it was successfully introduced on the market. Upto 1988, more than 130 spinning plants having the capacity of 120,000 spindles have been installed in 32 countries all over the world [11]. The largest market is in Europe. In mid March, 1988, Zinser introduced the Siro-spun system for short staple on the market [11].

When two strands are positively separated through out the complete drafting unit, they emerge at a fixed distance figure 3.a from the front rollers. Then they come together at a point where the double ply structure is formed. With perfect conditions and a fixed convergence point, each strand rolls into its two ply structure with fibre aligning substantially on the yarn surface. These type of yarns are termed as Siro-spun yarns. Each of the two strands of Siro-spun yarn is in "tension torque force equilibrium" at the convergence point which gives a different yarn appearance. It has been suggested [6] Siro-spun yarn appearance is something between a double roving and a conventional two ply yarn.

2.2.5 Wrap Spinning System

The main component in this operation is the hollow spindle, which was developed by Professor George Mintov [9] of the Institute of Clothing and Textile, Bulgaria. Filament is wrapped around staple fibres in order to make a yarn in which the binder filament holes the yarn together in place of twist. Wrap spinning produces a parallel yarn, which in the case of the Suessen system is known as PL yarn, the core of which consists of more or less untwisted fibres. The continuous filament, which is wrapped around them, provides radial tension and consequently friction between the individual fibres. The principle of spinning of this system is shown in figure 2.

The system was shown at ITMA in 1975 by Leesona on their "Coverspun" [9] machine and by Gemmill and Dunsmore with their GD machine [8, 9]. Since that time the system has received considerable attention and this is reflected by the large number of machines in industry as well as by the large number of machine makers now offering this system of spinning. The yarns produced by this technique are referred to many different names e.g. Parallel yarns, Wrap yarns, Wrapped yarns, Hollow spindle yarns, Parafil yarn etc. These yarns are claimed [15, 16, 17] to be bulkier, which is important for knitting yarns, since this gives improved cover in the fabric. Furthermore, the yarns are as strong or stronger than the equivalent ring spun yarns and they tend to appear to be more regular in appearance because of the lower tendency for twist to accumulate in thin places.

It was claimed [15] that wrapped yarn is more uniform and less hairy than a ring spun yarn and thus it is possible to replace a normal two-fold ring spun knitted yarn with a single wrap spun yarn. This offers considerable cost savings and reduces the problem of spirality due to the zero twist of the main body of the yarn.

2.2.6 Friction Spinning

In this system, drafted fibres are fed by means of air flow along the line of roller-nip which is made up of either two perforated rollers or one "solid" and one perforated roller. As the rollers rotate they cause the open end of the yarn to twist due to friction at a much higher speed and the incoming fibres are formed into yarn. Delivery speeds upto 300 meter/min. can be achived on this system.

Friction spinning does not have any rotating elements for the purpose of twist insertion, hence there is 20% less power consumption compared to ring spun yarn [10]. However, twist insertion efficiency (10-20%) is low because of slippage of fibres, and fibre consolidation is very poor. The strength of friction spun yarn is 50-60% [10] of that of ring spun yarn of equivalent count because of poor fibre parallelisation and consolidation. As a result, these yarns can not be used as single wrap yarn but can be used as weft for blankets, curtains, upholstery and wall coverings etc.

The statistics upto 1988 have revealed that only 35 machines of friction spinning machines are in operation.

2.2.7 Twistless Spinning

This is a novel technique of spinning yarn without the insertion of twist. Most of the earlier methods of twistless spinning work on the principle of applying an adhesive in either liquid or fibre form to the drafted strand. Some of the twistless spinning systems are Tek-Ja process and TNO process.

2.2.7.1 Tek-JA Process

The first twistless process, developed by Fibre bond Laboratories, was called Tek-JA process and this has been described by Wells and Powischill [12, 13]. Roving was drafted by conventional means and after leaving the front rollers the strand was wetted with an adhesive mix, which was usually starch based. The strand passed under a series of small rubbing rollers, which reciprocated axially and caused the strand to be made round in cross-section and furthermore served to force the adhesive into the structure. The yarn thus produced was dried and wound continuously at a production speed of 15-30 metre/min.

2.2.7.2 T.N.O. Process

The T.N.O. process [14] was introduced with the claim to overcome some of the problem associated with Tek-JA process such as:

i. Complicated arrangement for rubbing the yarn to effect yarn roundness.
ii. Drying of the yarn.
iii. Limited drafting capability.

The feedstock used for this process was cotton roving, previously scoured to remove fatty substances so as to improve liquor penetration. The fibres were drafted by a single zone roller drafting system after having been pre-wetted with water; the advantage of wet drafting being the much higher drafts which could be achieved without detriment to yarn regularity. The strand was then impregnated with potato starch held in fine suspension in cold water. The yarn package was formed with the strand still wet; temporary strength to enable winding was given to the yarn by a false twister device which was operated by an air-vortex. Once formed, the yarn was a steamed at 110°C for about 1 hour to activate the starch by causing it to swell and gelatinize and the package was then dried at 100°C.

However, the machine had very limited commercial success due to inherent problems associated with adhesive application and drying.

2.2.8 Rotor Spinning System

Within a short span of about two decades, about 8-10% of total world yarn production has been transferred on rotor spinning [10]. It appeared to be a strong contender to conventional ring spinning in the coarse and medium count ranges. Since the first commercial model of rotor system made its appearance in the textile industry, it has accelerated development activity in the field of engineering perfection and rotor design.

2.2.8.1 Advantages of Rotor Spinning System

The rotor spinning system offers the following potential advantages compared to ring spinning system [10]:

i. High productivity- about 4 to 5 times that of ring system.
ii. Shorter preparatory and post-spinning process.
iii. Lower power requirement due to separation of twisting and winding operations.
iv. Lower labour cost.
v. Lower mixing cost.
vi. Better yarn quantity.
vii. Improved weaving preparatory and loomshed efficiency because of better uniformity and less yarn faults in rotor yarns.
viii. Better fabric cover due to increased diameter of rotor yarns.

2.3 APRON DRAFT FLYER SPINNING MACHINE [19]

This machine is the latest addition by James Mackie and Sons Ltd. to their range of jute manufacturing machinery (Fig. 5). This machine is definitely an improvement on the roller draft sliver spinning frame and is capable of producing a yarn with improved quality at a higher rate of production.

Drafting of material in the machine is by means of a moving apron which provide a very good control of material through out the entire drafting zone. As a result, the yarn produced is more regular than a conventionally spun yarn. This regularity in the yarn brings in good appearance and increased strength.

Two types of spinning frame with this apron draft arrangement are available, that is 10.8 mm frame and 12 mm frame of 100 and 80 spindle per frame and flyer speed of 4500 rpm.

In this experiment 12 mm spinning frame of 8 spindle (laboratory type) has been used. Control draft not only brings yarn regularity, increased strength and better appearance but also reduces the number of breaks per unit time.

This apron draft sliver spinning frame has an automatic cleaner with traverse full length of machine and thus increase yarn cleaniless reducing operator work load.

The apron for drafting is removable to ensure cleaning and replacement of new apron if necessary.

All rollers are mounted on ball and roller bearings to allow smother running, reliability and durability. However the machine can not produce finer yarn like 3 count.

Specification of the machine (Apron draft spinning frame)

No of spindles	8
Pitch of spindles	12 mm
Range of Flyer speed	3500 - 4750
Draft constant	666
Twist constant	204
Motor power	3.75 kW

2.4 LIMITATION OF FLYER SPINNING MACHINE IN MAKING FINE JUTE YARN

Spinning tension of yarn is an important criteria for spinning of a desired count of yarn. Two levels of tension are generally encountered, on winding tension and transmitted tension. On-winding tension is the tension developed in the part of the yarn between the flyer eye and the surface of the bobbin. Transmitted tension is the tension in that part of the yarn above the wharp-cap (Fig. 3) The transmitted tension is alway lower than the on-winding tension.[20]

The relationship between the on-winding tension and the transmitted tension is given by $T_t = T_0 \exp(\mu\theta)$, where T_t is the transmitted tension, T_0 the on-winding tension μ the co-efficient of friction of jute yarn on steel and θ the total angle of wrap on the flyer leg and any other bearing surface.

In the flyer spinning system the spinning tension is comparatively higher than the spinning tension developed in the ring system. The fine yarn less than five count can not withstand the developed level of tension in the flyer system. As a result fine yarn like three count can not be produced by the flyer spinning system. Since on-winding tension is higher than the transmitted tension, it is observed that yarns always break at the on-winding part.

On the 10.8 mm frame a popular choice of hessian yarns, the on-winding tension is normally 0.8 kg, although wide variation in these values are found.

For producing 8 count jute yarn this may be around 1-1.5 kg. From this value the on-winding tension should be 0.375 - 0.562 kg for spun of 3 count yarn. But the actual tension in flyer spinning system is 0.8 kg which is about twice than the acceptable on-winding tension. So it is not possible to make fine yarn like 3 count by the flyer spinning system.

The limitation of producing fine yarn due to spinning tension of flyer spinning system may be overcome by introducing ring system in the flyer spinning machine. In the ring system on-winding tension is negligible because there is no drag force which is developed by the bobbin carrier of the flyer spinning system. It may be possible to produce fine jute yarn through introducing of ring system by eliminating flyer and bobbin carrier of existing flyer spinning system.

CHAPTER - 3
MODIFICATION OF THE MACHINE

The existing jute spinning machines which are being used in jute mills of Bangladesh are of flyer system and it can produce yarn upto 5 count or more. This system is not capable to produce yarn below 5 count. The ring system which has been extensively used in cotton system is capable to produce very fine yarn but there are difference, between cotton fibre and jute fibre.

In this modification, there is no on-winding tension due to replacement of flyer and existing bobbin by introducing ring and traveller. But proper spindle speed is essential for making a yarn of definite linear density. The proper spindle speed was fixed by a series of trials. From the result of trials it was found the machine can produce fine yarn between 6000 to 8000 rpm spindle speed.

In the modified system the following changes has been incorporated.

1. All the flyers were removed from the machine (Fig. 8)
2. A rail was fabricated and steel rings of 75mm diameter were installed in the rail (Fig. 9).
3. New bobbins and spindles (cotton type) were procured from the local market.
4. Power was transferred to the spindles by a flat cotton belt from main motor of the existing system.
5. A traveller (No.1.0, semicircular, thickness 1 mm) was incorporated with the ring.

3.1 SPECIFICATION OF DIFFERENT PARTS/ACCESSORIES USED IN THE ADAPTATION

NAME	SPECIFICATION
a. Roller	90 cm x 13.5 cm
b. Bearing	No. 6203
c. Roller stand	36 cm x 20 cm
d. Cotton flat belt	2 cm x 1 mm
e. U Channel	10 cm x 5 cm x 124 cm
f. Ring	75 mm
g. Traveller	No. 1.0
h. Yarn guide	74 mm
i. Bobbin	23 cm x 25 cm x 2 cm
j. Spindle	22 cm

3.2 WORKING PRINCIPLE OF THE MODIFIED SPINNING MACHINE

The finisher drawing sliver was taken for spun 103.5 tex yarn. The draft was fixed from the ratio of input sliver to output yarn for producing a particular count of yarn (here 3 count).

Weight of the input sliver was 2070 gm/1000 metre.
So required draft for producing 103.5 tex yarn = 2070/103.5 = 20.
Used draft change pinion in the experiment = 666/20 = 33.3 = 33 (number of teeth)
The obtained pinion of particular teeth was used for producing necessary count of yarn.
Draft const is fixed for a particular machine and it is supplied by the manufacturer. In the experimental machine it was 666.

Twist: The required pinion can be found from a gearing constant called the twist constant which is analogous to the draft constant. It is found by assuming that the drawing roller is driving the flyers and calculating the number of flyer revolutions made in the time taken for one revolution of the drawing roller. This number of turns of the flyers is then inserted into the length of rove delivered by one revolution of the drawing roller i.e. one circumference the pinion. In the experiment inserted twist was 2.16/cm (5.5/inch).

3.3 PROCEDURE OF YARN PRODUCTION IN THE MODIFIED SPINNING MACHINE

The slivers are received by the back rollers of the machine. Through this back roller it is passed between the Apron and roller to the front rollers. Drafting zone of the machine is from back roller to delivery roller where drafting of the processed sliver occurs. After passing the delivery rollers the yarn goes to the bobbin through traveller. The traveller is rotated on the ring with the help of bobbin speed. The bobbin gets speed from the main motor through a series of gear and a roller. When the traveller rotates a building motion is developed in the yarn. In this system two yarn of nearest spindle can touch each other, so breakage may occur. To overcome this problem a guide used for each spindle. The yarn spun by the rotation of traveller in the ring by modifying the flyer system which is absolutely a new technique.

The pinion changes are necessary when it is necessary to change the count of produced yarn. After setting the pinion, the sliver used for producing this fine yarn should be fed at the machine and the motor switch put on, and the speed should be increased gradually to finally reach the operating speed (in this case 8000 rpm). In the existing machine there is an additional advantage of pneumatic suction. When fibres are passing between apron and rollers there are some floating fibre. The floating fibres are removed by the pneumatic suction before yarn formation from sliver, as a result produced yarn are comparatively cleaner.

CHAPTER - 4
TESTING PROCEDURE

The yarns produced by the modified spinning system were tested by a Universal Testing Machine (Fig. 11) of the Testing Laboratory of BJRI.

4.1 DESCRIPTION OF THE INSTRON MACHINE

The Universal Testing Machine consists of three main component (i) Compressor, (ii) Load Frame and (iii) Computer.

i. **Compressor:** The compressor uses air pressure to compress the grip so that it can hold the yarn tightly.

ii. **Load Frame:** Load on the yarn is applied through this frame upto its failure.

iii. **Computer:** Its function here is to analyze the spinning properties and to process and display the actual values.

Software series IX Automated Materials Testing system has been used for testing the sample. Series IX is a comprehensive software package designed for use on a broad range of DOS Compatible computers. It provides colour menus for simple test method and report format, modification and creating and supports a wide range of tensile, compressive flexural, peal, tear and friction calculations and testing methods. Upto 400 different test types can be designed, including many ISO, BS, ASTM and DIN test Methods, and stored for easy recall. High resolution real-time graphics provide instantaneous information on the progress of test, and can be output to a range of different printers and plotters. Raw data can also be output in ASCII/DIF formats for external analysis. Series IX also incorporates specialised calculations including seam slippage, poision ratio, tear and friction, and stress relaxation to meet national and international standards. Series IX is available on either 5.25" disks or 3.5" disks and in language other than English.

4.2 TEST CONDITION

Sample comments	:	Jute yarn
Gauge length	:	50 cm
Test type	:	yarn
Interface type	:	5500
Sample rate (pts/sec)	:	10,000
Cross head speed	:	300,0000 mm/min
2nd cross head speed	:	0.0000 mm/min
Full scale load range	:	1.000 kN
Relative Humidity	:	65 ± 2%
Temperature	:	$20^{o} \pm 2^{o}C$

4.3 TESTING PROCEDURE

Estimate of the Count of the Yarn Sample:

The sample was measured by a motorized wrap reel (Fig. 4) and weighted by an analytical balance. The accuracy of the analytical balance was 0.1 mg.

