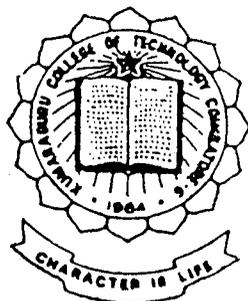


ENERGY MANAGEMENT IN SPINNING

P-583



Submitted by

R.S. VENKATESWARAN
K. NANDHAKUMAR
E. ELAMARAN

Guided by,

Asst. Prof.S.GANESAN M.Tech

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Department of Textile Technology
Kumaraguru College of Technology,

Coimbatore - 641 006.

Department of Textile Technology
Kumaraguru College Of Technology
Coimbatore - 641 006

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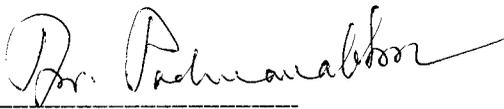
University Register No

Name Roll No.....

**Certified that this is Bonafide Record of the
Project Work Done by**

Mr / Ms

**In the partial fulfillment for the degree of Bachelor of Technology
in Textile Technology Branch of the Bharathiar University.**


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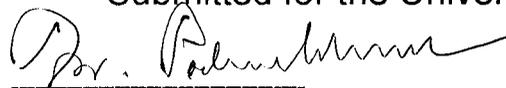
Head of the Department

Faculty guide

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Abstract

1.ABSTRACT

Energy is one of the major contributors in the selling price of yarn. This is more true because the cost of energy is increasing day by day in India. In a period where the profit margin is only in the range 2-3% care should be taken to conserve energy. In this context the authors have taken up this project to know the present systems prevailing in the industry through survey and also study the influence of few parameters on Ring frame Energy consumption as the Ringframe accounts for more than 50 % of the total energy consumed.

The studies undertaken include the influence of various parameters like spindle insert and spindle, oil type, cleaning cycle, spindle speed on ring frame power consumption. Apart from this the authors have attempted to recommend a few methods to save Energy in a Spinning Mill through datas collected from their survey and study.

The authors conclude from their study and survey the following

1. Energy Management should focus on Energy Conservation and should be a continuous and a regular one.
2. Through Comprehensive Energy Audit an energy conservation programme for short term and long term should be planned.
3. Energy cell should be constituted to look after the Energy Audit and Energy conservation programme and also the follow up.
4. During modernisation care should be taken in selecting the machine with regard to Energy Consumption level and Energy saving devices along with the productivity aspects.
5. Prioritize the Energy conservation Programme on the basis of intensity of

consumption. First being Ring frame followed by Humidification and Compressors and others.

6. Use of appropriate capacitors to maintain powerfactor and Energy Efficient motors suggested towards conservation.
7. Through their studies on the influence of a few parameters on the ring frame, the authors conclude that there is an increase in UKG when the spindle speed is increased. They also conclude that the influence of Cleaning cycle on Power consumption is only marginal and that the synthetic spindle oils consume less power compared to mineral based oils.
8. Through their survey the authors conclude that a reduction in spindle weight, wharve diameter, ring dia and lift helps to save power when going for higher productivity in Ring frame.

Introduction

2.INTRODUCTION

- Energy accounts for 12 – 15 % of the total costs in a spinning mill and ranks highest component of conversion costs next to labour.
- The cost of energy is increasing at a faster rate compared to any other facet and so this necessitates the need for the proper management of energy , as every penny saved is a penny earned in this competitive industry.
- Energy management is not only to monitor energy consumption, but also to conserve the same. Therefore, Energy Conservation Programme should be a part of the energy management. Through systematic Energy Audit one can monitor Energy Consumption.
- Energy Audit is the process of comparing the Mill's energy consumption details with a standard and thereby analyzing the shortfalls, if any and subsequently taking appropriate steps for improvement.
- Ring frame contributes bulk of the energy consumed in a spinning mill. Up to 50 % of the energy consumed is by ring frame and this percentage goes up as the count goes finer and so the ring frame is given importance in a spinning mill. Many research work that has been carried out in spinning mill towards conserving energy focuses the spinning process (**Ring frame**) .
- So in our project work on Energy Management in Spinning Mill, we have confined much of our studies to the Ring frame area only apart from studying the overall systems prevailing in the mills through survey towards knowing the status. The influence of few parameters that affect the power consumption on Ring frame are studied.

Literature Review

3.LITERATURE SURVEY

3.1 ENERGY CONSUMPTION PATTERN IN A MODERN MILL

Textile Industry is one of the major industries in India accounting for more than 30 % of the foreign exchange and it provides job opportunities for more than 400 million people, directly or indirectly . In South India more spinning mills are located and Energy Management ideas are given utmost importance here as its cost contributes sizable quantity in the conversion of fibre to yarn.

There are various forms of energy that are in use in a Textile Industry namely

1. Electrical Energy
2. Steam Energy

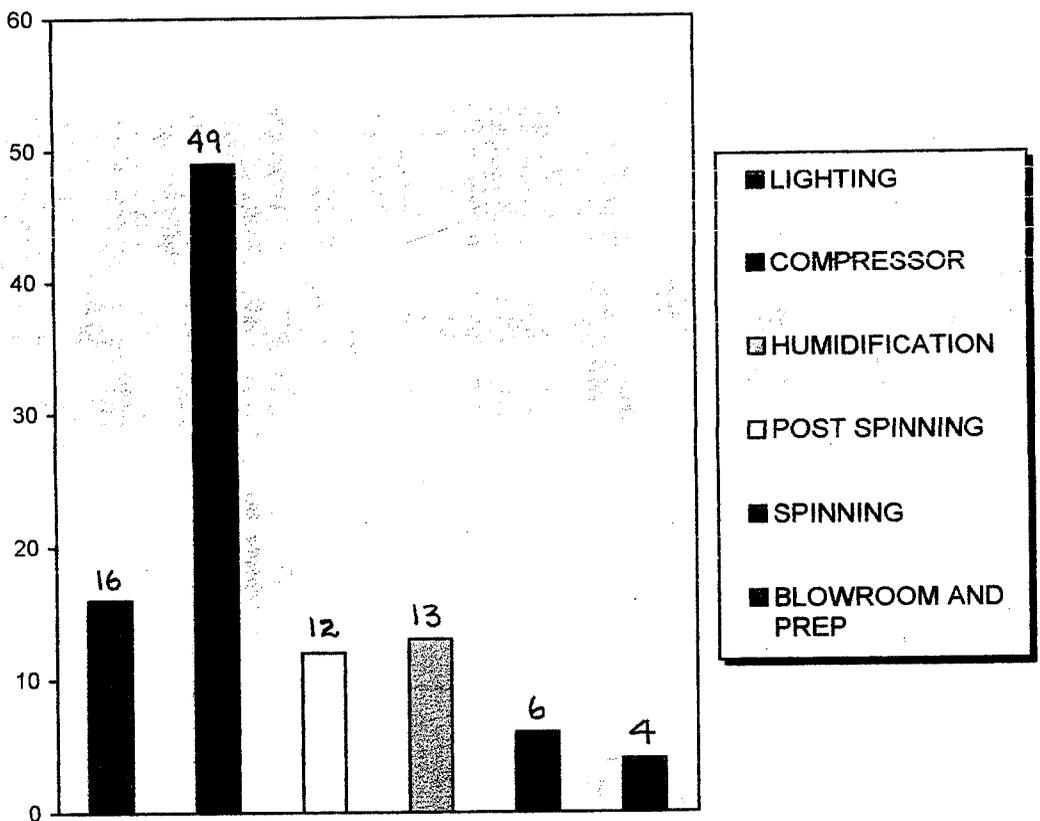


The Contribution of the same in a composite mill is given below

DEPARTMENT	ELECTRICAL	STEAM
SPINNING Process Air Conditioning	44 % 5 %	- 2 %
WEAVING Process Airconditioning	24 % 12 %	6 % 15 %
WET PROCESSING AND FINISHING	15 %	77 %

