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Modification of Adapter in Auto Cone Winding Machine for Better Performance

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Abstract: The economy of Bangladesh is largely depending on textile and garments industries at this moment. In this industry the overall demand of quality and cost reduction is increasing constantly along with steadily growing production capacities. For these reasons backward linkage industry like spinning plays a vital role for sustainable textile production in Bangladesh. Winding machine plays a significant role in quality of ring spun yarn in a spinning factory. Modification of adapter used in winding machine is accomplished in this work. Two diameter of adapter such as 58 mm and 68 mm was produced from nylon fibre and attached to the Muratec 21C winding machine. By using these two modified and one conventional metallic adapter three different fineness of yarn such as 30's Ne cotton, 40's Ne PC, and 50's Ne cotton was produced by ring spinning machine in the same processing parameters. Those yarns were wound with 900, 1100, 1300, 1400 & 1500 m/min with original and modified adapters. After winding of yarn different quality parameters like unevenness (%), imperfection index (-), hairiness (-), Count Strength Product (CSP) were tested through Uster Evenness Tester 5 and Ele Stretch XT tester accordingly and compared them. Power consumption was measured by TRINITY (NF29) energy meter. It was found from the analysis of all test results that adapter of 58 mm performed the best; 68 mm made from nylon fibre the better among three along with cost savings is also possible in using nylon adapter.

***Keywords**: Winding, Adapter, Yarn Properties, Power Consumption, Cost savings.*

I. INTRODUCTION

The textile industry is well-thought-out as a traditional because of its importance and necessity in the manufacturing world and provides employment to several million (or even more) people [1].This industry becomes more competitive today and giving tax to machine manufacturer so that they can produce more sophisticated, accurate technology for effective and economic benefit [2]. Ring spinning is considered the dominating spinning system for production of yarn for apparel application.

Two leading European machine manufacturers named Rieter (Switzerland) and Cognetex (Italy) have investigated in recent time for further development in ring spinning system for development of quality.

They found two major drawbacks that high-power consumption and lower capacity of ring package [3]. New spinning system alternative to ring spinning system is developed at late sixties and early seventies the course and medium fineness range. The reason of this development is that high production, removal of winding and roving and introducing automation [4]. Yarn is produced for making textiles for variety of process like weaving, knitting and felting. Winding section shows a vital role both in production and quality of yarn. The yarn obtained from ring frame cannot be used directly or sell to customer because they cannot use it in this form. To make the yarn usable it is passed through the optical sensor of winding machine and then can be sellable [5] although yarn hairiness increases after winding machine [6].“Winding is the process of transferring a yarn from one package to form another package that is more suitable for subsequent processing the yarn.” There are mainly two types of packages used in textile industry such as flangeless and flanged package. The main disadvantages of flanged package in winding is that, the whole package must be rotated for that reason flangeless package is preferable in spinning. There are three types of wound package s in terms of how the yarn is laid on the package like - the parallel wound package - the near-parallel wound package - the cross-wound package. In cross winding single yarn is arranged on the package at a considerable angle so that layers of yarn cross one another giving stability. Two types of packages are made on the cross winding one is that have the surface of the package tapered to its axis, and those that have the surface parallel to the axis. First one is called a cone whereas second one is known as a tube or cheese. Diameter and traverse length for cheese package are known although to specify a cone requires three parameters; the base diameter, the taper, and the traverse length [7].

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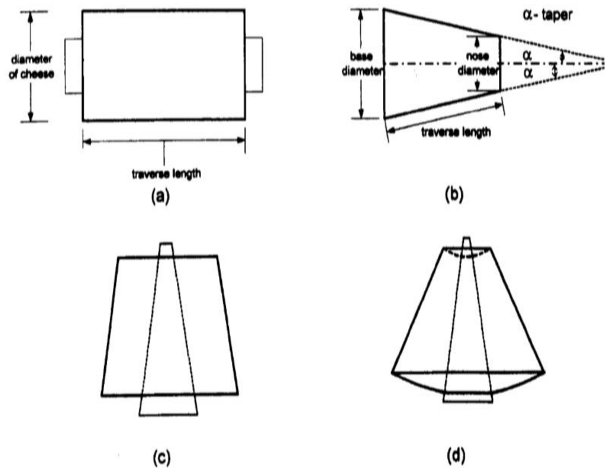

Fig. 1. (a) Cheese (b) Cone (c) Constant-taper cones (d) Accelerated-taper cones [7]

Groove drum winder machine is used mostly in spun yarn winding.