Count (lb/spindle) = weight in lb/14,400 yards of yarn. The yarns weighted by a analytical balance and the calculated count was set in the Universal Testing Machine. The specimen sample was put in the grip of the machine, then machine (Fig. 11) was switched on and tests were conducted under the principle of constant rate of elongation (CRE).

The Instron series 5565 load frames are the mechanical loading structures that form a part of the series 5500 Electromechanical materials testing system, which is used for testing a wide range of materials in tension or compression. The load frame is designed to be placed on a table top or work bench for use at a convenient working height.

The load frame is designed to secure a test specimen between the rigid frame base and the moving cross head. The drive system moves the cross head in an upward or downward direction to apply a tension or compressive load to the specimen. The applied load is measured by a transducer (load cell) mounted between the specimen and cross head. The load cell is interchangeable with others of different capacities to provide a range of load measurement capabilities. Control of the testing system comes from a special material testing software Programme running on a personal computer connected to the system. Tests parameters and other test setup information as well as test results and statistics reported are all selected from within the program.

The samples were put in a control room for two days and the test were done at RH 65% and Temperature 30^oC. This is the standard testing atmosphere for testing of Textile materials in tropical and sub-tropical regions [21].

CHAPTER - 5
RESULTS AND DISCUSSIONS

Two types of fibre have been used in this experiment. These are BWC and BTB. Yarns of 103.5 Tex were produced by using both grades of fibre. Yarn coarser than 103.5 tex were also produced for evaluating the yarn production range of the machine. It has been found that it is possible to produce yarns more than three count by this modified system. Yarns of 135.39, 138.00, 142.00 and 164.00. Tex were produced by the modified system and their spinning properties were tested and presented in the tables 7, 8, 9, 10, and the results are satisfactory. The following spinning properties were tested for determining the quality assessment of produced yarn.

5.1 LOAD AT BREAK

This is the load at which the specimen breaks. It was shown that in the case of both fibres when speed of the bobbin increased, load at break also increased which indicates the strength of the yarn was increased with the increase of bobbin speed. For BWC fibre, the breaking load of yarns were increased from 0.756 kgf to 0.800 kgf and presented in the tables 1 and 3. For the yarns produced from BTB fibres it was increased from 1.017 kgf to 1.293 kgf and presented in the tables 4 and 6. Although the load was not change in remarkable but the increased speed will definitely increase the rate of production. In addition from the breaking load of both the fibre it shows that yarn produced from BTB fibre is posses more strength than that produced from BWC fibre. [Tables 3 and 6]

5.2 LOAD-ELONGATION

An extremely important curve is produced when the load on a specimen is plotted against the elongation. This curve describes the behaviour of the specimen from zero load and elongation upto the breaking point. Load elongation characteristics of different jute yarns produced from BWC and BTB fibres at different spindle speeds are shown in Fig. 15 to 25. In this experiment it is shown that the mean elongation percentage varied from 1.39 to 1.66 and mean breaking load from 1.017 kgf to 1.293 kgf for yarns produced from BTB fibre and spindle speeds from 6000 to 8000 rpm [Tables 4 and 6]. The obtained results shows that yarn produced at 8000 rpm spindle speed possess higher extensibility and loading (Figure 12) which is desirable for a textile materials. In addition it is shown that jute yarn has no distinguished yield point like the synthetic fibre. It increases linearly and breaks at the breaking point. Yarn produced with spindle speed at 8000 rpm obeys the relationship of $y = 1.1 + 1.6x$.

where y = load in N and
x = percentage elongation

5.3 PERCENTAGE STRAIN AT BREAK

When a load is applied to a specimen a certain amount of stretching takes place. The amount will vary with the initial length of specimen. The strain is the term used to relate the stretch or elongation with the initial length;

strain = (Elongation/initial length) [23]

Yarn produced through the modified system shows its load at break and tenacity have no relationship with percentage strain.Sometimes percentage strain increased with increasing load [Tables 3 and 4] and sometimes it has decreased [Tables 1 and 2].

5.4 TENACITY OF THE PRODUCED YARN

Tenacity of the yarn defined as load is kgf/unit tex. In the experiment produced yarn shows that Tenacity of the yarn increased with the increase of quality ratio. It is exist a linear relationship.

5.5 TEXTILE MODULUS

It is evident that textile modulus of yarn produced from BTB fibre is higher than the yarn produced from BWC fibre [Tables 3 and 6]. Selection of textile modulus depend on the application of yarns. The yarns of low textile modulus is suitable for using in fabrics.

5.6 SPINNING BREAKAGE

The spinning breakage rate varies widely from mill to mill due to the difference of yarn quality, frame maintenance and variation of tension levels, virtually all breakages are caused by the spinning tension exceeding yarn strength as well as quality of fibre and performance of back processing, the exceptions being caused by the yarn striking an adjacent flyer when it balloons off a flyer leg or when one end breaks and becomes tangled with its neighbour, causing it to fall. It is directly related to the production efficiency which leads to the cost of production.

In this experiment fine yarns of 3 count were produced. The spinning breaks/spindle-hr was observed and it was found the spinning breaks increases with the increase of spindle speed (Fig. 14). At 5000 rpm it was found 4 no. of breaks/spindle-hr and 11 No. of breaks/spindle-hr when the speed was increased upto 8000 rpm [Table-14]. The spinning breakage of this modified machine follows a relationship of $y = 1.258 \times e^{0.167x}$

where y = number of breakage and

x = rpm of the spindle speed

Which can be compared with the yarn breakage of 8 count hessian warp produced from flyer spinning system. Where flyer speed varies from 3000 to 4500 rpm and yarn breakage varies from 2-4/spindle-hr.

In this study it was found that breakage was comparatively higher than those of coarse yarn which is produced from flyer system. One of the reasons of more breakage of yarn was the improper positioning of spindle. It could be minimized by introducing smooth and concentric rings, travellers and proper spinning tension.

5.7 QUALITY RATIO

Quality ratio is the property of jute fibre which indicate the load at break (lbf)/ count. A yarn of higher quality ratio indicate a yarn of higher strength. In the experiment the quality ratio was varied from 74.7% to 95% of yarn produced from BTB and presented in the tables 4 to 6. This is a quite acceptable quality ratio of a yarn of 103.5 tex.[1]

Quality ratio of yarns produced from BWC fibre by the modified ring spinning machine was compare with the yarn produced by the Gardella spinning machine. The quality ratio of the yarn produced by the modified machine was 58.8 and yarn produced by the Gardella spinning was 64.5 (Table 12) which is comparable.

In the experiment it is shown that tenacity and load at break of yarn was increased with the increase of quality ratio (Fig. 13). Tenacity was increased from 0.096 N/tex to 0.123 N/tex and load at break was increased from 1.007 kgf to 1.29 kgf. Load at break and tenacity at break have a linear relationship with quality ratio of yarn.

CHAPTER - 6
CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The present research work was oriented towards the experimental study of adaptation of ring spinning system in the existing flyer spinning machine. The following conclusion can be made as a result of the present research work.

1. It is possible to convert the existing apron draft flyer spinning machine into a ring system for producing fine jute yarn.

2. Yarn upto 3 count can be produced by using this modified machine at spindle speed of 8000 rpm.

3. Properties of the yarn produced by this modified machine is comparable with the yarn produced from spin gard machine.

4. Number of yarn breaks increases with the increase of spindle speed.

5. The better quality tossa jute is suitable for this system (i.e. BTA or BTB).

6. Traveller no. 1.0 (semicircular type) is more suitable for this modified ring system for making 3 count jute yarn.

6.2 RECOMMENDATION

The following suggestions may be recommended for future research work:

1. Study of the improvement of bobbin shape so that more yarn can be wind on the bobbin which will save down-time of the machine.

2. In this study the spindle speed was increased. As a result number of twist per unit length of yarn was changed from the inserted twist by the twist change pinion. For a certain twist, the twist constant of the machine will have to be determined due to this adaptation. An experimental study for determining the recommend altered twist change pinion for inserting twist can be undertaken.

3. Study of the adjustment of building motion of yarn, where correct building motion can be achieved for proper winding of yarn on the bobbin.

4. Further study is necessary to minimize the hairiness of produced yarn by the modified machine.

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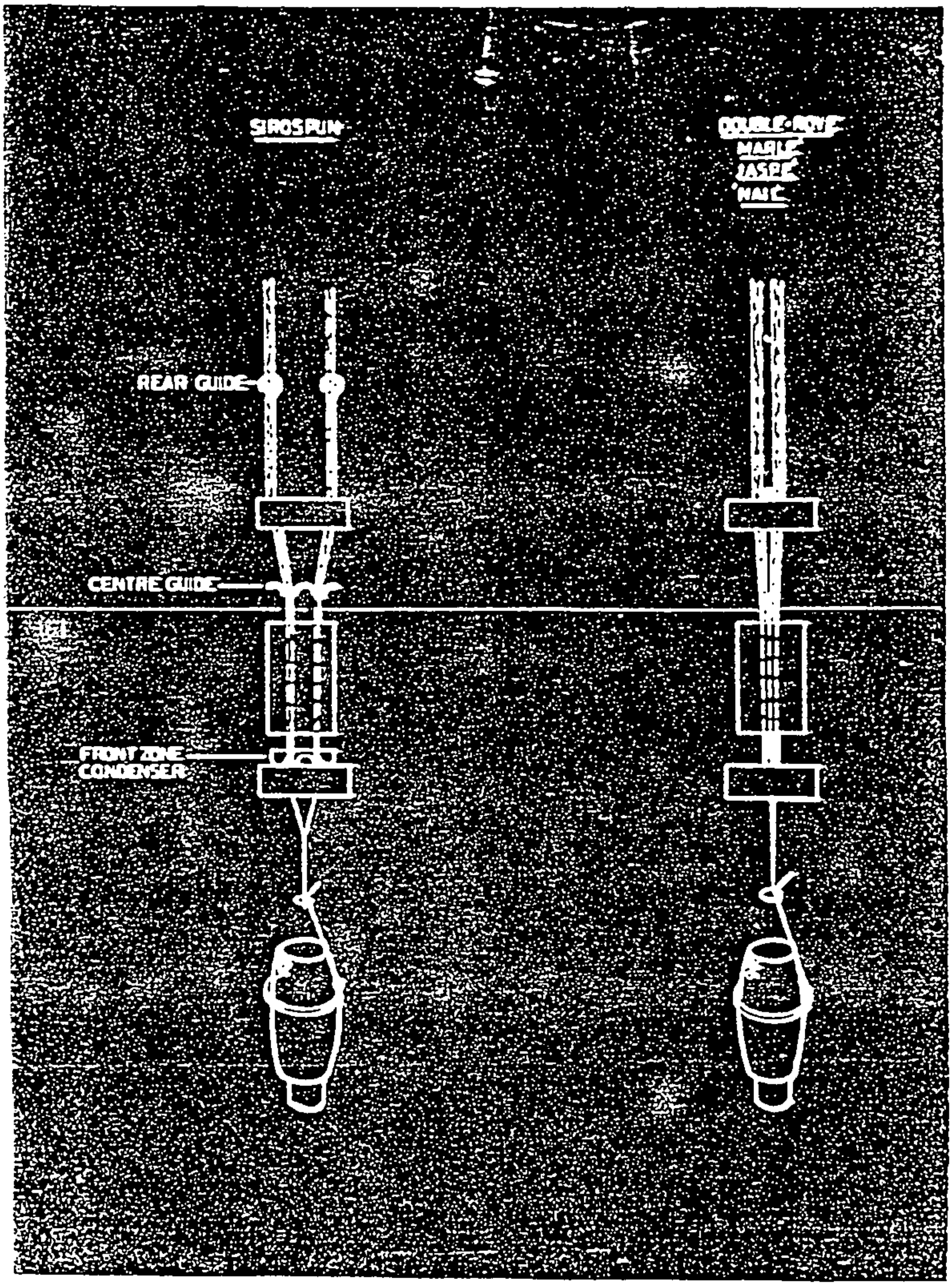


Figure 1: Photograph of siro spun and double-rove process.

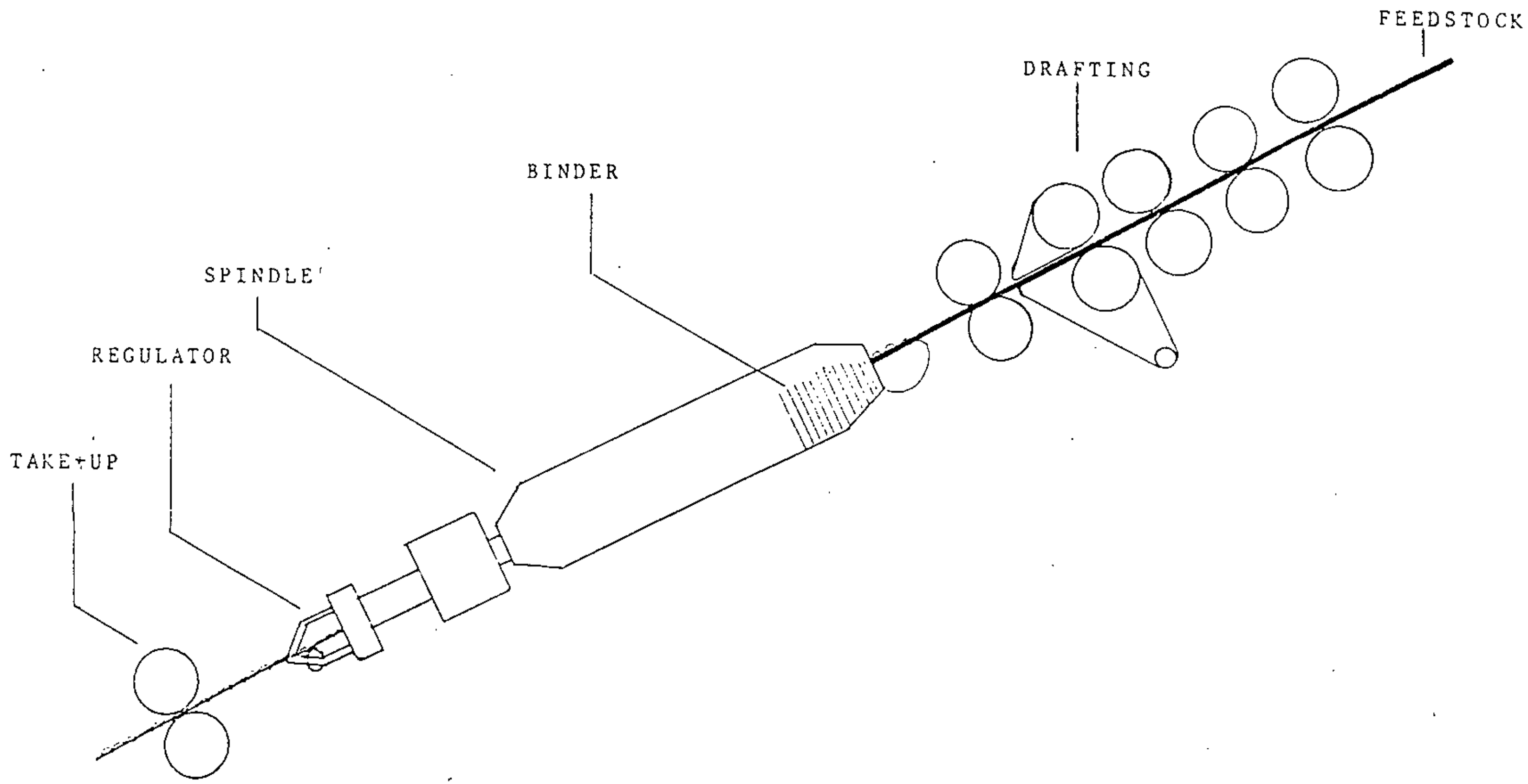


Figure 2: Principle of hollow spindle machine.