3.2 ENERGY CONSUMPTION PATTERN OF A MODERN SPINNING MILL

From the chart given below, which was reported by SITRA¹ one can infer that Ring Spinning takes up much of the power in a Modern Spinning mill.



Out of the total cost incurred by the Spinning mill, raw material account for more than 60 %. Of the remaining 40 %, energy cost accounts for 7-15% yarn cost for counts ranging from 20s to 100s. Energy costs increase at a rate higher than the wages and input costs. Energy cost increase at a rate of 12% per annum as compared to wages and raw material, which increases at the rate of 10 % and 8% respectively.

In the present state of recession, where the profit margin is 2 – 3%, care has to be taken to reduce power costs because the other main factors contributing to the sales revenue like the raw material cost and wages are out of the hands of the spinning mill. The importance of power conservation has assumed added significance with the onset of new high speed machines, which consume more power per unit production of yarn. Taking the above things into consideration the mills would be better of concentrating more on Energy Conservation Programme (ECP) along with the Process and Quality Control programmes (PQC). Confederation of Indian Industries (CII)² claim that there is a energy saving potential of upto 2500 Crore in Textile Industry in the present scenario.

SITRA¹ reports that for a 30000 spindle capacity mill the annual energy consumption is about 10 million units (KWh) .(At a rate of Rs 4.5 per unit the energy cost per annum is 4.5 Crores) . Every 10 paise increase in power tariff there is an additional expense of 10 lakh Rupees .

Factors affecting the Energy Consumption in a spinning mill are :

1. Level of Modernization and Automation.
2. M/C Speed & Material processed.
3. Age of machines.
4. Maintenance of Power Factor & Electrical distribution system .

5. Maintenance procedure adopted for Production Machines and Electrical Equipment.

6. Awareness and system adherence.

Mr.Chandran ,Mr.Balasubramanian & Mr.Muthukumaraswamy⁷ have extensive work on the influence of the above factors on Energy Consumption. In modern machines the higher speed mean that there is increased fluff and dust generation. Additional Exhausts and Waste transport systems are therefore added in the system to improve the quality of the end product. Also the increased heat generation demands the need for additional energy on humidification / air conditioning.

From this we come to know that the energy spent on auxiliary systems is more.

Following table furnish the details on UKG 40s for various levels of modernization

Energy consumption for various levels of Modernization ⁷

TYPE OF MILLS	UKG 40s		
	MODERN	PARTIALLY MODERN	CONVENTIONAL
Productive	4.29	3.92	3.09
Non Productive	3.65	1.05	0.49
Total	7.94	4.97	3.58

Power Consumption in Ring Frames ⁷

TYPE OF MILLS	MODERN	PARTIALLY MODERN	CONVENTIONAL
UKG 40s	2.49	2.54	2.56

Notably the UKG for spinning of a modern mill is marginally lower compared to the partially modern and conventional mill in spite of increase in spindle speed because, energy conservation measures like low wharve diameter, lighter spindles, individual pulley etc have been introduced. In general the overall UKG of a modern mill is about 2.2 times higher than the conventional mills. The non-productive machineries like humidification equipment, A/C chilling plant, central waste collection equipment, compressors, etc. accounts for 70 % of the increase. In a partially modern mill the increase on this account in UKG is about 40 % compared with that of conventional machines.

Note : Modern Mill described above has the features of automatic simplex and spinning bobbin transport system with automatic doffing and link winders. It is fully air conditioned and has got complete waste collection, transport and disposal mechanism. A partially modernized mill has latest preparatory machines and autoconers.

Apportionment of UKG ⁷

DEPARTMENT	UKG(40s) for Modern Mill	UKG (40s) for Partially Modern Mill	UKG (40s) for Conventional Mill
Blowroom	0.15	0.16	0.09
Carding	0.43	0.38	0.22
Hi-lap	0.07	-	-
Comber	0.16	-	-
Drawframe	0.05	0.16	0.06
Simplex	0.21	0.15	0.09
Ringframe	2.49	2.54	2.56
Winding	0.73	0.53	0.07
Total Productive A/C plant/ Hum.plants	4.29	3.92	3.09
Chill plant	1.07	0.54	0.29
Air Compressor	1.29	-	-
Lighting & Others	0.43	0.27	0.04
Waste Collection	0.16	0.24	0.16
Total Non-Productive	0.69	-	-
TOTAL	3.65	1.05	0.49
	7.94	4.97	3.58

3 ENERGY MANAGEMENT

ITRA⁴ says that Energy management should focus on Energy Conservation. For effective control over energy consumption in a mill, Energy conservation programme (ECP) must be a regular activity and should have its own staff.

Research Associations claim that an Energy savings up to 20-25% is possible with

Energy Management based on

- Systematic and regular energy auditing
- Conservation & Improvement in energy equipment and processes
- Continuous updating of Technology
- Adoption of good operational and maintenance practices

Energy Management should give importance to ECP. The ECP comprises of the following steps:

- Arranging systematic and comprehensive Energy Audit to locate and find the area and extent of deficiency.
- Chalk out conservation and improvement programme - short term and long term
- Implementation of the above.
- Arranging follow up action to confirm and sustain the gain.

The methods of doing systematic and comprehensive Energy audit are discussed in detail in the subsequent pages dealing with Energy Audit.

Confederation of Indian Industries (CII) define the process of Energy Management as the process of getting the required comprehensive data base and comparing the same with a standard and subsequently asking questions like why, what, how, etc to ascertain the system effectiveness & correct the shortfalls, if any.

3.4 Energy Audit :

Energy Audit is the most important step in Energy Management to know the present status, which will facilitate formulation of control and improvement measures.

It involves getting the power consumption pattern from various departments in the mill and comparing the specific energy consumption with the norms to ascertain the efficiency and effectiveness of the prevailing equipment and systems.

SITRA recommends an ECP staff assisted by an electrical staff in his work, particularly for carrying out Energy Audit.