The groove in the drum helps the intersection and depth of the groove helps the traverse hence the yarn is traversed across the package without the limitations of speed and power arising from the inertia of a finger type traverse, permitting high winding speeds up to about 1200m/min, lower power consumption, decrease maintenance costs, and relative velocity between the yarn and the guide [8].The two winding machine parameters which have prodigious influence on the properties of a spun yarn package are yarn tension and package cradle contact pressure [9].Bearing is a device which is used to reduce friction and it is worked on the principle of rolling friction [10]. In the processing of power conservation, a motor plays a vital role and many motor manufacturers as well as users have paid attention for factors affecting the normal operation of it. Bearing is one of the factors that affecting the normal operation of the motors and generators in recent time [11].

The aim of this paper is that to prepare a light weight adapter with attachment of right-hand side in bearing for winding machine which will help better gripping of paper tube as well as less power consumption of machine that will be more economical for a spinning industry in addition with improving yarn qualities.

II. MATERIALS AND METHODS

Materials

In this research work, shaft like nylon fiber rod was used as a raw material. The nylon rod was collected from the local market. It is very cheap and available in the market in different diameter. The specification of nylon rod is given bellow:

Table-I: Properties and specification of nylon rod

Description	Value	ASTM Test Method
Type of Nylon	Nylon 6 Cast (Rod Type)	-
Specific Gravity	(1.15-1.17) g/cm^3	D792
Tensile Strength	(10000-13500) psi	D638
Tensile Modulus	(400,000-500, 000) psi	D638
Melting Point	(420-440) ° F	D3418
Hardness (Shore)	(78-84) D	D2240
Thickness	26 mm	-
Diameter	80 mm	-
Weight	116g	-

Other raw materials used for this work were paper board which was collected from local market. Cameroon cotton and PET polyester fibres were used to produce yarn. Properties of paper board, cotton and polyester fibres are provided table 2, 3 and 4 respectively.

Table-II: Paper board specification

Description	Value/Name
Raw Material	Mixture of bamboo and wood pulp
GSM	150
Type	Craft paper board

Table-III: Cotton fibre properties

HVI		AFIS	
Properties	**Values**	**Properties**	**Values**
SCI	137	NEP (Cnt/g)	227
Moisture (%)	7.8%	NEP Size (um)	697
Mic Value	4.15	SCN (Cnt/g)	19
Maturity Ratio	0.86	SCN (um)	1060
UHML (mm)	29.62	SFC (%)	8.4
UI (%)	81.7	UQL (mm)	31.24
SF (%)	10.2	5% (mm)	35.81
Strength (GPT)	31.2	Fineness (mtex)	156
Elongation (%)	6.1	IFC (%)	4.8

Table-IV: Polyester fibre properties

Parameters	Values
Length (mm)	32
Fineness (Denier)	1.4
Tenacity(g/tex)	43
Moisture (%)	0.4

Methods

Right Hand Adapter Preparation

Two different diameters of adapters were produced firstly for this work. Lathe machine was used for making two adapters. Nylon rod of 80 mm diameter was firstly held between two rigid and strong supports called chuck or face plate which revolves. The cutting tool was rigidly held and supported in a tool post which was fed against the revolving work. The normal cutting operations were performed with the cutting tool fed at right angles to the axis of the work. The cutting tool may also be fed at an angle relative to the axis of work for machining tapers and specific angles. Plain turning was done for removing excess amount of material from the surface of a nylon rod and step turning produces various steps of different diameters. Then facing was completed to make the rod flat by removing material from it and producing a cylindrical hole in it. Next reaming operation was accomplished to finish and size of hole that drilled into the rod and boring was performed for enlarging the hole already produced by drilling. Subsequently grooving was acted of reduced diameter in the rod. Later forming was done to round the flat shape and filling for burrs, sharp corners and feed marks from the rod. After filing, the surface quality of the nylon rod was improved by the polishing operation with the help of emery cloth of fine grades. Afterwards the taper turning is achieved of producing a conical surface by gradual reduction in the diameter of a cylindrical rod. A bosh made of brush material was put inside the adapter center for smooth operation during running time. In this stage the main finishing task of adapter center is done by scraper for finishing of the roughness of the nylon shaft surface of adapter. Two nylon adapters were made in the same procedure. After making the adapter center it was installed in the adapter cradle. The produced two nylon and a mild-steel adapter are designated by the following way-