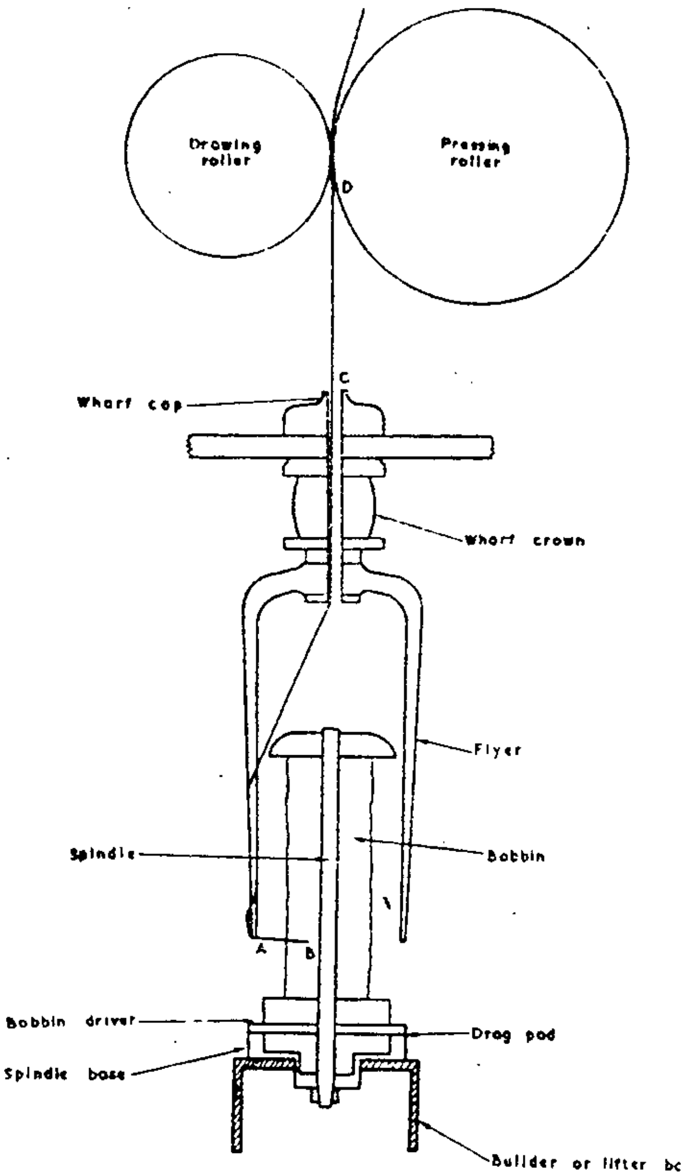


Figure 3: Twisting and winding-on section of a jute spinning frame.

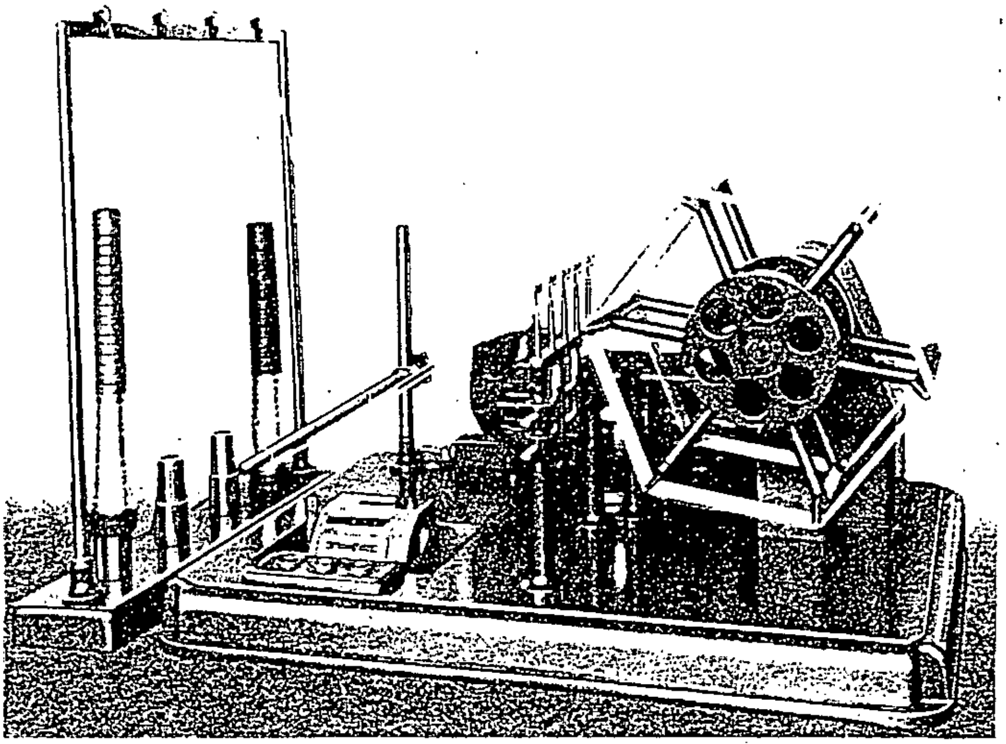
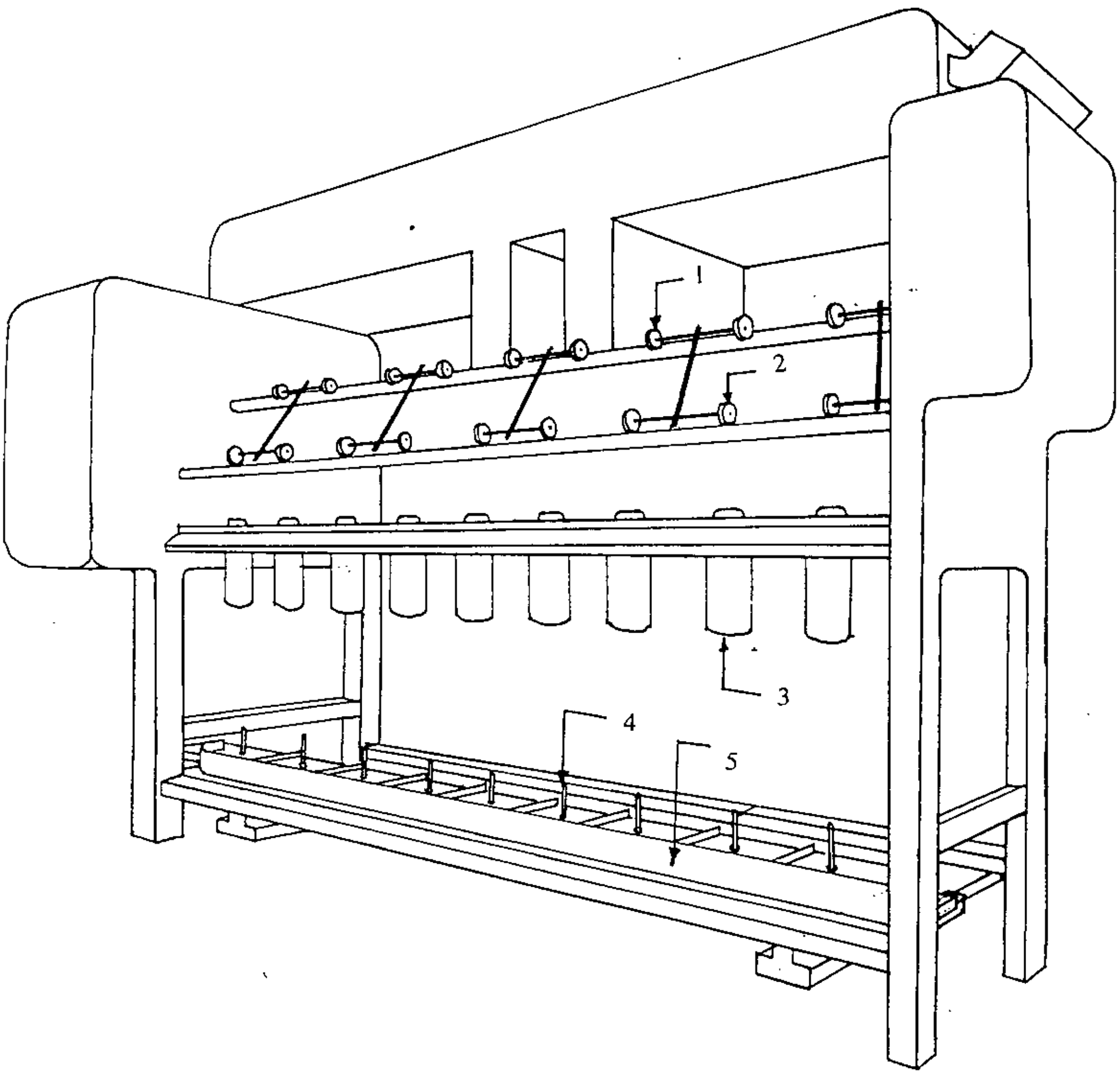


Figure 4: Photograph of motorised wrap reel.



1. Retaining Roller
4. Bobbin Carrier

2. Delivery Roller
5. Rail

3. Flyer

Figure 5: Existing apron draft flyer spinning machine.

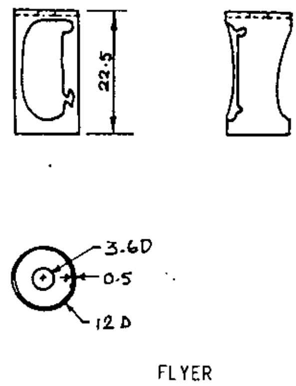


Figure 6: Flyer of existing apron draft spinning machine.

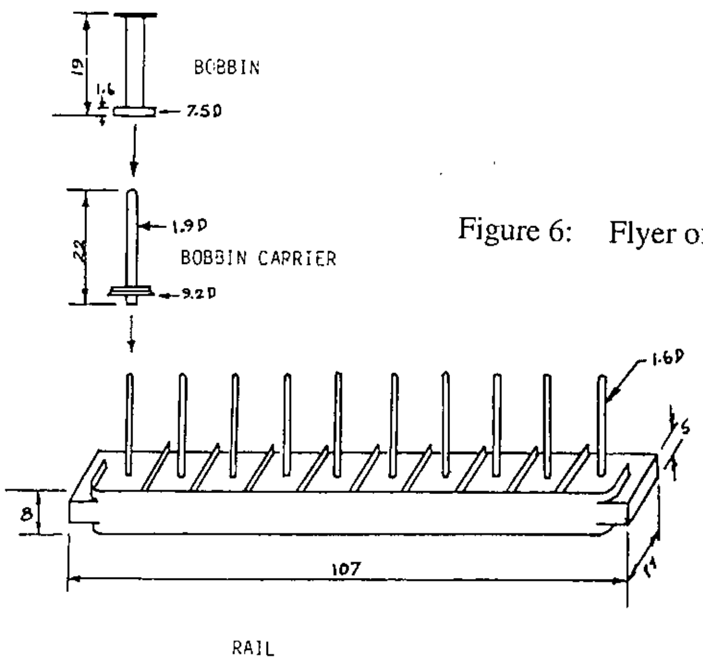
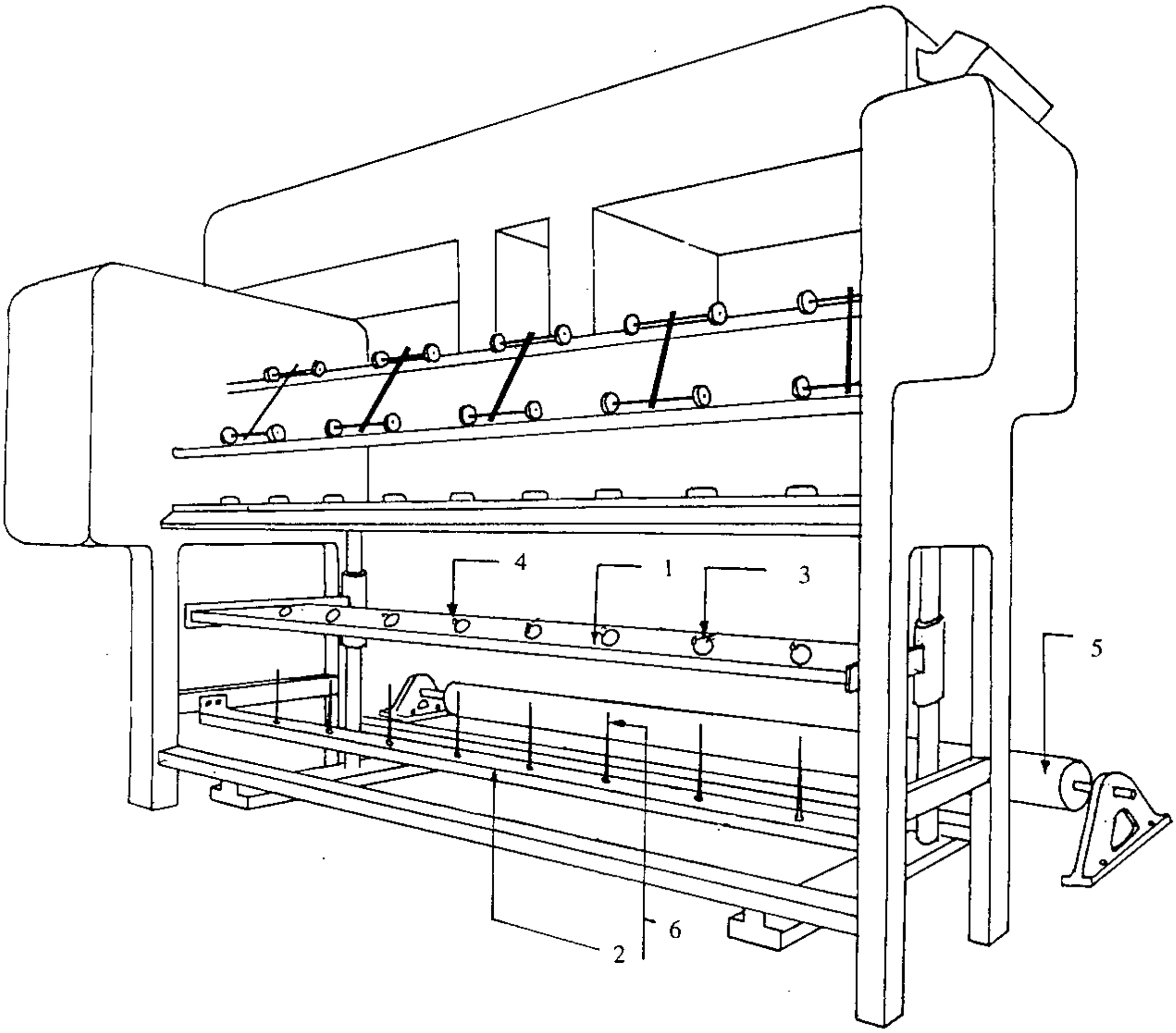


Figure 7: Rail of existing apron draft spinning machine.