The steps involved on Energy Audit as reported by SITRA ⁵

❖ Finding by Measurement the present consumption in

1. Production M/Cs

- ⇒ Make wise
- ⇒ Type wise
- ⇒ Hank wise
- ⇒ Ring Frame - For full doff

2. Non- Production M/Cs

- ⇒ Support services

3. Lighting

- ❖ Noting power installed & finding load factor
- ❖ Recording of MD & PF
- ❖ Noting the details of Capacitors installed
- ❖ Observation of no load power
- ❖ Diagnostic check on Motors
- ❖ Recording analysis of Motor burn out

- ❖ Select Ring Frame of very High/Low consumption in a make/model and count group and observe for component power.
- ❖ Listing relevant M/C and operating specification towards fixing norms
- ❖ Work out countwise UKG, based on actual measurement & m/c or spindle shift used.
- ❖ Power consumption on support services and lighting apportioned on the basis of Spindle Shift worked on each count and accounted.
- ❖ Tally, Measured Total power with that of calculated based on actual UKG for various counts and any differences between the two should be resolved.
- ❖ Fix count wise mill standard UKG for each process based on its good working.
- ❖ Compare actual UKG and Mill standard UKG with that of SITRA Standard.
- ❖ Workout Power Consumption Index -PCI and analyze the reasons for avoidable deficiency.
- ❖ Plan and take appropriate corrective & improvement measures for conservation.
- ❖ Monitoring UKG, USS, MD & PF through control charts
- ❖ In case of generators, particulars should be collected with reference to the number of hours run, loading, Units per litre (ULO) for each type of generator.

Equipment required for Energy Audit as suggested by SITRA are

- Electrical load meter consisting of voltmeter, ammeter and 2 single phase wattmeter.
- Lux meter
- Hydraulic or Electrical Dynamometer – to test motor efficiency
- DC Welding Transformer for measurement of stator resistance
- Departmentwise Energy Meter

Some of the other details recommended by SITRA through SITRA Focus⁵ to determine the power are :

1. In blowroom 3 readings are taken each for a period of 8 hours and the average is computed.
2. In Card and Drawframe 3 readings are computed each for a period of 6 hours and average is computed.
3. Auxiliary motors are also included in the study.
4. It should be noted that the energy consumption pattern should not be done based on the total installed power and loading percentage.
5. The power consumption on a ringframe is done machinewise and not departmentwise as is the case with the preparatory machines. A total of 6 readings are taken on each machine covering from the beginning to the end of doff so as to cover dual motors and variations in power consumption at various levels of packages.
6. In the case of conewinding 3 readings are taken each for a period of 6 running hours.
7. For the auxiliaries like lighting and humidification the apportionment is based on the machine.

The UKG is worked out for each count based on the above measurements. (see Annexure) If there is a large variation in the level of power consumption between machines, about 20% of the lowest consumption values for comparable conditions may be taken and weighted average of these values calculated to obtain the overall best performance. This may be taken as the mill's standard UKG against which the actual consumption on different machines may be compared.

3.4.1. Audit Reporting :

The reports need to be submitted by the energy cell to the management are as given by SITRA⁵

- The power consumption index (PCI),ie the actual power consumption expressed as percentage of that expected on the basis of the mill standard UKG. The difference in power consumption between the actual and standard may also be expressed as number of units per day.
- A comparison of the actual UKG and mill standard UKG should be made with the respective standards countwise.
- Departmentwise actual UKG and mill standard UKG is calculated, and the causes for the variations between the two are analysed.
- The average level of consumption in each department, machinewise, % machines and motors, where the level of consumption is close to the mill standard and the extent of variation in consumption between motors of different HP's on machines running in the same count.
- The number of units per 1000 spindle shifts (USS) , average and variation between days together with the standard USS. The number of days where the USS is significantly more along with the causes .
The units per litre for each generator as well as their utilisation,loading etc. Causes for the variation in the consumption of the lubricants between and within generators.
- The average power factor (PF) and maximum demand (MD) with level of variation from day to day and the causes.

- Comparison of existing motor HP and that recommended.
- Rate of motor burnouts for each HP and type.

For the above parameter control charts are used for easier manipulation. The above reporting is done every week. Compare the HP required and the HP used for various machines. Estimate the power savings of replacing the existing motors by lower capacity motors and the payback period. Other energy saving equipments are also considered taking into account the maximum energy saving and also the cost and payback period.

SITRA has developed norms for energy consumption taking into account the Units per Kilogram (UKG) , Power Consumption Index (PCI) values taken from a survey. The mill's values are converted to UKG & PCI values for standard count .With the computed UKG , Power Consumption index etc in depth analysis is made to find out the excess energy consumption in any particular machine depending on the department.

The research organisation ATIRA²⁰ recommends a similar procedure to find out the performance of the mill. In ATIRA's method the Actual consumption of power in the ring frame for full doff is compared with the theoretical energy consumption as calculated using Soliman's formula (see Annexure).

The Power Consumption Index is the ratio between the Actual power consumption and the Theoretical power consumption expressed as a percentage. If this index is 100 it is ideal. If this index goes beyond 100 the difference is accounted for and corrections are made either to the existing machinery or to the mode of calculating the power. This method helps to assess the performance of the mill with respect to its own standards rather than standards set by some other Research Organisations. }

3.5 RING FRAME

3.5.1 BREAK UP OF RING FRAME POWER

As said earlier Ringframe account for nearly 50 percent of the total energy consumed in a spinning mill.

According to SITRA studies the total power consumed in a ringframe can be broadly classified into :

1. Main Power

❖ Primary power

- Spinning power (traveller and balloon).
- Package power.

❖ Secondary power

- Spindle power.
- Tape power.
- Tin roller power.

2. Ancillary Power

- ❖ Driving gears
- ❖ Drafting system
- ❖ Pneumafil

Break up of ringframe power.

The table below gives the breakup of ringframe power as given by SITRA .

Component of Power	Percentage of Power
Spindle	39.3
Spinning	19.7
Tin Roller	12.3
Package	8.8
Drafting	6.6
Empty Bobbin	4.9
Motor	8.4

The above table is for an experimental speed of 10000 rpm for 400 spindle ring frame with 178mm lift and 41.3 mm ring diameter for 40s count.

The ring frame consumes about 40 percentage of the total power consumption for coarser counts and about 80 percentage for fine count spinning.

The table below gives the breakup of ring frame power for 100s count with 14400 rpm spindle speed and 440 spindles as given by NITRA ⁸

Component	Percentage of power consumed
Spindle power	29.60
Tension rollers	1.70
Bending resistance and air friction of spindle tapes	5.60
Tin roller assembly	14.14
Traveler friction	11.68
Balloon air drag	0.38
Package power	29.52
Drafting system	4.92
Driving head	2.46

From the above two studies one can conclude that Spindle, Package, Tin Roller and Spinning (Traveller & yarn balloon air drag) power accounts for the major portion of the power consumption in Ring Frame.

3.5.2 RING FRAME DRIVES :

There have been several developments that have taken place in the area of Ring frame drive. The different types of Main Motor drives available in the industry for Ring Frame are :

1. Dual motor drive with V-belts
2. Synthetic Flat belt drive

3. Variator (VPS /PIV)
4. Invertor
5. Drive M (Microprocessor based Variator)

3.5.3.1 V-BELT vs FLAT BELT

Apart from these there has been modifications in the way the drive that is being transmitted from the motor to different parts of the machine. Ringframes used to be driven by V-Belt.