Mild Steel Adapter of Diameter 68 mm = System A
Modified Nylon Adapter of Diameter 68 mm = System B
Modified Nylon Adapter of Diameter 58 mm = System C

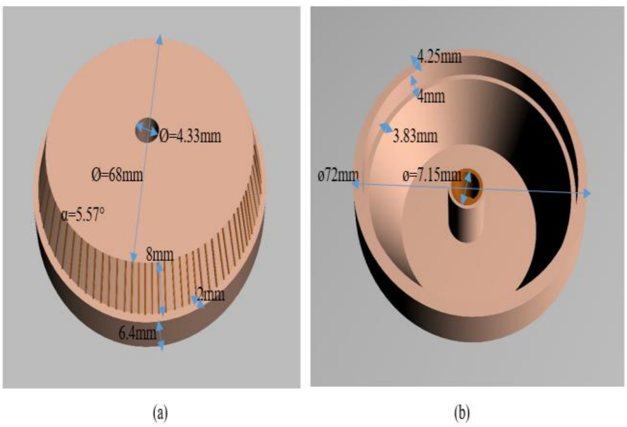

Fig. 2. (a) Front and (b) Back view of system B

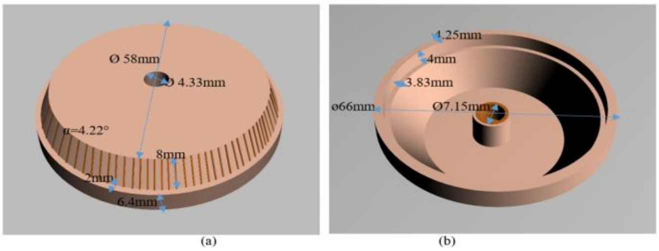

Fig. 3. (a) Front and (b) Back view of system C

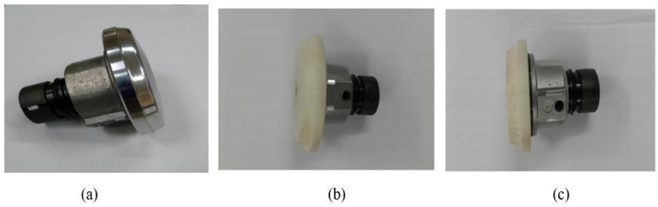

Fig. 4. After assembling the adapter in bearing (a) system A (b) system B and (c) System C

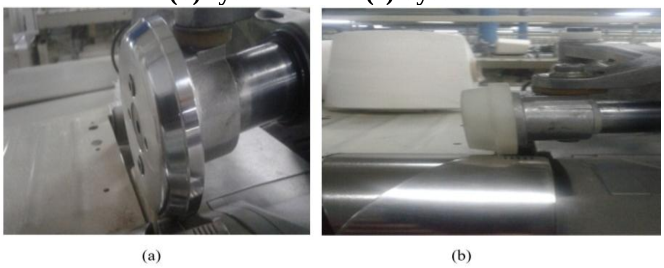

Fig. 5. Adapter in winding machine (a) Mild steel (b) Nylon

Table-V: Physical comparison of adapter

Parameters	System A	System B	System C
Diameter	68mm	68mm	58mm
Weight	225gm	39.5gm	26.5gm
Material	Mild Steel (MS)	Nylon	Nylon

Paper Cone Manufacturing

Paper reel was fed into the feeding unit of the paper cone manufacturing machine and then inside and outside printing was completed. Next the edge of paper was grinded and cut the paper sheet according to the measurement shown in table 6. After that winding and trimming was performed following by the drying process. Latter cutting of paper in v shape, line pressing were accomplished followed by head curling and collection. Two paper cones were made by table 6 in the same procedure with different specifications.