All dimensions are in centimeters.



1. Upper Rail
2. Lower Rail
3. Ring
4. Traveller
5. Roller
6. Spindle

Figure 8: Modified spinning machine.

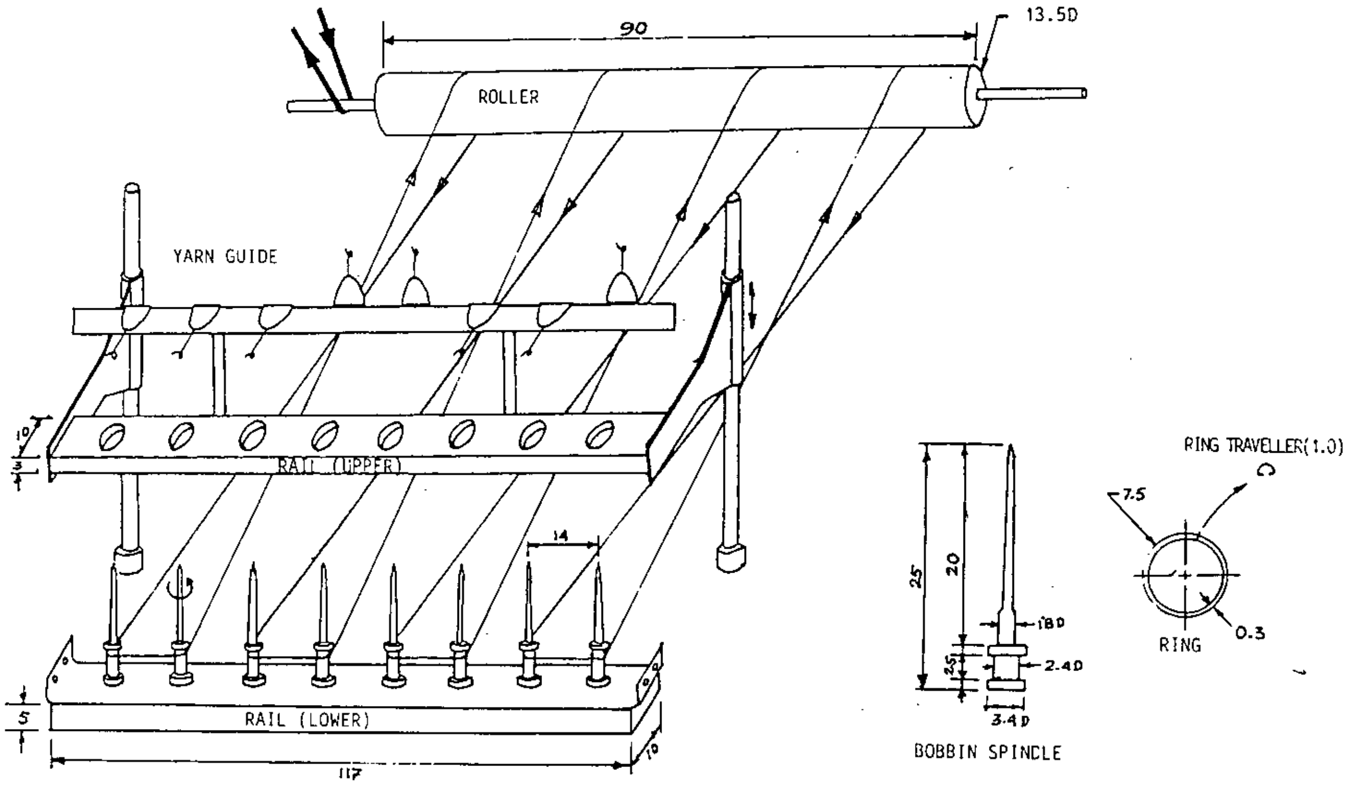


Figure 9: Modified rail with new attachment.

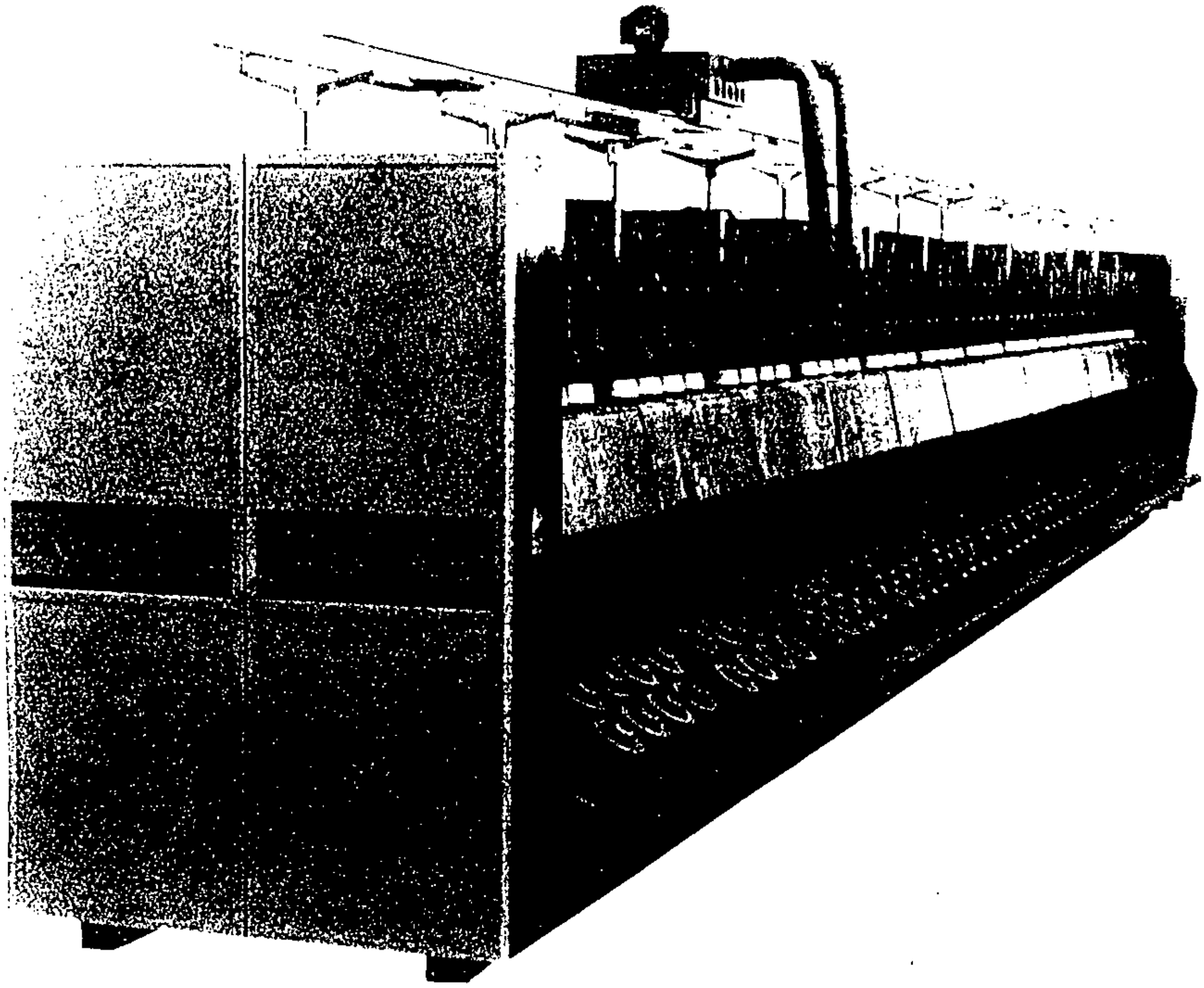


Figure 10: Phtograph of spingard 15 M high speed jute spinning frame.

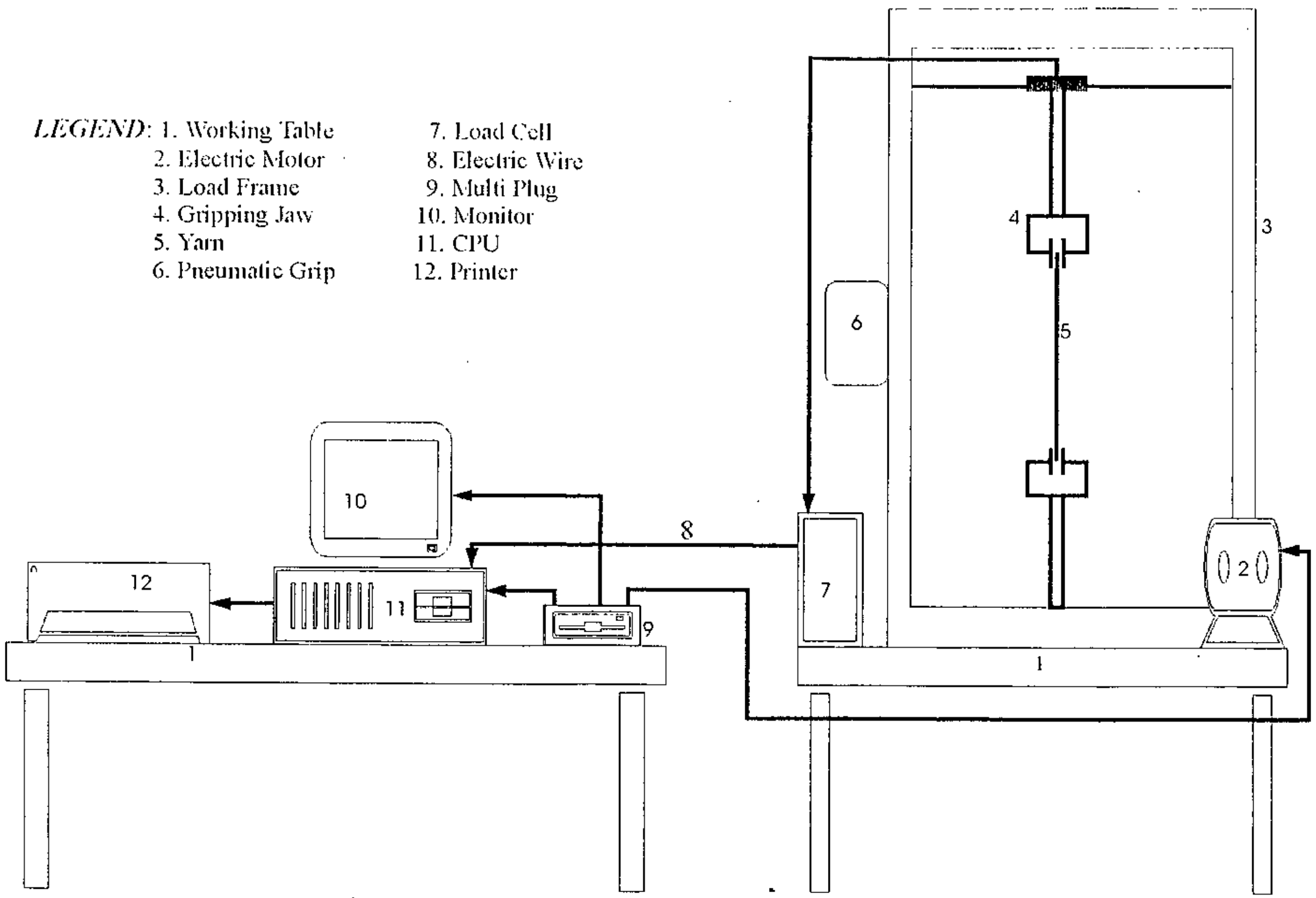


Figure 11: Experimental setup of universal testing machine for testing of produced fine jute yarn.

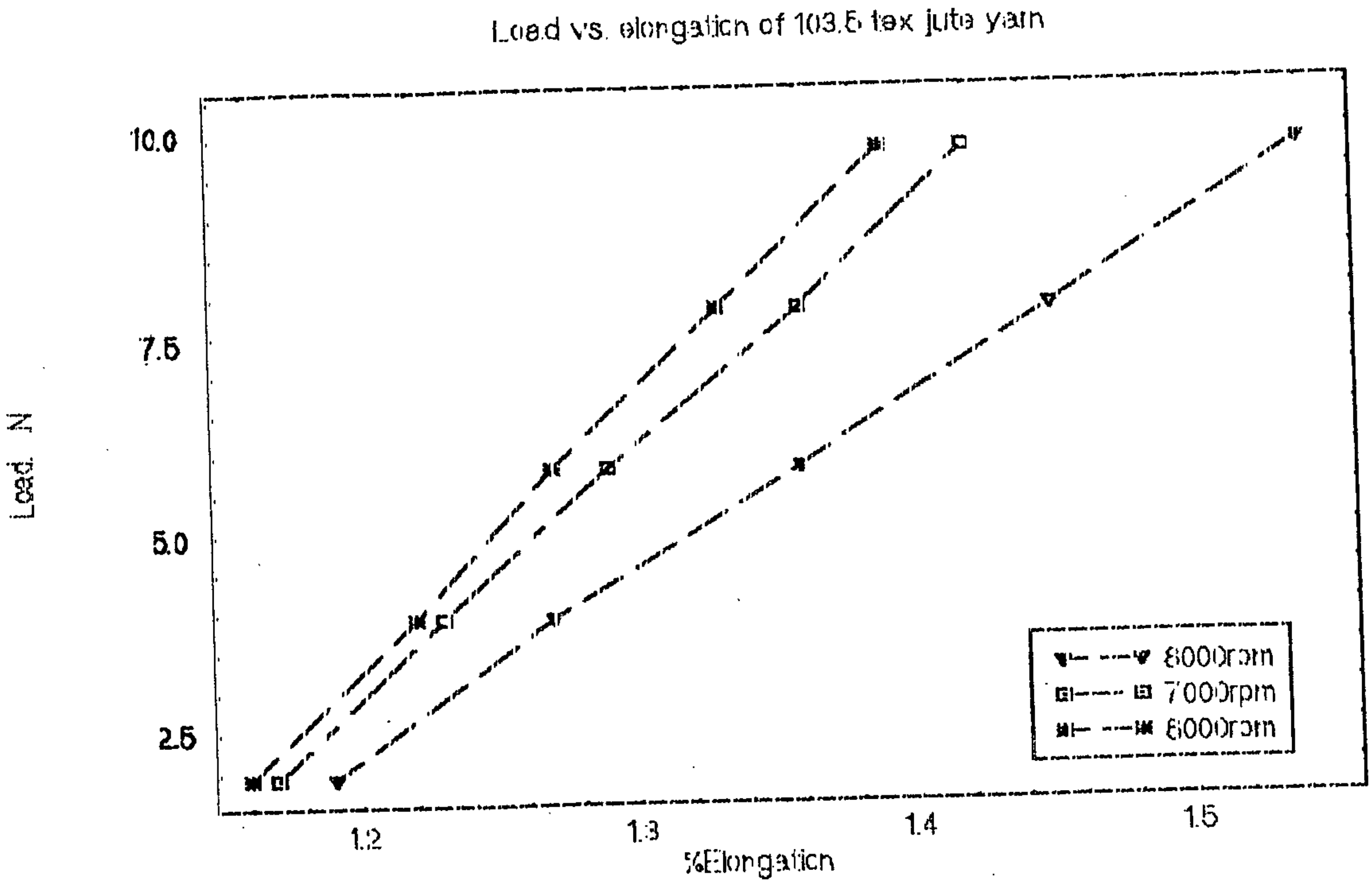


Figure 12: Load vs. elongation at various spindle speeds.