The V-belt has the disadvantage that more amount of energy is spent in overcoming the friction at the belt groove during revolution and in wedging. The rubber, which the V-belt is made of has considerable bending resistance. The material used to make the flat belt is nylon and leather belt sandwiched together and these type of tapes provide the required grip and at the same time reduces the energy consumed drastically.

The study conducted by SITRA³ reveals that flat pulleys for the tin roller shaft and the motor pulley tends to save energy. Another advantage that one can obtain is that the pulley width can be reduced from 11cm to 7 cm. Sandwich flat belt was used to transmit power. The result showed a drastic change in energy consumption as given below.

Comparison between V belt and flat belt drive

Particulars (for 40s count)	V belt	Flat belt
Motor Speed (rpm)	1492	1483
Tin roller speed (rpm)	982.5	987.9
Spindle speed (rpm)	10720	10780
Average running time	2 Hr 30 mins	2 Hr 30 mins
Unit / hour	1.86	1.56
Units / Kg (UKG)	1.55	1.3
Savings	-	16 %

From the above table it is clear that there is Energy saving in opting for Flat belt drive in ring frame .

3.5.3.2 INVERTOR DRIVE^{11 & 12}

Ring frames used to be driven and controlled by the use of mechanical based drives but in the recent past Electronic based drives have been introduced. One must consider that even though the electronic drives help in smooth changeover from slow speed to high speed and thereby ensure lower end breakage rate and hence more production the energy spent in just operating them is more. The gain in production in such modern drives is about 1 percent but corresponding increase in power consumption is about 1 – 3 % depending on the type of drive chosen .

Comparison between different types of drives :

Study was conducted by NITRA⁸ on a Texmaco ringframe keeping all the parameters constant and by altering only the type of drive employed .

Count - 30s(PV) Number of Spindles – 480 Ring dia – 42mm

Lift – 7 inches Motor Rating 20 HP

Particulars	VPS	Inverter	Drive M
Total doff power consumption(KWh)	25.88	27.01	26.05
Total doff time (Hrs)	2.23	2.24	2.24
Production Kgs /doff	27.15	27.48	27.47
UKG	0.94	0.983	0.948
Gain in production Percentage	-	+ 0.78	+ 0.77
Power saving %	-	-2.6	-0.85
Average spindle speed	14600	14630	14610

From the above table it is clear that the new Microprocessor controlled Variator otherwise known as Drive M is the most economical way to achieve higher production without a very big hike in power costs.

3.5.3.3 SITRA “ ENERSPIN ” DRIVE

In order to reduce power consumption SITRA has come out with a new driving system . Instead of the conventional 4 spindle drive one can go for group drive by which multiples of 4 spindles can be driven. This drive is more useful, when one

utilises this type of drive upto 16 spindle beyond which there is a chance of slippage. The aim of this drive is to minimize the tin roller friction, air friction and bending resistance of the spindle tapes and also to minimize the tension roller losses. This is incorporated in Ringframes and Doubling frames. The special feature of the Enerspin is achieved using a specially designed tin roller and one tape with guide roller.

Advantages :

- ❖ Reduction in mechanical load in the bearing.
- ❖ Reduced speed of tin roller drive.
- ❖ Reduction in resistance to tape drive system in terms of air drag.
- ❖ Reduction in vibration and noise.
- ❖ This can be fitted to an old machine.

Design modifications used in the Enerspin :

1. Number of tin roller pulleys reduced from 110 to 36 for a short frame.
2. Total weight of the tin roller pulleys reduced from 77.1 Kgs to 27 Kgs.
3. Number of jockey pulleys used has been increased from 110 to 180.
4. Length of one tape in mm is increased.
5. Total length of tape is reduced from 335.5 m to 173.8 m
6. The solid tin roller shaft (147 Kgs) is replaced with a hollow tin roller shaft (77.6 Kgs).

Comparison between the Enerspin drive and conventional 4 spindle drive ⁸

S.No	Particulars	4 spindle drive	Enerspin 12 spindles
1	Count	100s C	100s C
2	TPI	37.46	37.46
3	Spindle speed	14500	14500
4	Number of doffs	15	15
5	Hanks per doff	12.5	12.5
6	Hours per doff	17	17
7	Average production /doff in Kgs	23.8	23.8
8	Average Units per doff	109.5	99.9
9	UKG	4.601	4.198
10	Saving	-	8.8 %

The savings of 8 – 10 % is achieved in a ring frame because of the decrease in weight of the rotating components. The slippage is not increased significantly and is maintained at an 3 – 5% which is expected even for a 4 spindle drive.

3.5.4 SPINDLE WHARVE DIAMETER

SITRA studies reveal that the drive to the tinroller / tin roller pulley accounts for about 50 % of the total power consumption in a ring frame and so any minor saving in this area will suffice substantial energy saving in the ringframe. The smaller diameter of the spindle wharve reduces the revolutions required per minute in the tinroller to drive the spindle in the required revolutions per minute.

$$\text{Tin roller speed} = \text{Spindle speed} \times \text{Spindle wharve diameter} / \text{tin roller diameter.}$$

The spindle wharve diameter has been reduced from 25 mm to upto 18mm through research by SITRA and other research organisations .But there are worries that the reduction in spindle wharve beyond a certain limit increases the spindle slippage.

SITRA have conducted experiments in the same ringframe keeping all the other parameters constant except for the spindle wharve. The comparative study between 25 mm and 22 mm is given in the table below and as expected there is a drastic reduction in the power consumption. Power meter was fixed to the ringframe and the study was taken for 2 doffs. The corresponding hank meter reading were also noted.

Comparative Study between 25 mm wharve and 22 mm wharve ¹⁶

Spindle speed : 11000 rpm
Lift : 203 mm

Count : 20s
Ring diameter : 44 mm

Particulars	25 mm spindle wharve	22 mm spindle wharve
Spindle wharve	25	22
KWh per hank	10.65	8.05
KWh per hour	9.00	7.28
Count / CSP	19.5 / 1824	20.7 / 1814
Saving	-	20 %

The tape slippage is not appreciable with 22 mm spindles.

The spindle dimensions for the different wharve diameters ¹⁴

Particulars	25mm wharve	22mm wharve	20.2mm wharve	18.8 mm wharve
Dia top	15	15	15	15
Dia bottom	20	20	20	20
Wharve height	16	16	15	17
Acron height	29	29	25	28
Lift	190	190	190	190
Spindle wt	340	320	290	300

Comparison between 20.2 mm and 18.8 mm spindle wharve ¹⁴

Count – 40s

Spindle speed – 13300 rpm

TPI - 21.6

Particulars	20.2 mm wharve	18.8 mm wharve
Total energy Consumed (KWh)	417	415
Total Yarn Production (Kgs)	332	342
Average production /doff (Kgs)	22.2	22.8
Average waste / doff (gms)	658	640
UKG	1.256	1.215
Percent Saving	–	3.3

3.5.5 SPINDLE WEIGHT

Spindle is a continuously moving part and its movement involves overcoming of friction, it utilises power from the prime over . Thus the power consumed by the spindle is one of the most important part of the ring frame power. The weight of the spindle is a major characteristic of the spindle that determines the power consumed by the spindle. The spindle weight which used to be in the order of 350 gms in older frames but due to the research the weight of the spindle has been reduced to 200 gms. The heavier spindle consumes more power because more energy is required to rotate it. With speed of the spindle which is the main contributing factor for increase in production the relative increase in power of the heavier spindle is more in relation to the increase in weight.