Table-VI: Specification of paper cone

Description	Measurement	
	System A & B	System C
Length	172 mm	172 mm
Large diameter	68 mm	58 mm

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Small diameter	28 mm	26 mm
Thickness	2.3 mm	2.3 mm
Angle of tapering	5.57°	4.22°

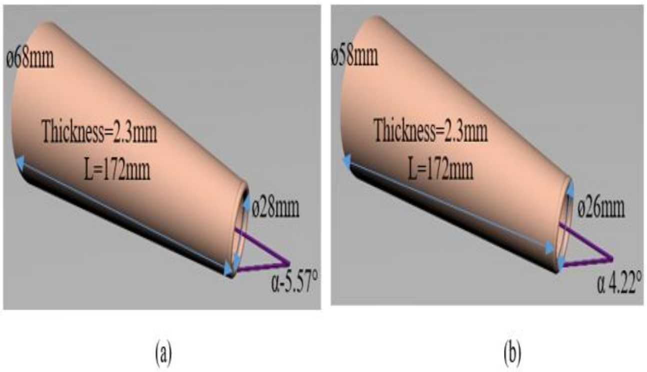

Fig. 6. New paper cone (a) for system A and B (b) for system C

Yarn Production

Three different yarn fineness such as 30's Ne (100% Cotton), 40's Ne [50% Polyester and 50% Cotton (PC)] and 50's Ne (100% Cotton) was produced from Cameroon cotton and PET polyester fibre by using combed process. Roving fineness of 1.00 Ne was kept during the processing of material. The same roving was fed to each spindle of ring frame so that variation can remain less. Ring frame parameters are given in table 7.

Table-VII: Processing parameters of ring frame

Parameters	30 Ne	40 Ne	50 Ne
Break Draft	1.13	1.25	1.19
Total Draft	30.91	41.04	51.9
Spindle Speed (R.P.M.)	16000	16000	16000
TPI	21.9	25.29	28.28
Traveller No.	4/0	8/0	10/0
Drafting Roller Pressure	14 kg	18 kg	14 kg

After making yarn in ring frame it was wound on the winding machine with five different winding speeds like 900m/min,1100m/min,1300m/min,1400m/min and1500m/min for three fineness of yarns using A, B and C system in winding machine. Winding machine brand and model was Muratec 21C.The yarn packages were conditioned at testing atmospheric conditions before testing. Different properties of yarn such as evenness properties and hairiness are carried out in Uster Evenness Tester 5. Test speed of evenness tester was 400 m/min and the test time took 1 minute for each test. Other important properties like fineness strength product (CSP) and power consumption was performed with Ele Stretch XT tester and TRINITY (NF29) energy meter respectively. Lower clamp speed was 250 mm/minute in Ele Stretch XT tester.

Table-VIII: Unevenness (%) of yarn for different finenesss and systems

Winding Speed (m/min)	U_m (%)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
900	8.15	8.07	8.01	10.97	10.95	10.67	9.62	9.57	9.42
1100	8.35	8.3	8.08	11.04	11.01	10.74	9.69	9.63	9.5
1300	8.55	8.48	8.17	11.06	11.03	10.8	9.73	9.7	9.55
1400	8.61	8.53	8.29	11.21	11.18	10.96	9.77	9.76	9.65
1500	8.69	8.57	8.33	11.37	11.33	11.33	9.81	9.77	9.69

Table-IX: Imperfection index of yarn for different finenesss and systems

Winding Speed (m/min)	Imperfection Index (-)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
900	32.8	28.4	25.1	371.5	353	305.5	132	125.2	102.4
1100	38.5	33.8	30.2	380.3	365	326	143.9	139.3	113.5
1300	44.6	40.3	37.3	394.5	397	342	151.1	147.2	129.1
1400	48.3	45.2	43.4	410.5	401.5	384	164.7	159.2	141.5
1500	53.6	49.5	48.4	469.5	454	454	174	169	154