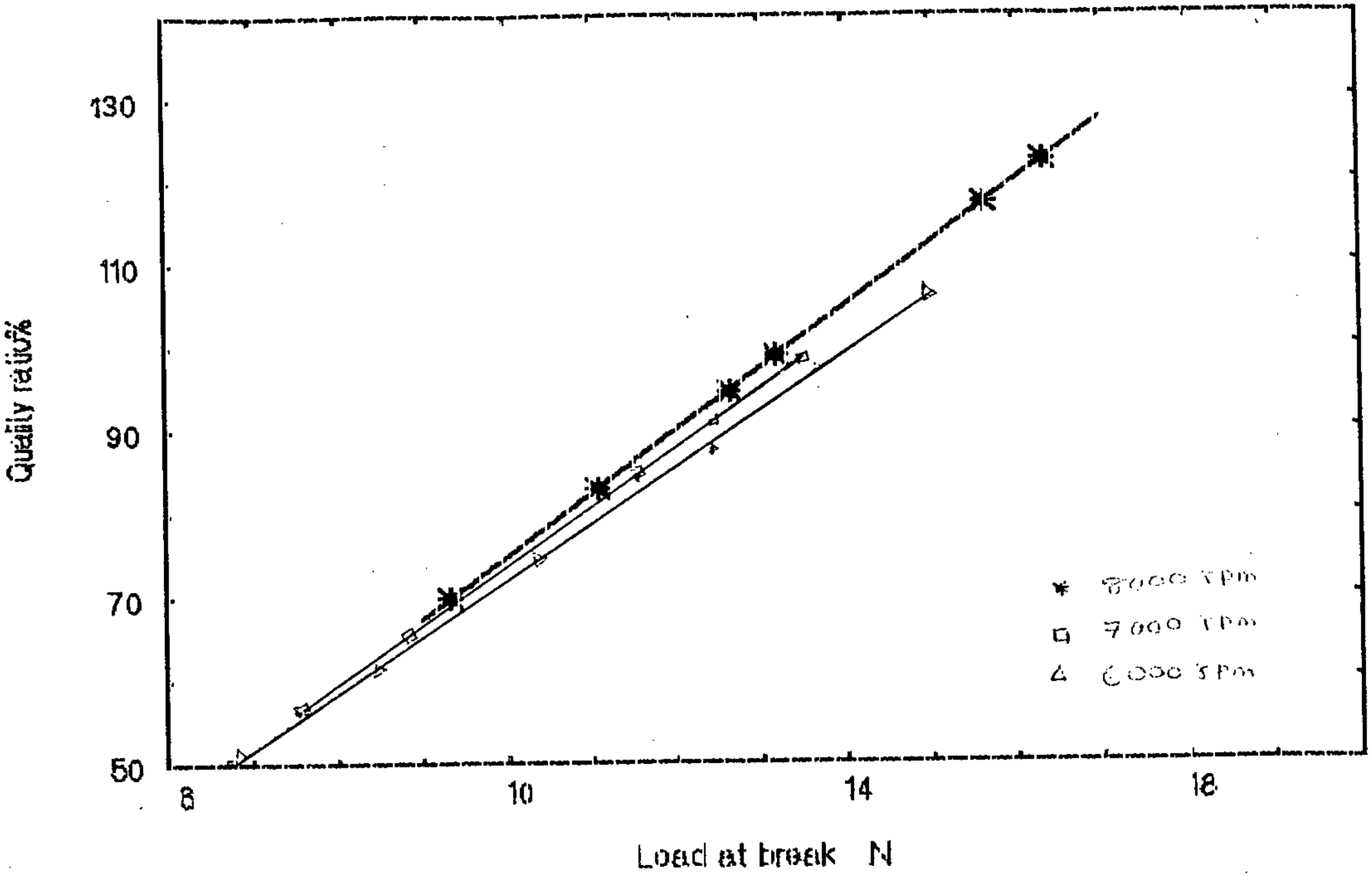


Figure 13: Load at break vs. quality ratio of the yarn at various spindle speeds.

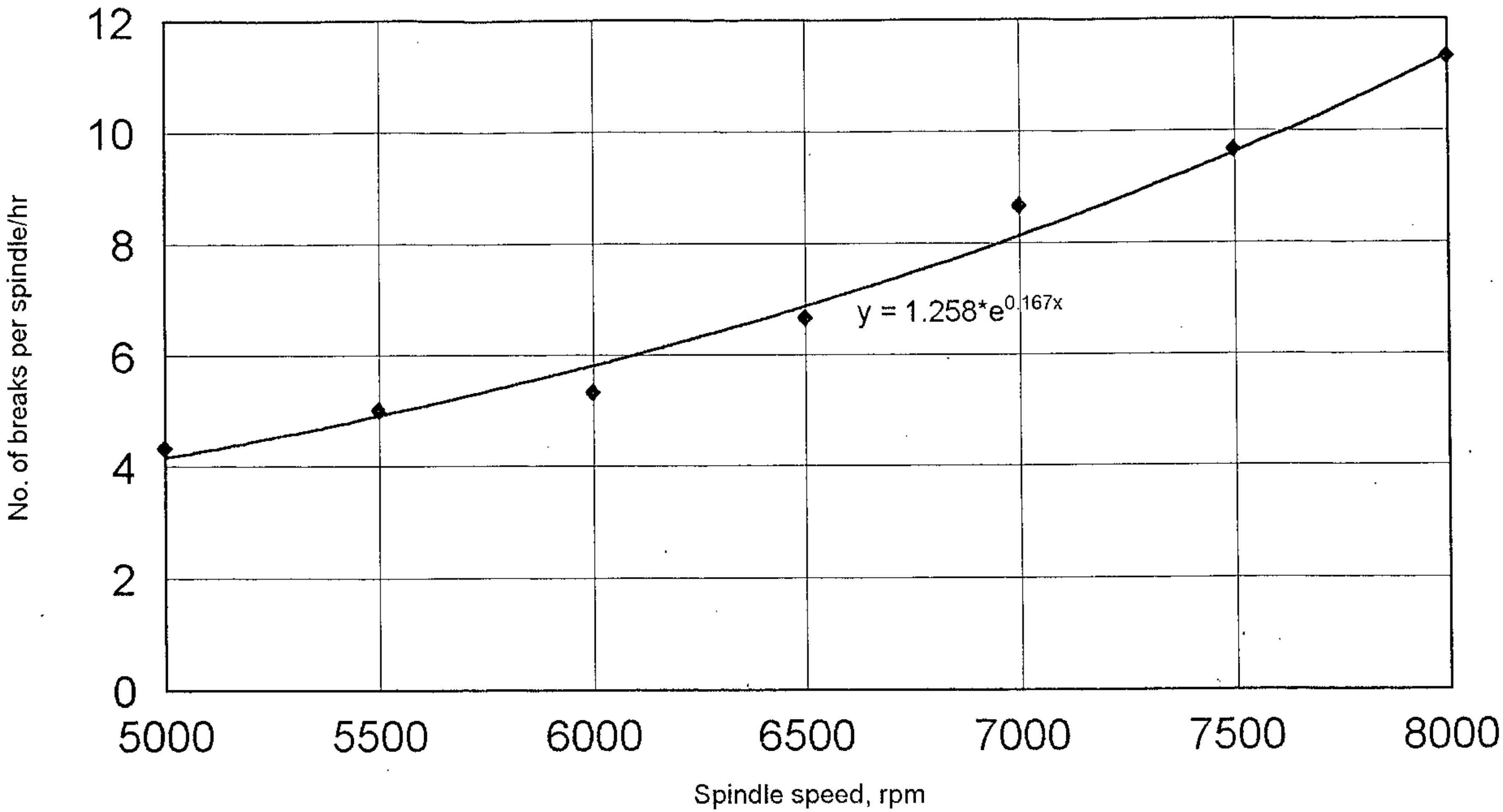


Figure 14: Spinning breaks vs. spindle speeds.

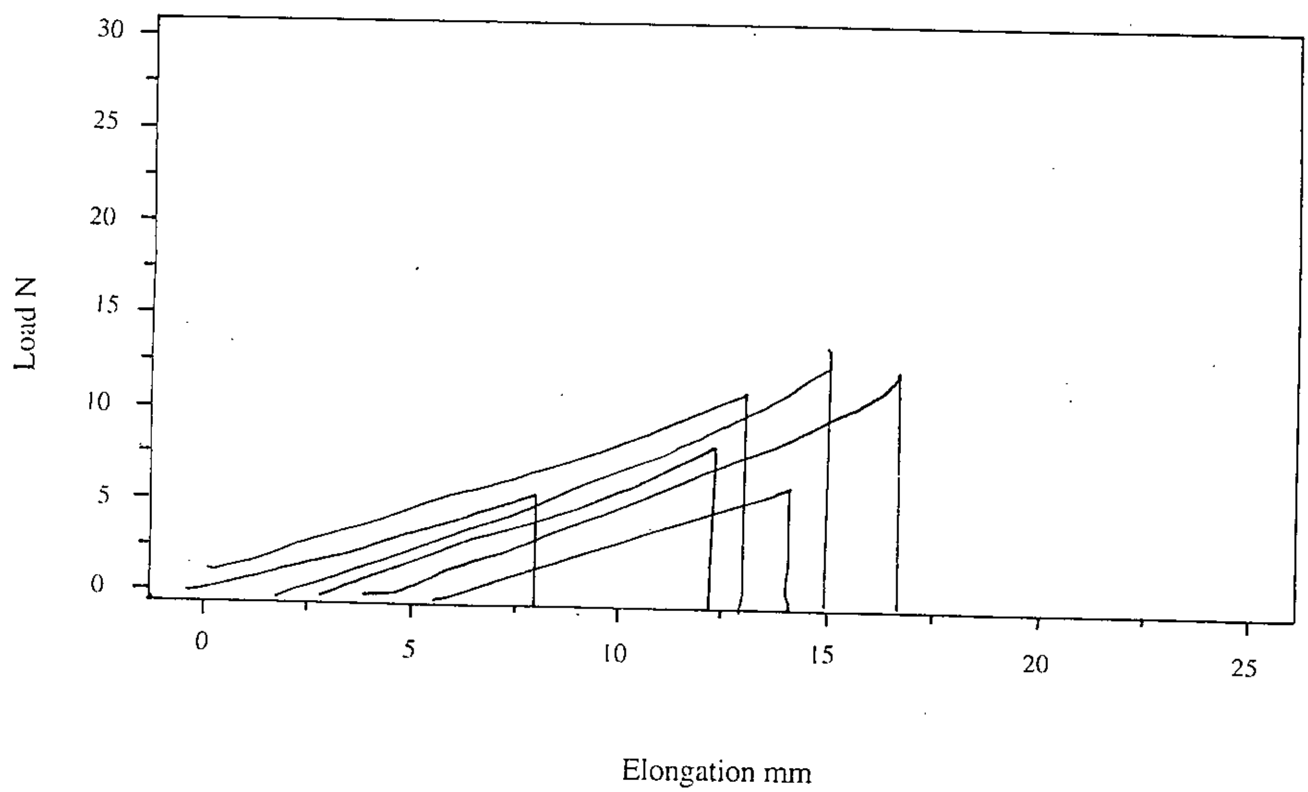


Figure 15: Load vs. elongation of 103.5 tex yarn produced from BWC jute fibre at 5000 rpm spindle speeds.

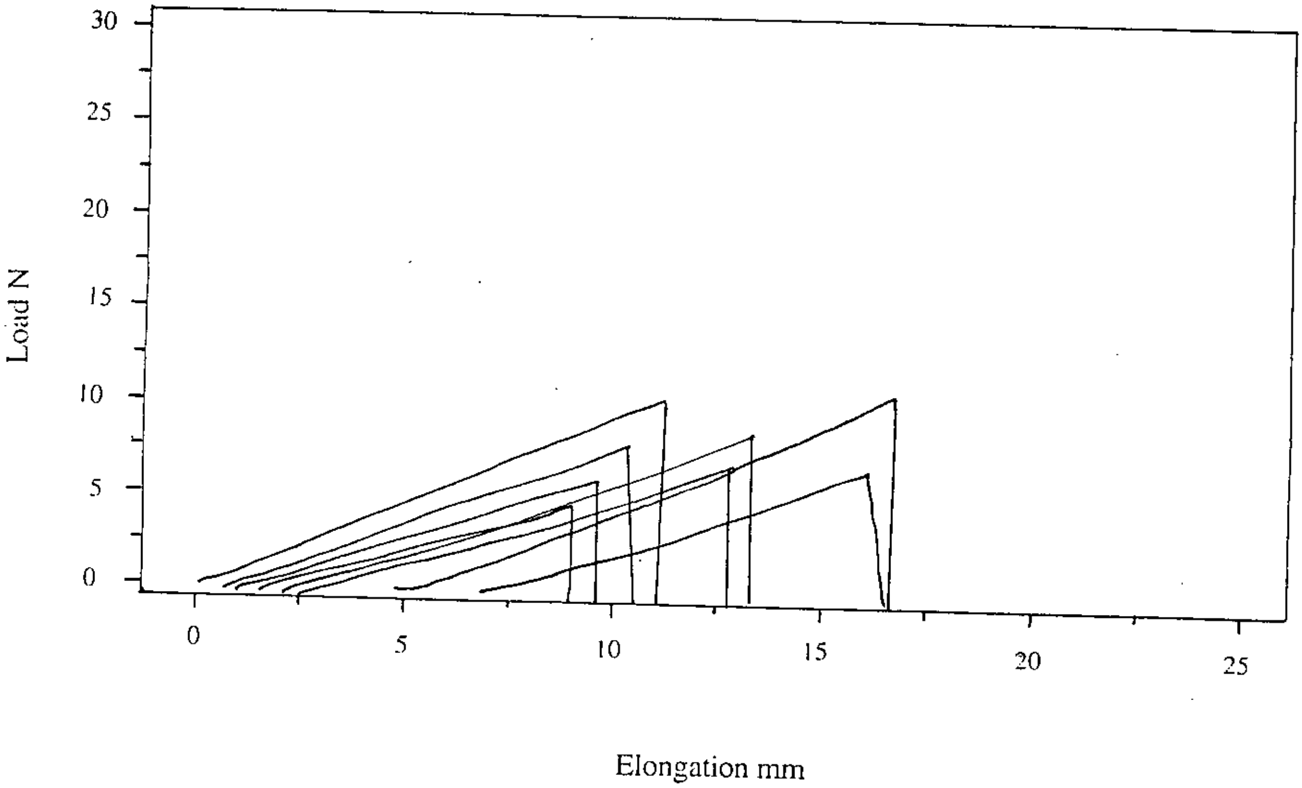


Figure 16: Load vs. elongation of 103.5 tex yarn produced from BWC jute fibre at 7000 rpm spindle speeds.