The above effects may be due to the formation of vortex at higher spindle speeds and also may be due to the difference in lateral pressure which the spindle exerts on the bearing due to excess weight. Also the rate of decrease in power consumption is more than the relative decrease in power consumption and the lighter spindles have more advantages at higher spindle speeds.

It is found from SITRA studies that the power consumed the ring frame reduces by 1 % for every 10 gm reduction in weight.

There are 2 major ways by which the spindle weight is reduced and they are :

- ◆ By reducing the spindle wharve
- ◆ By increasing the taper of the spindle (instead of the conventional 64 : 1 , modern spindles have 40 : 1)

The study given below is a comparison between the ordinary spindle weighing about 350 gms and an Energy saving spindle weighing about 200 gms conducted by SITRA

Comparison between normal spindle and Energy saving spindle for fine counts ¹⁵

Particulars	Normal spindle	Energy saving spindle
Count	100	100
Spindle speed	14000	14000
Hank/doff	10.5	10.5
Hours per doff	13.9	13.9
Production per doff	20.1 Kgs	20.5 Kgs
Unit per doff	90	79.3
UKG	4.483	3.861
Saving %	-	13.9

Comparison between normal spindle and energy saving spindle for coarser counts ¹⁵

Particulars	Normal spindle	Energy saving spindle
Count	40	40
Spindle speed	11000	11000
Hank per doff	5.2	5.2
Hours per doff	5.1	5.1
Production per doff	23.3	23.6
Units per doff	22.5	21.3
UKG	0.960	0.9
Saving %	-	6.3

The SITRA studies reveal that the power savings for 40s count for the same set of 2 spindles is just about 6.3% as opposed to 13.9 % as observed for 100s count and this underlines the fact that lighter spindles are more advantageous for higher speeds.

3.5.6 SPINDLE TAPE

Power is transferred from tin roller pulley to spindle through spindle tapes.

There are several factors of the spindle tape that affect the energy consumption.

The various factors that affect the power transmitted and the power consumed are :

- Mass of the tape
- Thickness
- Width of tape
- Metal to tape friction

If the material by which the tape is made is the same, parameters like width, thickness and tensile strength (if construction and the count are identical) are all related to the number of fibres per unit area of cross section of the tape and consequently indirectly related to the mass per unit length of the tape. The mass per unit length is proportional to the bending resistance of the tape and hence to the power consumed.

Tape weight g / m	Power consumed UKG
3.50	1.260
5.85	1.338
6	1.303
6.25	1.280
6.75	1.324
7.25	1.310
8.25	1.374

The above table was collected from the literature Energy Conservation in Spinning Mill which is a collection of all the works done in this area over the years. Thus a 3.5 gms / meter saves about 8 % energy compared to 7.5 gms / meter. In general a lighter and thinner tape consumes lesser power.

There are 2 types of spindle tapes in use they are

1. Cotton tapes
2. Synthetic Sandwich tapes (polyester – cotton , nylon – cotton)

Of these nylon sandwich tapes are mostly used. The synthetic portion of the spindle tape helps to save energy. The polyester cotton tapes which were introduced before the nylon sandwich tapes have shown 8-10 % reduction in power consumption. The nylon tapes are made of polynosic fabrics on one side and nylon on the other. Here lower tape width upto 10mm are feasible. There is an energy saving of upto 17 % by replacing cotton tapes with nylon sandwich tapes.

As the width of the tape is reduced the power consumption reduces. The power consumption for a 16mm width tape is 6% more as compared to 13mm width tape. The higher power consumption is due to greater bending resistance and windage losses. The difference in spindle speed is only marginal and does not affect twist level or yarn properties. Habasit Iakoka which is one of the leading manufacturers of spindle tapes have made spindle tapes with a width of only 10mm.

[Comparison between 13mm and 16mm tapes ¹⁶

Width of tape (mm)	13 mm	16 mm
Actual Spindle speed (rpm)	13252	13157
Power Consumption (Units /hour)	2.66	2.83

Comparison between Cotton and Nylon sandwich tapes ¹⁶

Type of spindle tape	Cotton	Nylon
Average Units per hour	9.55	7.89
Percent reduction in power	-	17.4

3.5.7 SPINDLE OIL

Generally spindle oil used has the viscosity index of 10 – 15 cst at 40 degree centigrade.

The spindle oils used in the industry are basically of 2 types namely :

1. Mineral based (from coal)
2. Synthetic based (from organic processed chemicals like diesters)

Usually ISO VG -12 grade is preferred for a ring frame and an ISO VG – 22 grade spindle oil is preferred for doubling machines.

The spindle rotates in the insert in a medium of a viscous oil. The purpose of the spindle oil is to act as a lubricant. The viscosity of the spindle oil dissipates energy and so if the level of oil in the bolster is high then energy is wasted in overcoming the fluid friction. According to the SKF spindle insert manufacturers 4.5cc of spindle oil is required in the bolster for effective working. A study was therefore undertaken to estimate the influence of spindle oil level in bolster. The trials were done by using different levels of spindle oil in the bolster keeping all the other parameters constant.

The table below shows the rate of increase in power consumption with respect to spindle oil level.

SITRA studies³ reveal that there is a relation between the oil level and the power consumption

Percentage increase in volume of oil	Percentage increase in the power consumption
8	5
18.5	33
29	51

The percentages mentioned above are only percentages of spindle power and not the total ring frame power.

In General the quality of the spindle oil can be estimated using 2 factors namely :

- ❖ Power consumption in KWh.
- ❖ Reduction in bolster temperature rise over ambient.

Synthetic based spindle oils are found to save power in the ringframe by 5-7% and this is achieved using special additives. The mineral oils incorporated with the same dispersant additive system is found to give a saving of 3 % compared to the ordinary spindle oil.

The dispersant helps to avoid coagulation of materials due to the spindle rotation and there reduces resistance to rotation of the spindle and hence reduces the power consumption.

Comparison between synthetic oils and Mineral oil properties ¹⁷

Characteristics	Mineral based	Synthetic based
Nature / base	Mineral	Diester
Viscosity Index	96	144
Flash point degree Centigrade	176	224
Total Acid Number	0.14	0.15
Evaporation loss % at 150 degree x for 6.5 hours	1.01	0.33
Rust test 24 hours	Pass	Pass

Comparison between different spindle oils (as given by SITRA) ¹⁸

Particulars	KW / hour	KW /hour/UKG	Percent savings
DD SPIN – 12	-1.76	-1.96	-1.76
EE SPIN – A	10.11	6.67	10.11
EE SPIN – B	2.07	2.91	2.07
EE SPIN – C	4.1	2.81	4.1
EE – 10	3.77	2.69	3.77

The negative number indicates that there is a additional power consumption in the DD Spin –12. The Energy Saving oils also were found to have a low gradient of temperature rise in the bolster on continued running.