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Table-X: Hairiness of yarn for different finenesss and systems

Winding Speed (m/min)	Hairiness (-)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
900	4.47	4.4	4.34	5.04	5	4.97	3.42	3.41	3.29
1100	4.53	4.46	4.46	5.11	5.11	5.06	3.53	3.46	3.36
1300	4.62	4.57	4.52	5.2	5.15	5.13	3.58	3.5	3.5
1400	4.7	4.61	4.55	5.31	5.25	5.25	3.64	3.54	3.5
1500	4.77	4.67	4.6	6.04	5.5	5.5	3.68	3.59	3.54

Table-XI: Count Strength Product (CSP) of yarn for different finenesss and systems

Winding Speed (m/min)	CSP (Ne*lb)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
900	3170	3196	3240	3157	3166	3170	3250	3268	3278
1100	3157	3175	3220	3150	3154	3158	3210	3245	3251
1300	3142	3160	3190	3146	3153	3155	3171	3225	3227
1400	3130	3138	3165	3140	3145	3151	3161	3195	3211
1500	3118	3125	3138	3136	3141	3148	3155	3172	3192

Table-XII: Tenacity (cN/tex) of yarn for different finenesss and systems

Winding Speed (m/min)	Tenacity (cN/tex)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
900	21.71	21.89	22.19	21.62	21.68	21.71	22.26	22.38	22.45
1100	21.62	21.75	22.05	21.58	21.60	21.63	21.99	22.23	22.27
1300	21.52	21.64	21.85	21.55	21.60	21.61	21.72	22.09	22.10
1400	21.44	21.49	21.68	21.51	21.54	21.58	21.65	21.88	21.99
1500	21.36	21.40	21.49	21.48	21.51	21.56	21.61	21.73	21.86

Table-XIII: Power consumption in winding machine for different finenesss and systems

Winding Speed (m/min)	Power Consumption (KW/Hr.)								
	30 Ne			40 Ne			50 Ne		
	System A	System B	System C	System A	System B	System C	System A	System B	System C
1300	1.54	1.43	1.32	1.35	1.3	1.25	1.21	1.09	0.99
1400	1.75	1.65	1.58	1.5	1.4	1.32	1.32	1.16	1.01
1500	1.95	1.81	1.65	1.64	1.5	1.4	1.4	1.23	1.08

III. RESULT AND DISCUSSION

Yarn Unevenness

Unevenness is a statistical parameter to express the evenness properties of the yarn. It is a significant property of yarn which helps the spinners to take decision for the assumption of the quality of yarn. It is seen from Fig 7that unevenness percentage is the lowest in 900 m/min speed and all system C which is the adapter made from nylon and small diameter among three. It may be assumed that due to the groove in nylon adapter which absent in mild steel adapter and surface is plain gripping is better in small diameter adapter and unevenness properties becomes lower. The value remains in the lowest in 30's Ne yarn because it is the coarser fineness among them.

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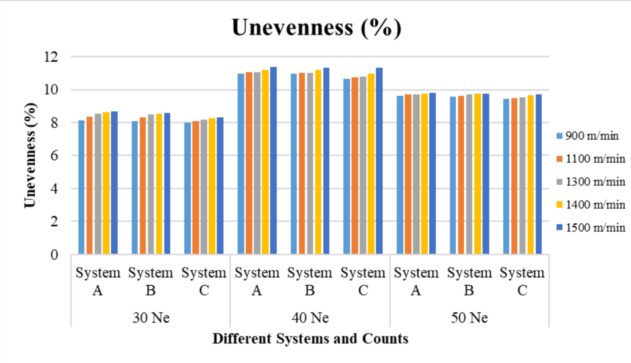