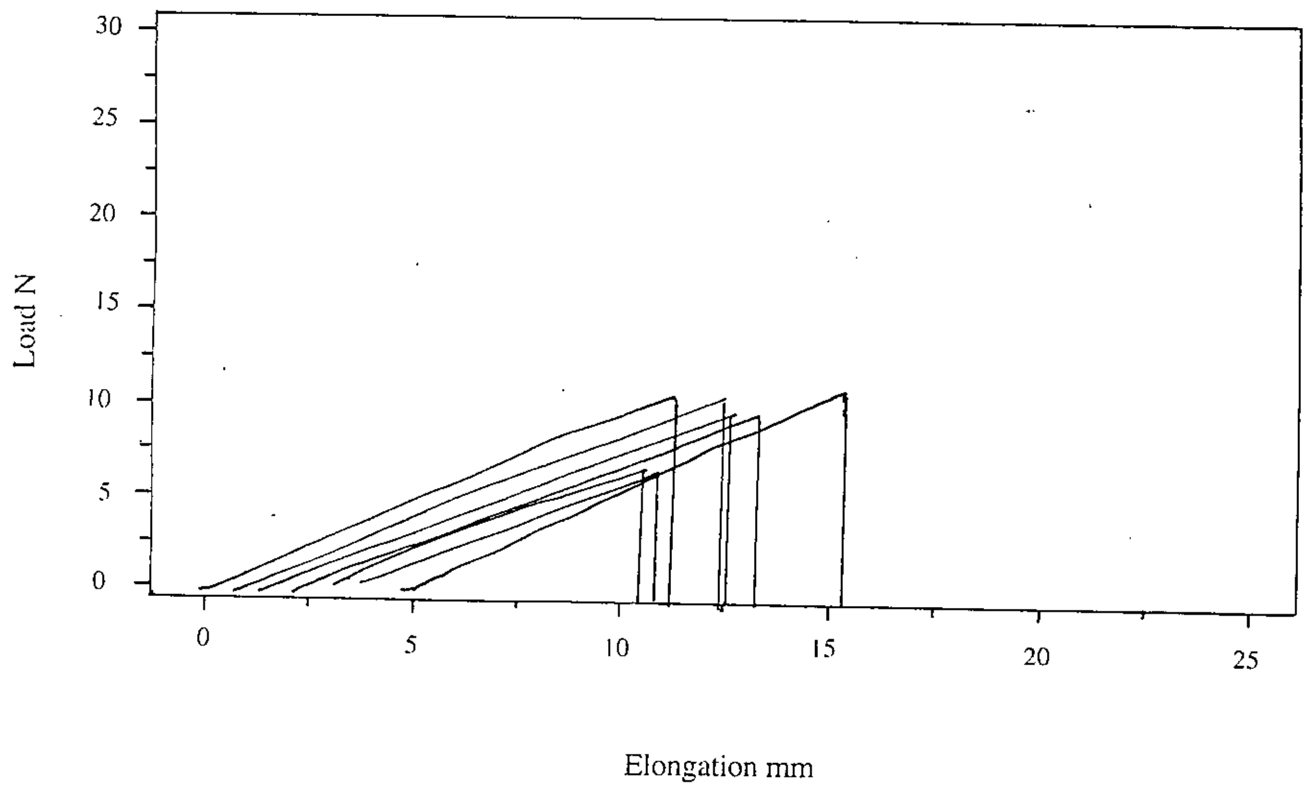


Figure 17: Load vs. elongatrion of 103.5 tex yarn produced from BWC jute fibre at 8000 rpm spindle speeds.

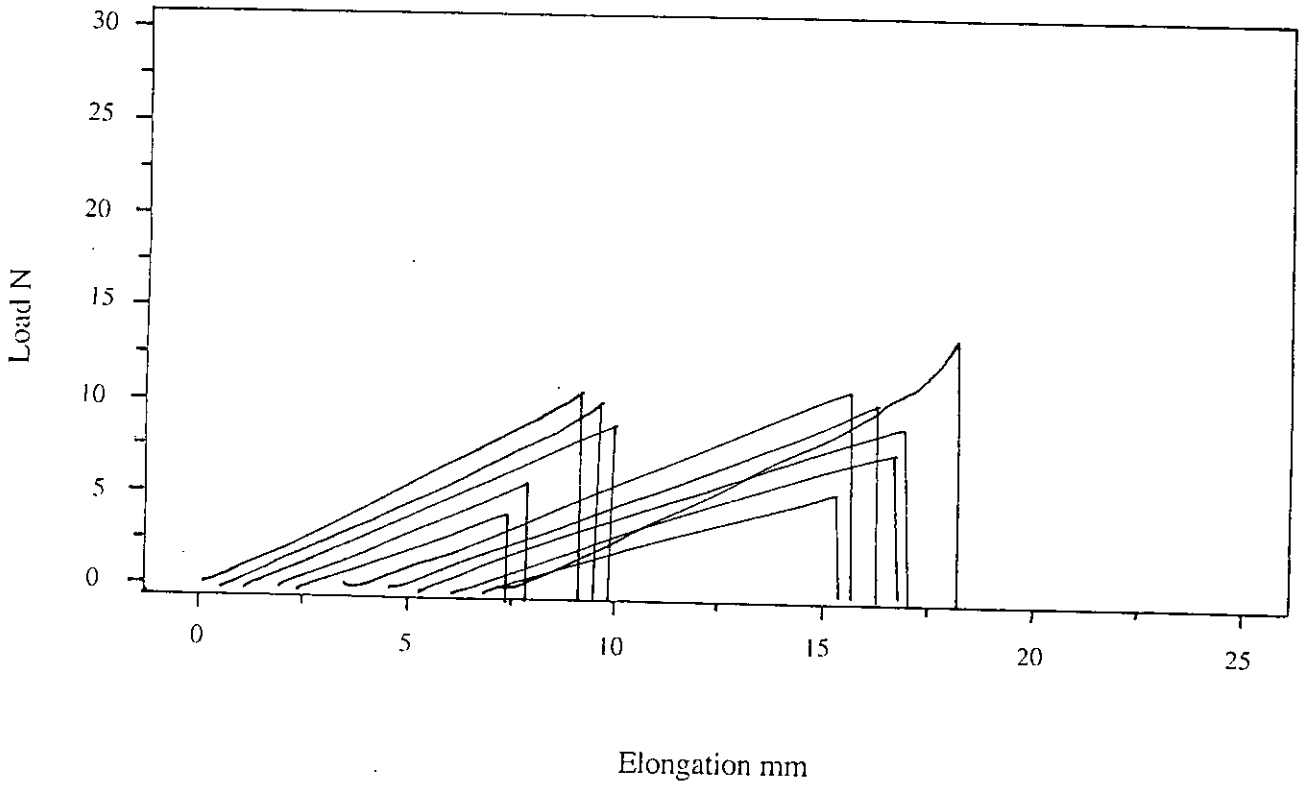


Figure 18: Load vs. elongation of 103.5 tex yarn produced from BTB jute fibre at 6000 rpm spindle speeds.

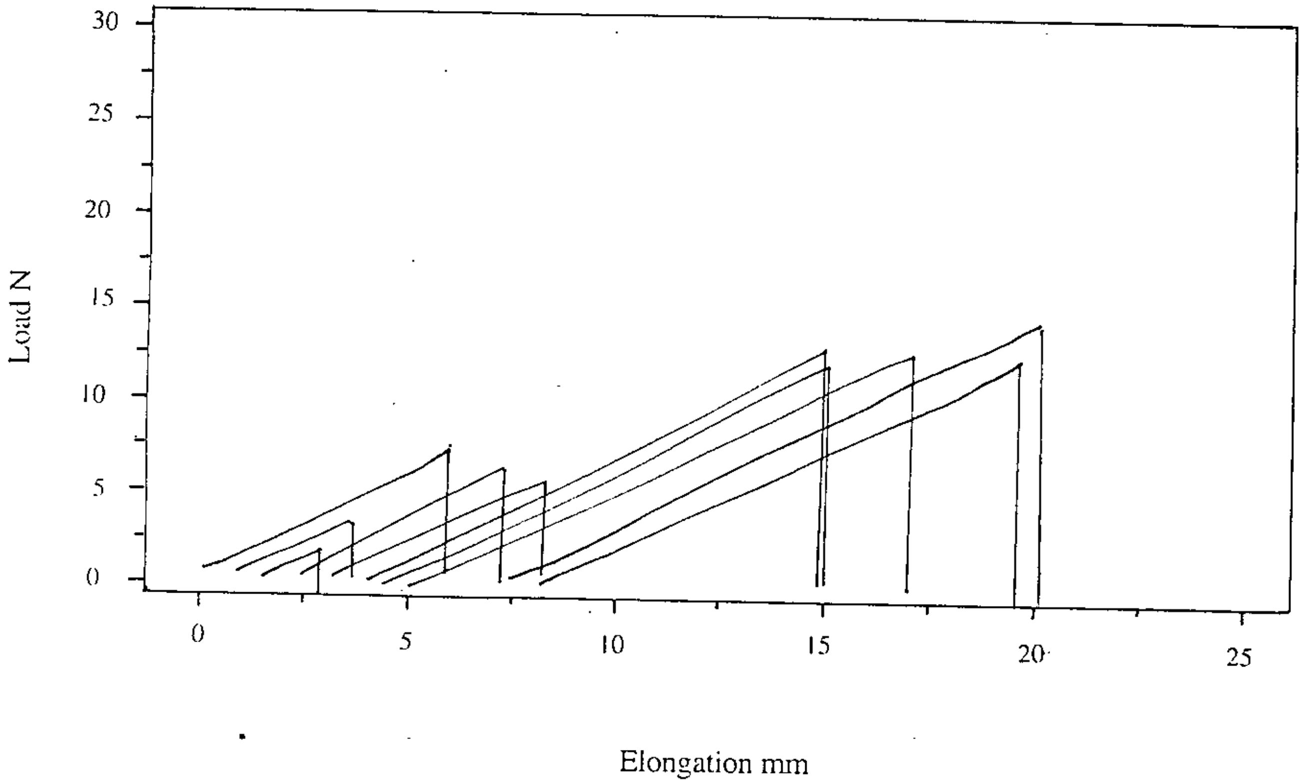


Figure 19: Load vs. elongation of 103.5 tex yarn produced from BTB jute fibre at 7000 rpm spindle speeds.

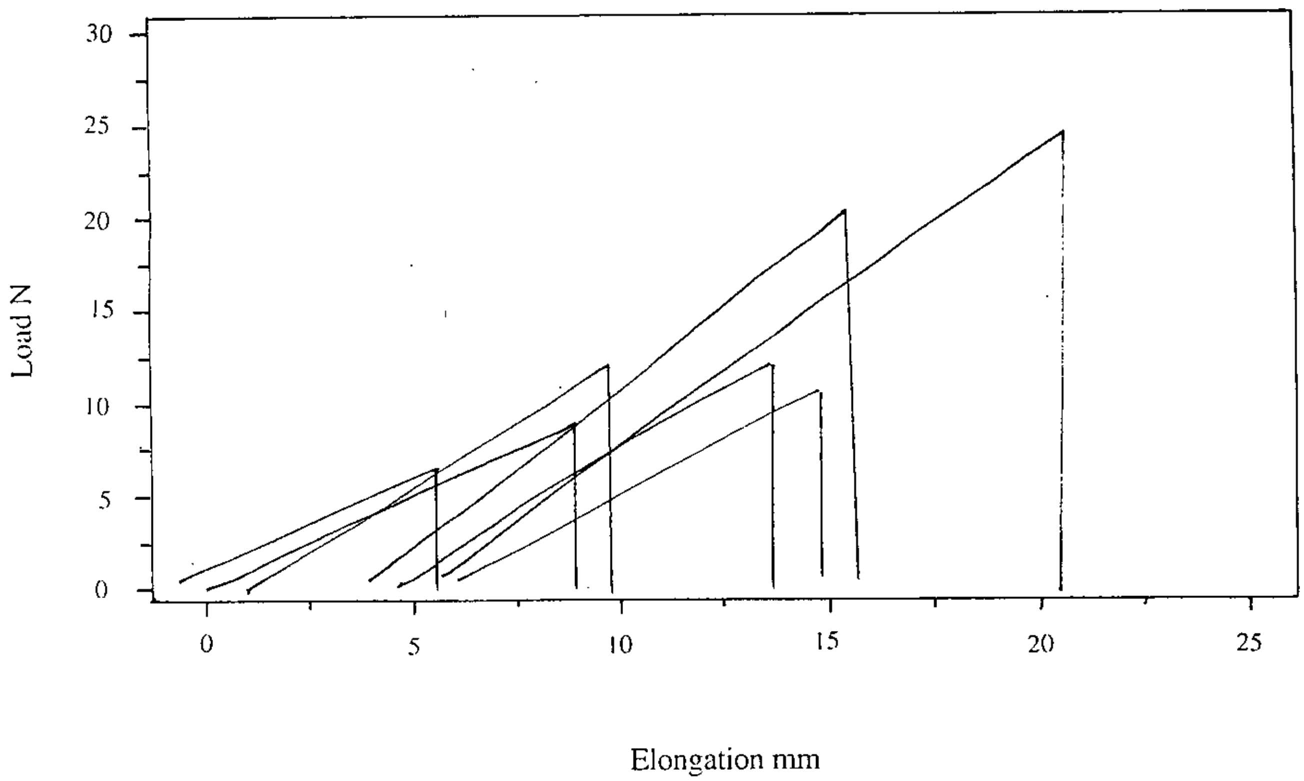


Figure 20: Load vs. elongation of 103.5 tex yarn produced from BTB jute fibre at 8000 rpm spindle speeds.

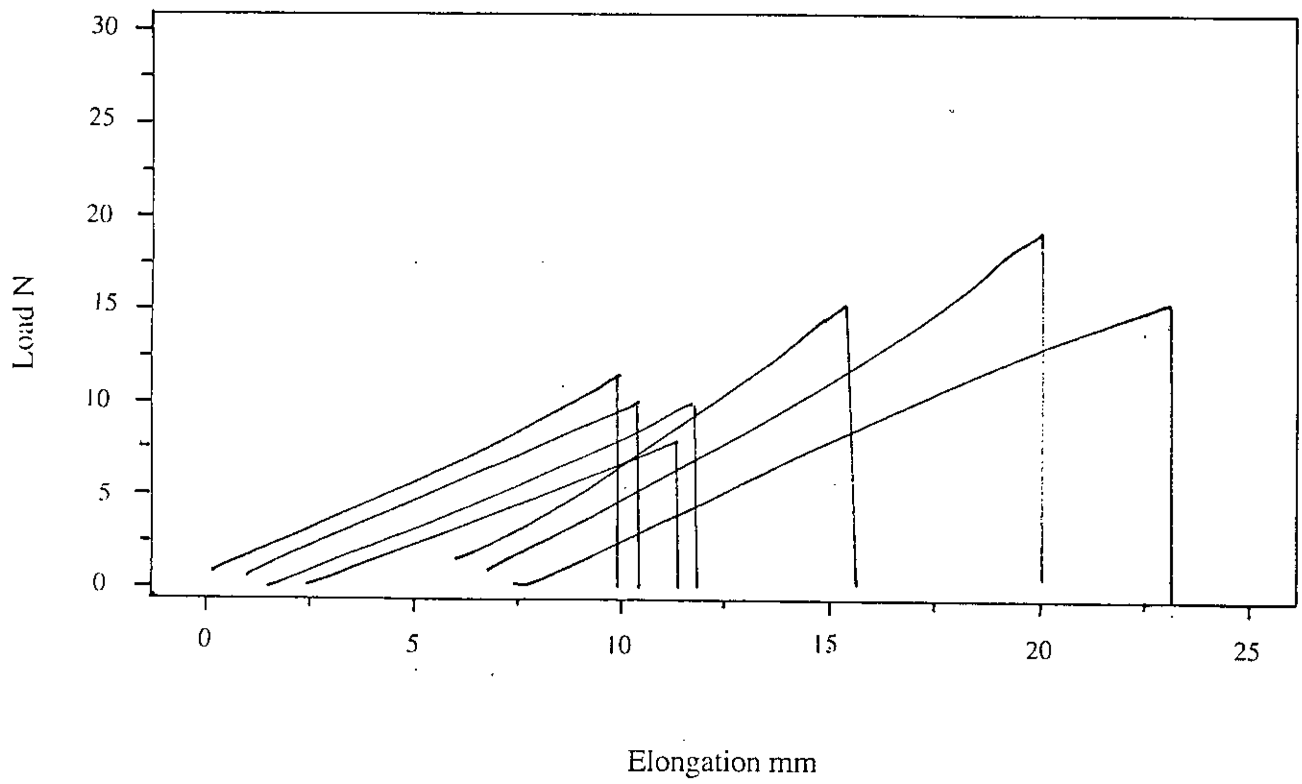


Figure 21: Load vs. elongation of 135.39 tex yarn produced from BWC jute fibre at 8000 rpm spindle speeds.