3.5.8 LIFT AND RING DIAMETER :

The combination of lift and ring diameter determines the package power in a ring frame. As the package size increases the package power incurred increases as the package offers resistance to rotation. It also indirectly increases the spindle power. The decrease in package size in ring frame leads to a heavy loss in winding efficiency and so an optimum should be arrived at.

The optimum package recommended for some of the standard count to get optimum performance are given below as suggested by SITRA.

- 8 inches X 1.75 inches for counts 20s (lift X ring diameter)
- 7 inches X 1.5 inches for count 30s
- 6 inches X 1.5 inches for counts 60s
- 5 inches X 1.5 inches for count 80s and above

Smaller package size in addition to energy conservation offers scope to increase the spindle speeds due to reduction in tension acting on the yarn balloon. One can achieve about 10 – 12 % energy saving by adopting the above standards and a higher spindle speed upto 15 % more is achievable.

The power consumption of a 5 inch lift is 20 % less compared to a 7 inch lift and 6 inch lift consumes 10 % less compared with the 7 inch lift .The 8 inch lift used for coarse counts consume 10 % more power compared to the 7 inch lift. Similarly by reducing the ring diameter by 1/8 inch one can achieve about 13.5% reduction in power consumption. In other words a reduction in ring diameter by 1/8 inch saves more power than reducing the lift by 1 inch.

Energy costs Rs/Kg @ Rs 1.75 per unit with respect to ring diameter and lift (from the research work done at Textool ¹⁰

Count	Ring dia (inches)	Rupees per Kg of yarn For various Lift (inches)			
		5 inches	6 inches	7 inches	8 inches
20s	1 ½	0.967	1.071	1.173	1.256
20s	1 5/8	1.112	1.214	1.337	1.441
20s	1 ¾	1.256	1.4	1.523	1.646
30s	1 ½	1.606	1.791	1.996	2.163
30s	1 5/8	1.854	2.059	2.286	2.491
30s	1 ¾	2.121	2.367	2.614	2.863
40s	1 ½	2.367	2.656	2.964	3.273
40s	1 5/8	2.717	3.067	3.438	3.788
40s	1 ¾	3.129	3.521	3.933	4.344
60s	1 ½	3.891	4.427	5.004	5.559
60s	1 5/8	4.509	5.146	5.806	6.444
60s	1 ¾	5.167	5.909	6.692	7.433
80s	1 ½	5.333	6.156	7	7.823
80s	1 5/8	6.177	7.123	8.133	9.179
80s	1 ¾	7.123	8.215	9.369	10.448
100s	1 ½	6.959	8.071	9.223	10.336
100s	1 5/8	8.050	9.346	10.686	11.983
100s	1 ¾	9.26	10.769	12.313	13.815

3.5.9 SPINDLE SPEED

The spindle speed is one of the major factors that determine the power consumption in a ring frame. The power consumed per spindle is proportional to the square of the ring frame speed (refer annexure).

Influence of speed on energy consumption ¹⁹

Spindle speed rpm	Units per hour	UKG
10675	4.27	2
12075	5.377	2.3
14095	7.125	2.6
14867	7.85	2.7
15859	9.377	3.1
16500	10.310	3.3

The above table is a result of the research work carried out to determine the influence of ring frame spindle speed at SITRA

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3.5.10 INFLUENCE OF COMBINATION OF FACTORS

Having said the different modifications of the ring frame that help to achieve power savings, it would be very interesting to note that the studies conducted by spindle manufacturers Kunal reveal that when all the above parameter in a ringframe are optimised then there is drastic reduction in power consumption.

The tables below are studies given by Kunal ⁶

Study 1 :

Particulars	Kunal APT	Kunal ESS
Yarn count	40s C	40s C
Spindle speed	16800	16800
Lift (inches)	7	6.5
Ring diameter (mm)	38	38
Weight of spindle (g)	302	202
Wharve diameter(mm)	25.4	20.2
Motor HP	17.5	15
Number of doffs	9	12
Hours per doff	3.54	3.54
Units per doff	15.09	12.64
UKG	2.619	2.104
Percentage saving	-	19.66

The above table shows the combined influence of various factors like lift, weight of the spindle, motor HP etc, while keeping the speed and Ring dia as constant on energy consumption, which is significant.

Study 2 :

Particulars	Kunal APT	Kunal ESS
Yarn count	100s C	100s C
Spindle speed	16200	16200
Lift (inches)	7	6.5
Ring diameter (mm)	42	38
Weight of spindle (g)	320	202
Wharve diameter(mm)	20.2	20.2
Motor HP	25	25
Number of doffs	20	20
Hours per doff	17	17
Units per doff	10.826	9.096
UKG	7.103	5.916
Percentage saving	-	16.72

The result of the study 2 as given in the table shows the combined influence of ring diameter and lift, while keeping other factors viz. motor HP, wharve diameter and speed as constant. There is a significant power saving in this case also

Study 3 :

Particulars	Kunal APT	Kunal ESS	Kunal ESS	Kunal APT	Kunal ESS
Yarn count	30sPV	30s PV	30sPV	60sPV	60sPV
Spindle speed	13700	13700	15500	16500	19500
Lift (inches)	7	6.5	6.5	7	6.5
Ring diameter (mm)	42	38	38	42	38
Weight of spindle (g)	354	222	222	315	202
Wharve diameter(mm)	20.2	20.2	20.2	22.2	20.2
Motor HP	25	25	25	15(S) 20(H)	15(S) 20(H)
Number of doffs	15	15	15	Cont...	Cont...
Hours per doff	3.10	3.1	2.45	7.16	6.06
Units per doff	2.55	10.22	12.17	8.89	8.84
UKG	1.35	1.10	1.14	2.59	2.24
Percentage saving	-	18.50	15.50	-	17

The result of the above study as given in the table shows for 30s and 60s PV that when all the five parameters namely

1. spindle speed
2. lift
3. spindle weight
4. ring diameter &
5. wharve

are changed 15 to 17 % power savings in Specific Energy Consumption is obtained.

However when you increase the speed keeping all other parameters constant, which is the case in column3 compared to column2 (for 30s) a marginal increase of 3% in Specific energy Consumption is found.

3.6 MOTORS

Motors used in Textile industry are mainly Totally Enclosed Fan Cooled Squirrel Cage Induction motors. Apart from this the other types of motors used in the Textile Industry are DC Motors and Stepper motors. Motor is one major area where there is immense potential for energy saving as there are so many losses taking place.