Fig. 7. Unevenness properties of the yarn

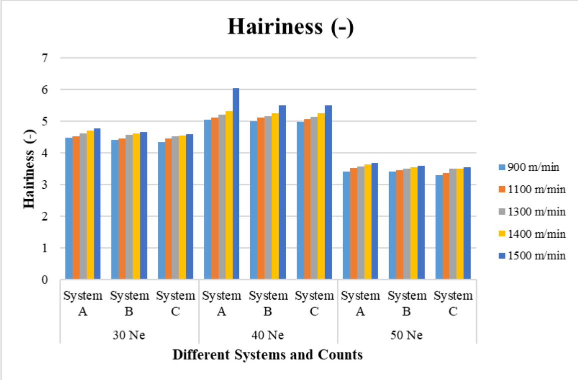

Fig. 9. Hairiness of yarn

Yarn Imperfection

Imperfection index is a good indication to know about the amount of the thick, thin place and neps in the yarn. It will help a spinner to take the necessary steps to process control and ensure the quality of the produced yarn. If the number is high it will create a big problem in further processing like weaving, knitting etc. and breakage will be more as a result more wastage generation will happen and faulty products will be produced. Fineness of 40's Ne yarn shows the highest value whereas 30's Ne the lowest as well as best in three systems. It may be predicted that due to the small diameter and light weight the friction will be optimum which results in low imperfection value of yarn.

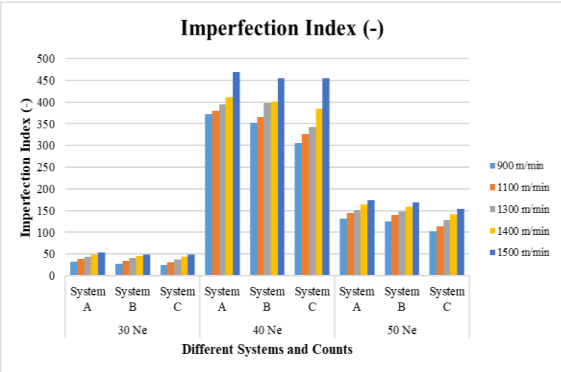

Fig. 8. Imperfection index in yarn

Yarn Hairiness

Hairiness is the summation of length of all protruding fibres which is not incorporated to the yarn body. Hairiness plays a vital role in the hand feel of the ultimate products. Without hairiness textile products especially, apparel will not be comfortable. It can be said from Fig 9 that hairiness value demonstrates higher results in 50's Ne yarn in system C. This is happened because it may be tension is transfer smoothly in this system due to adapter specification and the better alignment of the fibre in the yarn. As the draft in the main drafting zone in ring frame is higher than other two fineness of the yarn, it may happen that fibres become straighter and more parallel when leaving the drafting zone which is not possible in other two finenesss and systems. For this reason, the fibres integrated more evenly to the main body of yarn and the yarn gets more clear appearance.

Yarn Count-Strength Product and Tenacity

Strength of yarn is an important property among all properties. One of the main reasons to produce yarn from fibres is of its strength. The processing performance of next steps depends on these properties of yarn especially weaving. Count-Strength Product along with tenacity of system C of 50's Ne yarn indicates the best results among the other systems. A possible explanation may be that due to the higher draft in the main drafting zone in ring frame machine. Better straightening and parallelization of fibres may occur before converting into the yarn. However, there are less amount of folding end and dis-alignment fibres in the drafted ribbon, maximum fibres can contribute in yarn strength. Nevertheless, the diameter of the adapter is less and fluted surface as a result proper gripping and friction is less in this system than others. That's why, the yarn strength remains in the highest position in this system.