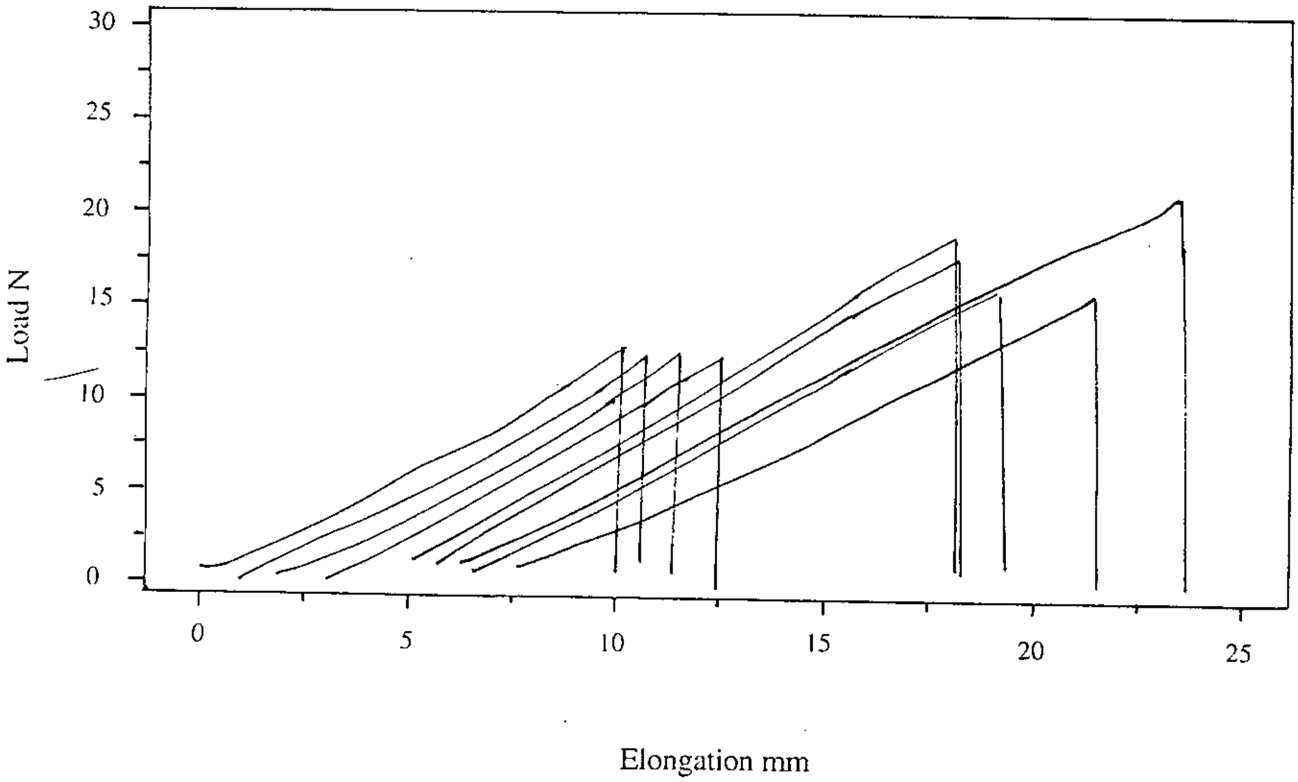


Figure 22: Load vs. elongation of 138 tex yarn produced from BWC jute fibre at 8000 rpm spindle speeds.

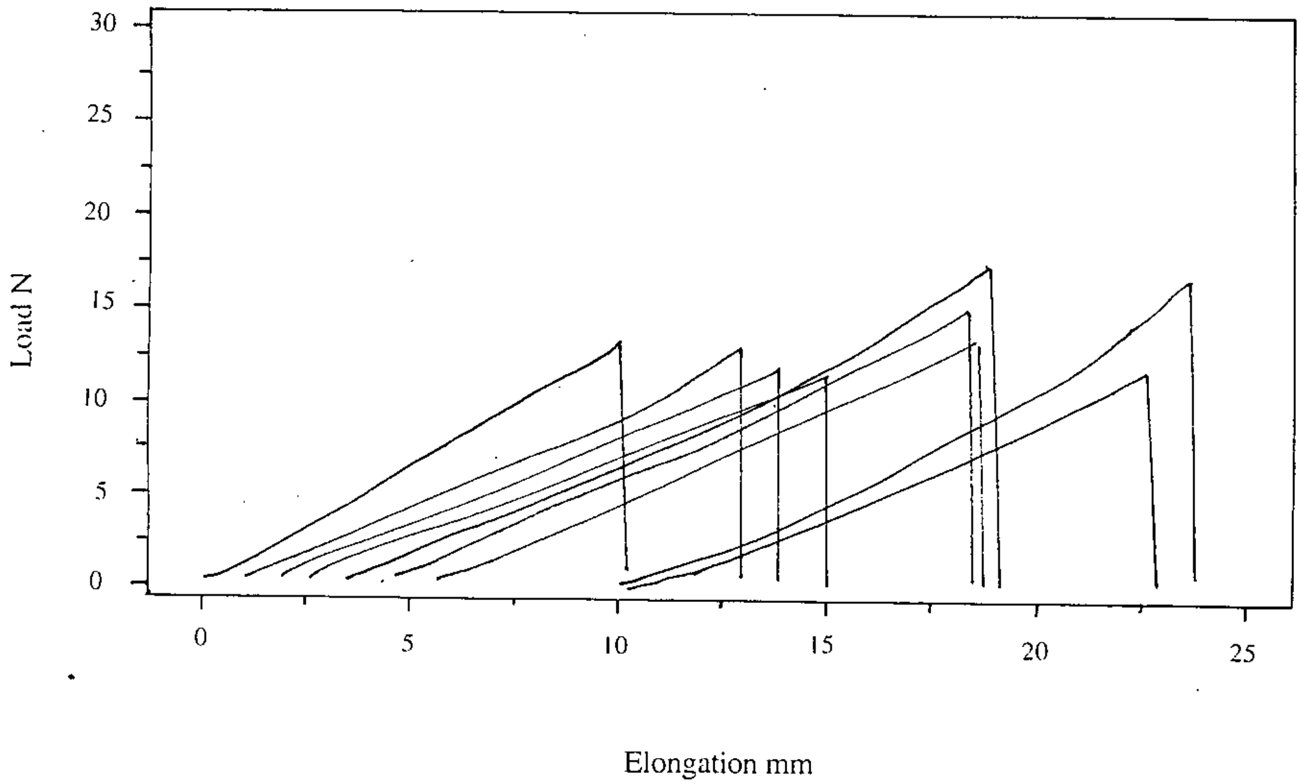


Figure 23: Load vs. elongationof 142 tex yarn produced from BWC jute fibre at 8000 rpm spindle speeds.

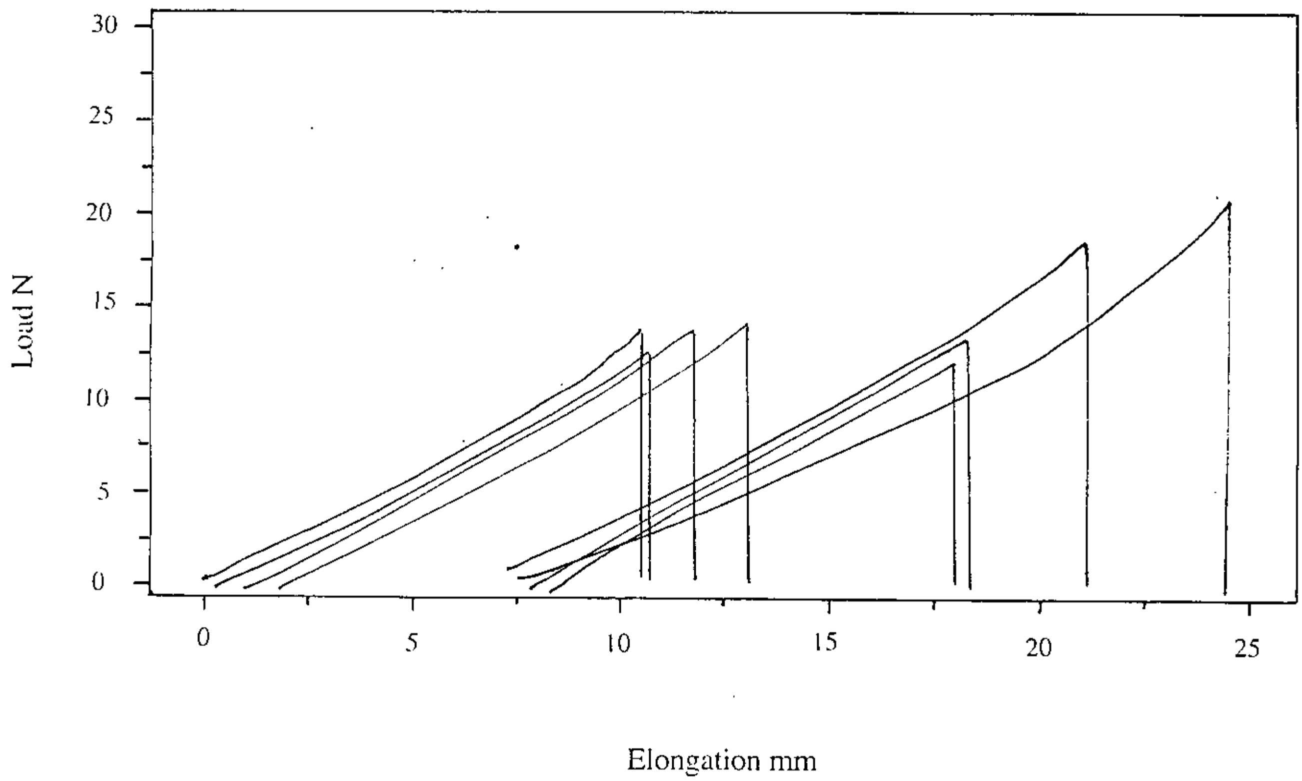


Figure 24: Load vs. elongation of 164 tex yarn produced from BWC jute fibre at 8000 rpm spindle speeds.

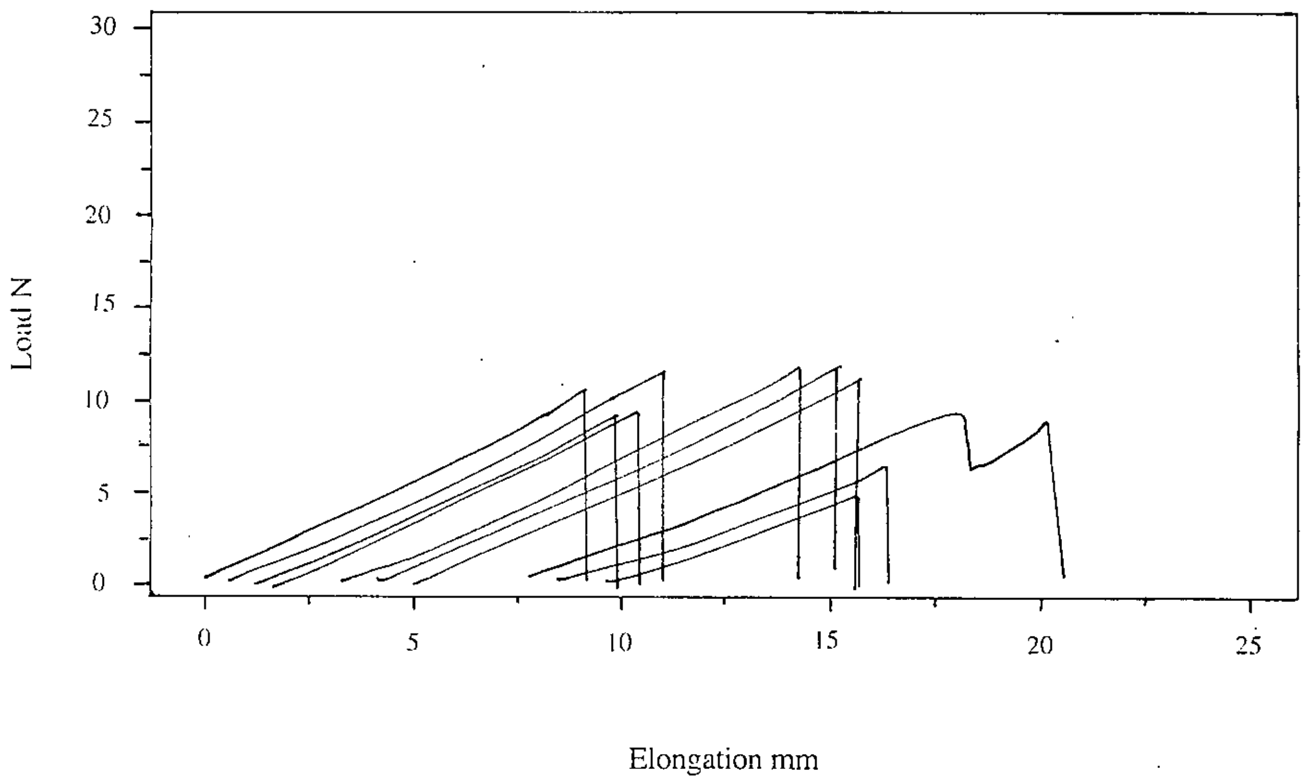


Figure 25: Load vs. elongation of 103.5 tex yarn produced from BWC jute fibre by Gardella spinning.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.494	1.135	0.047	4.12	36.3
2	1.082	1.944	0.103	5.27	79.5
3	0.845	1.330	0.080	6.02	62.1
4	0.480	1.078	0.045	4.22	35.3
5	0.797	1.368	0.076	5.53	58.6
6	1.000	1.545	0.095	6.23	73.5
7	1.079	1.595	0.102	6.41	79.3
8	0.480	1.425	0.046	3.19	35.3
9	0.801	1.303	0.076	5.82	58.8
10	0.498	1.142	0.047	4.13	36.6
Mean	0.756	1.387	0.072	5.10	55.5
S.D.	0.252	0.260	0.024	1.10	18.5
C.V.	33.289	18.766	33.289	21.60	33.3
Minimum	0.480	1.078	0.045	3.19	35.3
Maximum	1.082	1.944	0.103	6.41	79.5