CII studies² reveal that the losses in a motor are :

TYPE OF LOSSES	PERCENTAGE LOSSES
Windage / Friction losses	0.3 – 2.6
Core losses (Magnetisation losses)	1 – 4
Stray load losses	2 – 3.2
Copper losses	3 – 9
Total losses	6.3 – 18.8

CII studies reveal that on account of these losses the Motor Efficiency which is the ratio of the Output power to the Input power is only 84 – 94 %. The losses in a motor can be categorized into 3 main classification namely :

- ❖ Voltage Dependent - iron losses
 - ⇒ Magnetisation losses
 - ⇒ Eddy current losses
- ❖ Current Dependent – Copper losses

⇒ Stator

⇒ Rotor

❖ Friction and Windage losses

Energy losses in Motor are due to

- ⇒ use of less efficient motors
- ⇒ oversized / underloaded motors
- ⇒ improper supply voltage
- ⇒ voltage fluctuations
- ⇒ poor powerfactor
- ⇒ less efficient – driven equipment
- ⇒ idle running.

Of these the use of oversized motors is one big source of power loss as the mills tend to prefer oversized motors for the sake of future alteration in the processed material speeds etc. This results in under loading of Motors during their regular run. It must be noted that the efficiency of a motor depends on the rate of loading. More the rate of loading better is the efficiency.

The Research studies by SITRA³ as given below clearly shows the drop in efficiency in the motor and power factor for an application which requires only 12.5 Hp motor .

	12.5 Hp	15 Hp	17.5 Hp
Motor Efficiency	90	88	86
Power Factor	0.92	0.85	0.75
Motor Input	10.36	10.59	10.84
Power Consumption (KWh)	62160	63540	65040
Saving	-	-3%	-4.5%

3.6.1 ENERGY EFFICIENT MOTORS

Losses should be minimized to improve the efficiency of Motors. In the Energy Efficient Motors the losses are minimized and the efficiency of the motor is improved by 4 - 6%. It also has the capacity to withstand voltage fluctuations and imbalances.

The Energy Efficient Motors have the following features:

- More copper wire in stator and rotor to cut resistance losses.
- Longer stator and rotor cores to reduce magnetic losses.
- Precision air gaps to reduce current requirements.
- Improved winding and lamination design to maximise energy consumption .
- Special steel processing in stator to minimise core losses.
- Improved fan design that increases motor insulation life and also gives cooler operation .
- High power factor so there is no need for power factor corrections
- Better quality bearings are used .

The studies conducted CII prove the worthiness of the Energy Efficient Motors in a textile Industry. For the study, Ordinary motors in 30 ring frames were replaced by Energy Efficient Motors.

Comparison between ordinary Motor and Energy Efficient Motor

- CII studies²

MOTOR	RATED KW	NO LOAD KW	LOAD KW
Old motor	15	2.32	9.92
Energy Efficient Motor	15	1.56	7.36
Difference in Power Consumption		0.76	2.56

The Total Investment on the energy Efficient Motors was Rs 7.2 lakhs and Saving per year was found to be Rs 6.7 lakhs. The Payback Period was found to be 13 months.

3.6.2. Corrections during Operations :

3.6.2.1. Voltage Optimisation :

Impact on motor operating parameters:

- ⇒ Reduction in voltage dependent losses .
- ⇒ Capacity reduces .
- ⇒ PF, Load Factor and Efficiency improves .
- ⇒ Load current improves .

3.6.2.2 Optimization of Lightly Loaded Motors:

Options for energy saving on lightly loaded motors are

- Delta to permanent Star for steady load applications .

- Automatic star – delta – star converters for shock loads .
- Soft starter cum energy savers – high starting torque applications .
- Down sizing .
- Overall voltage optimization .

3.6.3 STARTERS

The type of starter used also determines the energy consumption pattern in a machine.

As the line voltage increases so does the magnetisation losses. CII studies² recommend that for motors where the percentage of loading is less than 38% , delta connection in starter should be converted to star connection because under normal mode the voltage losses and copper losses are high and power factor and efficiency are low.

Comparison between different mode of connection on starters²

TYPE OF CONNECTON (for 30 % loading)	RATED KW	ACTUAL KW
Delta Mode	15	4.5
Star mode	15	3.5
Savings in KW		1

Another innovation in the field of starter is the use of Automatic – Star Delta – Star starter and these type of starters find its use in applications where shock loads is applied. These types of starters are fitted with load sensor and timer. The load sensor senses the

protection and if the loading is below 38 % then the star mode is opted and this is an energy saving measure. Another energy saving gadget is the Soft Start Cum Energy Saver which continually senses the load and applies the load accordingly. These type of starters cost about Rs 20000 and the pay back period of this is about 6 months.

During the survey undertaken it was found that in a mill on an average there are about 1 – 2 motors burning out a month. In most of the cases the motors are given for rewinding and it should be noted that each rewinding costs about 2-3 % loss in efficiency. CII² recommends that a motor is not ideal for usage after 3 such rewinding.

This loss in motor efficiency is due to the following reasons

- ⇒ Rotor scratches the stator
- ⇒ Air gap becomes uneven
- ⇒ Torque induced is not uniform
- ⇒ Net torque developed is less

3.6.4.DISTRIBUTION SYSTEM

CII² suggests the following to improve power distribution system

- ⇒ Proper location of Powerhouse and use of cable of correct size to limit cable loss to -1%.
- ⇒ Limiting voltage drop(4-5v / Phase) in distribution by appropriate capacity and location of capacitors to maintain Power Factor of not less than 0.90.
- ⇒ Capacitor bank at the main and at end of distribution for good PF Control so as
 - to keep MD at reasonable level
 - reduce voltage drop in distribution
 - to reduce the copper loss in transformer

3.6.5. POWER FACTOR & CAPACITORS

The power factor is a major influencing factor in the total energy consumption because the Maximum Demand in KVA is determined by the value of Power Factor. More the power factor lesser is the Maximum Demand and so lesser is the Energy consumed. The ideal power factor is 1 but this is impossible to achieve. From the SITRA survey³ conducted it was found that in practice the mills are maintaining a power factor ranging between 0.77 – 0.99. One has to take into account of present day policy that the Industries are penalized if the power factor maintained is less than 0.9. To correct the Power factor one uses capacitors. There are many types of capacitors used in the Textile Industry namely

1. polypropylene
2. paper
3. dielectric

SITRA³ studies reveal that the capacitors by itself consume energy during working and this ranges between 0.5 – 3.5 Watt / KVAR. It was found that the polypropylene capacitors consumed the least and the paper capacitors consumed the most energy.

One may be aware of the fact that power is transferred from the power house to the motor through cables. If low power factor is maintained between the power house and distribution board the cable losses increases enormously. CII claim that there is enormous saving of 38%, if capacitors are installed both at the Powerhouse and the load end.

SITRA recommends the following formula to determine the rating of a capacitor that is required to correct the power factor.

Rating of the capacitor in KVAR = Load in KW (Tan existing PF – Tan desired PF)

Influence of location of Capacitors³

Particulars	Capacitance at Power house	Capacitance at both ends
KVA rating	1266	1000
Line Current in Amps	1761	1391
Cable Losses (KW)	37	23
Savings in KW	-	14

3.6.6. TRANSFORMERS

The purpose of the transformers is either to step up or step down the supply voltage. There are many different ways to achieve energy saving in this area. Some of the recommendations by CII² are :

- ⇒ Transformer capacity has to kept at 60% loading so as to achieve 98-99% efficiency and operated near to unit power factor.
- ⇒ In opting for energy efficient transformer (amorphous metal core) 50% reduction in energy loss over iron core transformer.
- ⇒ Selection of transformer should take into consideration recurring no load and load loss apart from its cost.