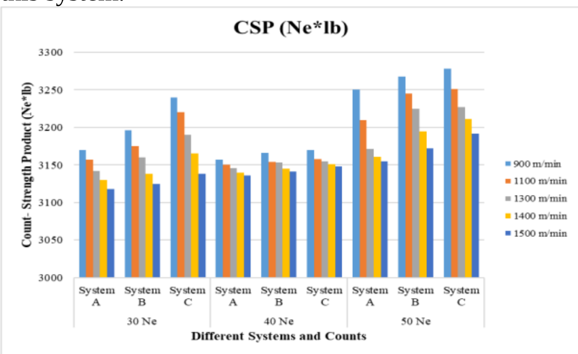

Fig. 10. CSP of yarn

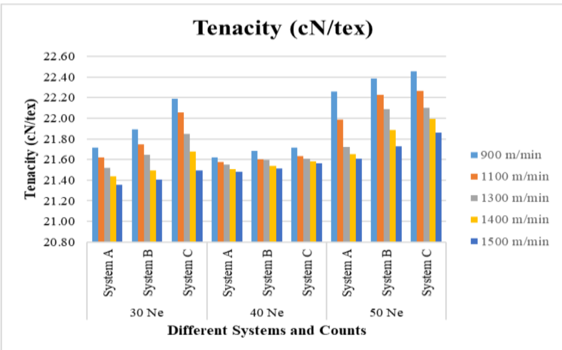

Fig. 11. Tenacity of yarn

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Energy Consumption

Power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines. It is a crucial and most significant matter for any production process. Without power or energy bulk production cannot be imagined. It is also a limited natural resource for this reason whole world is concerned about its optimum use. It is observed from the Fig 12 that, less amount of power is required in system C of 50's Ne yarn among the others in addition to 1300 m/min. It can be enlightened that, the diameter is small, weight is low of the adapter, speed is less and yarn is comparatively finer than others. Therefore, the least amount of power is required for this fineness of yarn.

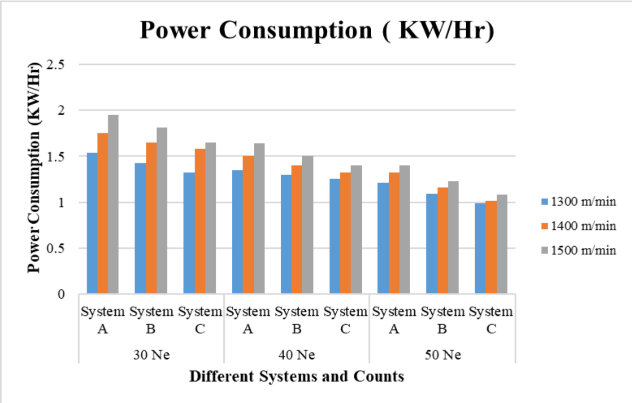

Fig. 12. Power consumption of winding machine

IV. CONCLUSION

Yarn made with using 58 mm adapter from nylon roll shows the best results in all cases. Unevenness and imperfection properties is good in 30's Ne system C yarn while hairiness, fineness-strength product (CSP) and power consumption shows the best value in 50's Ne yarn in the same system. This is because 30's Ne yarn is coarser so that unevenness and imperfection outcomes is better which is not good in other fineness. Nevertheless, the reason of good results of hairiness, fineness-strength product (CSP) and power consumption is better in 50's Ne yarn because of higher draft fibres come to be straighter and parallel. As a result, fibres get into incorporated further uniformly in yarn body.

The reason of less power consumption may be that less diameter, finer yarn fineness as well as light weight of nylon adapter. All yarn properties values exhibit best results in winding speed 900m/min but power consumption in winding speed 1300m/min whereas reverse in winding speed 1500 m/min. This is due to the fact that in lower speed friction is less and fibre damage is low which is opposite in high speed. Modified small diameter adapter demonstrates best yarn properties as well as economic as it saves energy 14.63%, paper cone cost 17% and adapter manufacturing cost 96.2%than metallic one.

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AUTHORS PROFILE

Prof. Dr. Hosne Ara Begum, graduated from University of Dhaka(Ex. College of Textile Technology, Tejgaon), now Bangladesh University of Textiles with first class first position. She has completed her M.Sc. in Textile Engineering from TU Dresden, Germany with a very good result. She has completed her Ph. D from Bangladesh University of Engineering and Technology. Now she is working at Bangladesh University of Textiles as Professor and Dean of Faculty of Textile Engineering. She also has a remarkable number of national and international publications and text books of textile engineering. Recently she has published a paper at the Journal of the Textile Institute about a non conventional natural fiber called Areca. Her keen interest on sustainable, natural, biodegradable and environmental friendly process and product development and the areas are:

- Jute process and product development
- New process development of Areca and Banana fiber
- Utilization of wastage of cotton and jute mill
- Utilization of Apparel and Garments wastage
- Biodegradable and environmental friendly composite manufacturing
- Manufacturing of low cost jute shopping bag for kitchen market and shop..