Table-1: Mechanical properties of 103.5 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 5000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.988	1.556	0.094	6.02	72.6
2	1.178	1.420	0.112	7.87	86.6
3	0.505	1.287	0.048	3.97	37.1
4	0.743	1.144	0.070	6.15	54.6
5	0.647	1.163	0.061	5.27	47.5
6	0.796	1.343	0.075	5.72	58.5
7	0.592	1.131	0.056	4.99	43.5
8	1.239	1.447	0.117	8.12	91.0
9	0.480	1.001	0.045	4.54	35.3
10	0.795	1.237	0.075	6.09	58.4
Mean	0.796	1.273	0.075	5.87	58.5
S.D.	0.265	0.170	0.025	1.32	90.4
C.V.	33.236	13.387	33.236	22.53	33.2
Minimum	0.480	1.001	0.045	3.97	35.3
Maximum	1.239	1.556	0.117	8.12	91.0

Table-2: Mechanical properties of 103.5 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 7000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.843	1.587	0.080	5.10	61.9
2	0.879	1.360	0.083	6.13	64.6
3	0.992	1.294	0.094	7.26	72.9
4	0.719	1.294	0.068	5.26	52.8
5	0.698	1.209	0.066	5.47	51.3
6	0.942	1.401	0.089	6.35	69.2
7	0.748	1.216	0.071	5.83	55.0
8	0.765	1.281	0.073	5.66	56.2
9	0.681	1.313	0.065	4.90	50.0
10	0.732	1.345	0.069	5.16	53.8
Mean	0.880	1.330	0.076	5.71	58.8
S.D.	0.108	0.108	0.010	0.071	7.9
C.V.	13.480	8.130	13.480	12.52	13.5
Minimum	0.681	1.209	0.065	4.90	50.0
Maximum	0.992	1.587	0.094	7.26	72.9

Table-3: Mechanical properties of 103.5 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	1.016	1.473	0.096	6.53	74.7
2	0.923	1.413	0.088	6.16	67.9
3	1.150	1.426	0.109	7.64	84.5
4	0.708	1.370	0.067	4.90	52.0
5	0.717	1.297	0.068	5.23	52.6
6	1.135	1.476	0.108	7.29	83.4
7	1.109	1.409	0.105	7.45	81.5
8	1.168	1.515	0.111	7.30	85.8
9	1.447	1.542	0.137	8.89	106.3
10	1.007	1.253	0.095	7.61	74.0
11	1.121	1.354	0.106	7.84	82.3
12	0.705	1.237	0.067	5.39	51.8
Mean	1.017	1.397	0.096	6.85	74.7
S.D.	0.224	0.098	0.021	1.22	16.4
C.V.	22.005	7.050	22.005	17.75	22.0
Minimum	0.705	1.237	0.067	4.90	51.8
Maximum	1.447	1.542	0.137	8.89	106.3

Table-4: Mechanical properties of 103.5 tex jute yarn produced from BTB fibre by the modified machine at spindle speed of 6000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.795	1.247	0.075	6.04	58.4
2	0.786	1.307	0.074	5.70	57.8
3	1.114	1.535	0.106	6.88	81.9
4	1.221	1.534	0.116	7.55	89.7
5	1.263	1.447	0.120	8.28	92.8
6	1.182	1.337	0.112	8.38	86.8
7	1.149	1.165	0.109	6.75	84.4
8	0.947	1.438	0.090	6.24	69.6
9	0.995	1.406	0.094	6.71	73.1
10	1.040	1.726	0.099	5.72	76.4
11	1.350	1.644	0.128	7.78	99.2
Mean	1.077	1.476	0.102	6.91	79.1
S.D.	0.184	0.150	0.017	0.97	13.5
C.V.	17.050	10.142	17.050	13.99	17.0
Minimum	0.786	1.247	0.074	5.70	57.8
Maximum	1.350	1.726	0.128	8.38	99.2

Table-5: Mechanical properties of 103.5 tex jute yarn produced from BTB fibre by the modified machine at spindle speed of 7000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.600	1.186	0.057	4.78	44.1
2	0.987	1.539	0.094	6.07	72.5
3	1.345	1.483	0.127	8.59	98.8
4	1.666	1.981	0.158	7.97	122.4
5	1.870	2.294	0.177	7.74	137.4
6	1.291	1.661	0.124	7.50	94.5
7	1.595	1.913	0.151	7.90	117.2
8	1.498	1.921	0.142	7.39	110.1
9	1.130	1.296	0.107	8.25	83.0
10	0.951	1.374	0.090	7.66	69.9
Mean	1.293	1.665	0.123	7.37	95.0
S.D.	0.407	0.374	0.039	1.20	29.9
C.V.	31.469	22.485	31.469	16.27	31.5
Minimum	0.600	1.186	0.057	4.78	44.1
Maximum	1.870	2.294	0.177	8.59	137.4

Table-6: Mechanical properties of 103.5 tex jute yarn produced from BTB fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	1.048	1.904	0.076	3.96	58.8
2	1.108	1.703	0.080	4.71	62.1
3	0.859	1.408	0.062	4.42	48.2
4	0.892	1.557	0.065	4.15	50.1
5	1.078	1.545	0.078	5.05	60.5
6	0.998	1.449	0.072	4.99	56.0
7	0.933	1.510	0.068	4.47	52.3
8	1.221	1.609	0.088	5.50	68.5
9	1.288	1.762	0.093	5.29	72.2
10	1.260	2.168	0.091	4.21	70.0
Mean	1.069	1.662	0.077	4.68	59.9
S.D.	0.152	0.233	0.011	0.52	8.5
C.V.	14.230	13.993	14.230	11.06	14.2
Minimum	0.859	1.408	0.062	3.96	48.2
Maximum	1.288	2.168	0.093	5.50	72.2

Table-7: Mechanical properties of 135.39 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	1.132	1.663	0.080	4.84	62.4
2	0.996	1.501	0.071	4.71	54.9
3	1.181	1.537	0.084	5.46	65.1
4	0.916	1.541	0.065	4.23	50.5
5	1.637	2.380	0.116	4.92	90.2
6	1.464	2.207	0.104	4.80	80.7
7	1.276	1.818	0.091	4.98	70.3
8	1.039	1.494	0.074	4.94	57.2
9	1.095	1.648	0.078	4.72	60.4
10	1.230	1.699	0.087	5.15	67.8
Mean	1.197	1.749	0.085	4.88	65.9
S.D.	0.219	0.307	0.016	0.32	12.1
C.V.	18.310	17.547	18.310	6.52	18.3
Minimum	0.916	1.494	0.065	4.23	50.5
Maximum	1.637	2.380	0.116	5.46	90.2

Table-8: Mechanical properties of 138 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	1.204	1.583	0.083	5.25	64.4
2	1.028	1.798	0.071	3.95	55.0
3	1.625	2.215	0.112	5.07	86.9
4	0.966	2.093	0.067	3.18	51.7
5	1.162	1.896	0.080	4.23	62.2
6	0.997	1.600	0.069	4.30	53.4
7	1.371	1.879	0.095	5.04	73.4
8	1.205	1.852	0.083	4.50	64.5
9	1.237	1.962	0.085	4.35	66.2
10	1.567	2.776	0.108	3.95	83.9
Mean	1.236	1.965	0.085	4.38	66.1
S.D.	0.226	0.344	0.106	0.62	12.1
C.V.	18.291	17.526	18.291	14.24	18.3
Minimum	0.966	1.583	0.067	3.18	51.7
Maximum	1.625	2.776	0.112	5.25	86.9

Table-9: Mechanical properties of 142 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	1.396	1.835	0.084	4.55	64.7
2	1.422	1.790	0.085	4.75	65.8
3	1.150	1.531	0.069	4.49	53.3
4	1.320	1.443	0.079	5.47	61.1
5	1.646	1.804	0.098	5.46	76.2
6	1.414	1.745	0.085	4.84	65.5
7	1.301	1.587	0.078	4.90	60.2
8	1.252	1.573	0.075	4.76	58.0
9	1.702	1.946	0.102	5.23	78.8
10	1.820	2.005	0.109	5.43	84.3
Mean	1.442	1.726	0.086	4.99	66.8
S.D.	0.214	0.185	0.013	0.38	9.9
C.V.	14.820	10.748	14.820	7.56	14.8
Minimum	1.150	1.443	0.069	4.49	53.3
Maximum	1.820	2.005	0.109	5.47	84.3

Table-10: Mechanical properties of 164 tex jute yarn produced from BWC fibre by the modified machine at spindle speed of 8000 rpm.

Sample No.	Load at Break (kgf)	% Strain at Break (%)	Tenacity at Break (N/Tex)	Textile Modulus (N/Tex)	Quality Ratio (%)
1	0.787	1.615	0.078	4.84	60.7
2	1.019	1.677	0.101	6.03	78.5
3	1.047	1.568	0.104	6.62	80.7
4	0.794	1.428	0.079	5.53	61.2
5	0.678	1.062	0.076	6.31	52.2
6	0.835	1.526	0.082	5.65	64.4
7	0.760	1.476	0.075	5.12	58.6
8	0.786	1.352	0.078	5.76	60.6
9	0.905	1.383	0.090	6.48	69.7
10	0.756	2.186	0.075	4.65	58.3
Mean	0.837	1.528	0.083	5.70	64.5
S.D.	0.126	0.305	0.012	0.72	9.7
C.V.	15.016	19.991	15.016	12.67	15.0
Minimum	0.678	1.062	0.067	4.65	52.2
Maximum	1.047	2.186	0.014	6.62	80.7

Table-11: Mechanical properties of 103.5 tex jute yarn produced from BWC fibre by Gardella spinning machine.

Name of the Machine	Load at break (kgf)	% strain at break	Tenacity at break N/Tex	Textile modulus N/Tex	Quality ratio %
Gardella spinning	0.837	1.528	0.083	5.70	64.50
Modified ring spinning machine	0.880	1.330	0.076	5.71	58.80

Table-12: Comparison between properties of yarns produced by Gardella spinning machine and modified ring spinning machine (103.5 Tex, BWC fibre).

Load at Break (N)	Quality Ratio (%)	Load at Break (N)	Quality Ratio (%)	Load at Break (N)	Quality Ratio (%)
6000 rpm		7000 rpm		8000 rpm	
6.91	51.8	7.71	57.8	5.88	44.1
6.94	52.0	7.79	58.4	9.32	69.9
7.03	52.6	9.29	69.6	9.68	72.5
9.05	67.9	9.76	73.1	11.08	83.0
9.87	74.0	10.20	76.4	12.66	94.5
9.96	74.4	11.59	81.8	13.19	98.8
10.87	81.5	10.92	81.9	14.69	110.1
10.99	82.3	11.27	84.4	15.64	117.2
11.13	83.4	11.90	89.7	16.34	122.4
11.28	84.5	12.39	92.8	18.34	137.4
11.45	85.5	13.24	99.2	---	---
14.19	100.3	---	---	---	---

Table 13: Variation of Quality Ratio with Load at Break of 10.35 Tex (3 Count) Jute Yarn Produced at Different Spindle Speeds.

Spindle Speed	Break per Spindle-hr			Average Breaks per Spindle-hr
	1st	2nd	3rd	
5000	4	4	5	4.33
5500	6	4	5	5.00
6000	7	5	4	5.33
6500	7	7	6	6.66
7000	8	9	9	8.66
7500	8	11	10	9.66
8000	11	13	10	11.33

Table 14: Effect of Spindle Speed on Spinning Breaks 103.5 Tex Jute Yarn.

Region/ Country	1986/87 1989/90 (Average)	1990/91	1991/92	1992/93	1993/94 Provisional
(............................Thousand tons....................................)					
World	**3296.2**	**3639.9**	**3410.7**	**3153.4**	**2975.9**
Bangladesh	849.5	914.6	945.1	885.4	783.0
China	619.4	726.6	513.0	619.0	650.0
India	1375.5	1638.5	1620.0	1332.0	1224.0
Nepal	18.1	16.1	19.1	10.0	10.0
Thailand	186.5	181.0	157.2	130.4	134.0

Table 15: Production of Jute, Kenaf and Allied Fibres in Major Jute Producing Countries.[4]

Region/ Country	1986/87 1989/90 (Average)	1990/91	1991/92	1992/93	1993/94 Provisional
In Thousand tons					
World Total	**444.8**	**378.9**	**350.3**	**347.8**	**n.a.**
Bangladesh	327.6	288.0	275.9	282.2	324.0*
China	61.8	45.0	36.3	32.1	n.a.
India	7.5	10.1	9.0	9.0	n.a.
Nepal	12.0	0.8	1.3	1.0	n.a.
Thailand	5.5	6.6	6.2	5.9	n.a.

Table 16: Export of Raw Jute, Kenaf and Allied Fibres.[4]

Country	1986-89	1990	1991	1992	1993
In Thousand tons					
Bangladesh	641.4	644.5	530.6	600.5	535.2*
China	728.4	709.2	608.4	588.5	n.a.
India	1412.7	1527.4	1546.1	1248.6	364.4*
Nepal	17.2	13.2	16.4	11.8	n.a.
Thailand	207.9	163.0	146.1	141.0	19.7*
Pakistan	112.6	99.7	108.6	106.5	25.5*

Table 17: Production of Jute Goods in the Major Jute Manufacturing Countries.[4]

Product Type	1986/87 1989/90 (Average)	1990/91	1991/92	1992/93	1993/94 (July-Oct./93)
Hessian (40"/10 oz) (US$/100 Yards)					
Bangladesh	19	20	17	15	14
India	21	23	18	15	15
B-Twist (Sacking) (US$/100 Bags)					
Bangladesh	44	43	39	38	39
India	56	67	45	44	42
Carpet Backing (US$/Metric Ton)					
Bangladesh	724	672	658	633	571
India	736	669	675	747	606
Yarn (US$/Metric Ton)					
Thailand	530	638	687	730	764

Table 18: Export Prices of Jute Products.[4]

Region/ Country	1986/87 1989/90 (Average)	1990/91	1991/92	1992/93	1993/94
In Thousand tons					
World	**1076.3**	**872.9**	**912.4**	**924.6**	**n.a.**
Developing	**977.6**	**760.0**	**817.4**	**831.7**	**n.a.**
Bangladesh	515.3	386.7	487.0	491.7	n.a.
India	233.2	196.8	186.2	215.4	n.a.
Nepal	10.9	14.6	11.4	10.0	n.a.
Thailand	113.3	85.8	69.0	55.3	n.a.
China	78.4	57.6	47.8	50.0	n.a.
Developed	**98.7**	**112.9**	**95.0**	**92.9**	**n.a.**

Table 19: World Export of Products of Jute, Kenaf and Allied Fibres.[4]