Toufiqua Siddiqua, has completed Master Degree in Textile Engineering from Bangladesh University of Textiles (BUTEX) (http://www.butex.edu.bd/) with first position in 2018. She has also completed her undergraduate from same University with distinction in 2013.

After about a year of working in a Spinning Industry as a Production Officer, she decided to return to University to complete her Master degree, hoping that it would enhancing her understanding of real-world problems facing the industry and allow her to come up with more innovative solutions. Next, she had worked in an institution as a Lecturer about 1.5 years. Now she is working as an Assistant Professor at Bangladesh University of Textiles (BUTEX).
She has been awarded with government scholarship in primary, junior, secondary school certificate, higher secondary certificate and undergraduate examination. She feels proud that she is a winner of Rieter Award 2016 and visited Switzerland for a week. Rieter is a reputed Spinning machinery manufacturer in the world. Abdul Motin Trust Foundation Scholarship was given to her for outstanding result in M.Sc. She is also a member of institutions of The Institution of Textile Engineers and Technologist, Bangladesh and The Institution of Engineers, Bangladesh.
She had worked in a blood donating volunteer organization named "Badhan" during her student life and now working in that institution as an advisor. She is also an active member of another club named "Spinners' Club" which performs many volunteers works besides accomplishing their regular cultural activities. She has two publications and involved in five research works now.

Abul Kalam Mohammad Mazed, graduated from University of Dhaka (Ex. College of Textile Technology, Tejgaon), now Bangladesh University of Textiles. He has completed his M.Sc. in Textile Engineering from Bangladesh University of Textiles.
Now he is working at a reputed spinning mill as a General Manager. He has worked in many spinning industries in different positions for about 18 years. He has a good academic excellence in his school and college life. He has also achieved different awards in his life. He is also a member of institutions of The Institution of Textile Engineers and Technologist, Bangladesh and The Institution of Engineers, Bangladesh.

Course Teacher: Prof. Dr. Engr. Abu Bakr Siddique, Dean, Faculty of Textile Engineering of BGMEA University of Fashion & Technology (since February 2016), Dhaka, Bangladesh. Previously, he was Professor and Head of department of Textile Engineering in European University of Bangladesh as well as in Green University of Bangladesh. He also served as Associate Professor in Primeasia University in department of Textile Engineering for many years.
He had been appointed as scientific officer at ITV Denkendorf for four and half years (01.01.2002-31.06.2006). He had received his doctorate (Dr. -Ing.) in 2006 from Stuttgart University and M.Sc. in Textile and Clothing Engineering from Technical University, Dresden, Germany in 2001. He has completed his B.Sc. in Mechanical Engineering from Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh.He has a significant number of publications such as journals, seminar papers and text books.His research fields are the development of Textile Machinery, Fiber (high-performance and renewable textile fibers), Environmental textiles, Recycling Technologies. Dr. Siddique developed the Sizing Materials on the basis of Chitosan for the Ecological & Technological Aspects. He also developed new type of CSB (Compact Size Box), which gives the thermal equilibrium and save the sizing materials and energy during sizing. His existing researches are Jute fiber composite for Geotextile, Non-Woven from Natural Fibers for Geo-membrane and Renewable Fibers from Chitosan, Banana, Pineapple, Hemp, Beetle Nut etc.
Pre-washing/heating during sizing a new technique has been developed with Deutschen Institute für Textil- und Faserforschung Denkendorf (DITF).
He worked as a consultant in a largest project of the department of textile (DOT) under the ministry of textile & jute of Government Republic of Bangladesh as well as consultant of different reputed textile industries in Bangladesh.
Current Research Projects:
Project Director: German-Bangladesh Higher Education Network for Sustainable Textiles with Technical University Chemnitz cooperation with DAAD, GIZ and UGC.
Project Supervisor: Textile wastage management and its utilization in Bangladesh.
Project Supervisor: Recycling of Textile and RMG waste and their diversified uses.
Further Cooperation projects with German Universities: Technical Textiles, Nonwoven, Textiles composites and 3D-warp, weft knitting Technology and Recycling Technology;