3.6.7 DIESEL GENERATORS

Apart from the point given above for energy management ,Units per litre ,load and the hours of run in the case of generated power is also considered because most of the mills have gone for self generation to cope up with the voltage fluctuations in the supply from the mains.

3.7 FANS & BLOWERS :

In textile industry 2 types of fans are used

1. Axial fans – for low pressure and high volume applications like Humidification , cooling towers.
2. Centrifugal fans – for high pressure and low volume applications like pneumafil system. There are 3 types of centrifugal fans
 - a) forward curved blade
 - b) radial blade
 - c) backward curved blade

The efficiency of centrifugal fan is higher.

The pneumafil fan is installed in a ring frame to suck the drafted ends coming out of the front roller nip during an end break. The pneumafil is installed at the off-end of a ring frame and a centrifugal fan is used to suck the air through the orifices in the pneumafil duct . The pressure at the off-end is obviously greater than the pressure at the gear end. SITRA studies conclude that the minimum suction required for efficient working is 6cm water column pressure. To have a pressure of 6 – 8 cm of water column at the gear end a 3HP motor is normally installed at the off-end for a short frame.

The following are the deficiencies in the existing fans are

- The energy required is high
- The suction performance is not uniform due to turbulence
- These fans have large moment of inertia. This leads to motor burnout problems.
- Handling during maintenance work is difficult
- The noise and vibration levels are more.

To overcome these difficulties SITRA¹³ has developed energy Efficient “ **SITRA Excel fans** ”. The blade angle and geometry of blade is altered to obtain the required power saving and efficiency. The existing diameter, width , diameter ratio, blade angle, blade profile, material and manufacturing methodologies of fan impeller are changed for efficient suction with minimum losses and turbulence. The salient features of this fan are

- About 3 times reduction in weight of fan impeller.
- Comparatively less instantaneous current value to reduce the motor burnout rate.
- Technical perfection in manufacturing with the help CAD/ CAM technique.
- Superior finish with special powder coating for less accumulation of dust.
- Dynamically balanced.
- Reduction in air turbulence.
- Reduction in noise and vibration.
- Very easy to retrofit in the existing system.

Comparative study between the existing fan and SITRA "Excel fan"¹³

Number of spindles :440 Count - 100s spindle speed – 17500 rpm

Pneumafil motor – 3 HP Pneumafil motor speed - 2880 rpm

Particulars	Conventional fan		Excel fan	
	Fan material	Aluminium		Aluminium
Fan diameter (mm) and width(mm)	445 & 60		4.3 & 60	
Fan weight (kg)	6.3		2.2	
No of blades	9		9	
Instantaneous current (A)	3.5		2.8	
Energy consumption / hour (KWh)	1.779		1.255	
Percent saving	-		25 %	
Suction performance (cm of water column)	Right	Left	Right	Left
Gear end	7.7	7.65	7.85	8.2
Middle	8.64	8.66	9.88	9.9
Offend	10.06	10.42	10.4	12.02

The Excel fan used in the above case study has 10% lower diameter and 65% lesser weight. In the longer frame fans with 50 % lesser weight are used but it should be noted that eventhough the energy saving is as high as 33% there is a 10% drop in suction pressure.

Similarly Excel fans have found application in Simplex , Drawframe and Card where the changes made are as follows.

- Simplex - 4% reduction in diameter and 30% reduction in weight and savings obtained is around 35%.
- Drawframe – 4% reduction in diameter ,10% reduction in width and 50% less weight with 40% power saving.
- Card – 4% reduction in diameter ,25% lower width and 30% less weight and saving is 35%

The cost of this fan ranges between Rs 5000 – Rs 6000 and the payback period is between 1.5 to 3.5 months.

Apart from this feature the use of Fibre reinforced plastic fans has given 10 to 15% energy saving.

3 HUMIDIFICATION :

Humidification is one area accounting about 12% of total energy in a spinning mill according to SITRA's studies¹. It help to improve spinning efficiency and hence increase the quality of the yarn produced.

CII² recommend various energy saving ideas in the field of humidification which include :

- Use of favourable weather conditions.
- Use of dual drive system.
- Use of Variable frequency drive – to vary the rpm of fan as per requirement.
- Installing ATIRA Cell type air washer instead of the spray type washer.
 - Energy consumption in pumping is only 1/10 th.
 - Energy consumption in air flow is lower by 50%
 - Low water pressure.
 - Saturation efficiency as high as 95%.
 - Only small quantity of water required and easier maintenance.
- Installing Axial fans instead of Centrifugal fans to handle high volume air at low pressure.

3.9 AIR COMPRESSOR :

There are 2 major types of compressors they are :

- Positive displacement
 - ❖ reciprocating vertical type (100 – 500 cfm) and horizontal balance opposed (200 – 5000 cfm)
 - ❖ rotary screw (high speed) ; the advantage here is that the inlet air need not be moisture free but the discharge has oil carry over
- Centrifugal type (> 12000 cfm)
 - ❖ Radial flow
 - ❖ Axial flow

Some new ideas of energy saving in the compressors as recommended by CII² are:

- ❖ Installation of after coolers to remove the water droplets that make the system sluggish and hence increase the energy consumed. (upto 7% energy saving)
- ❖ Installation of the proper type and capacity of compressor
- ❖ Improving the working efficiency
- ❖ Use of correct type of dryer.
- ❖ Installation of VFD for compressors saves upto 4% as pressure is kept constant.
- ❖ Monitoring the waste and the pressure losses.
- ❖ Use of transvector nozzle for cleaning purpose serves to reduce power consumption by 50% as atmospheric air is also sucked through the nozzle
- ❖ Cool inlet air for the compressor

Comparison between the different type of compressors²

Particulars	Reciprocating	Centrifugal	Screw
Capacity (cfm)	3950	3950	3950
KW	549	521	650
Specific power (KW metre ³ /min)	4.9	4.65	5.8

Leakage is one aspect that goes virtually unnoticed but the table below shows the loss of energy at 7 Kg / cm² as revealed through the studies conducted by CII².

Orifice diameters (mm)	Air leakage (cfm)	Power wasted (KW)	Annual savings @ 3.50 /KWh (Rs)
1.6	6.5	1.26	35000
3.2	26	5.04	140000
6.4	104	20.19	425000

3.10 LIGHTING :

Modern developments in the area of energy saving :

- ❖ Use of high efficient tube lights which provide more light output for the same Wattage. More than 40 % increase in output is achieved.
- ❖ Use of 36W tube lights instead of 40W tube lights.
- ❖ Use of electronic chokes instead of Copper choke serves to save upto 19W
- ❖ Use of compact flourescent lamps for corridors etc helps to save upto 50% energy consumed per tube light.
- ❖ Use of automatic switching off mechanism for the outer lights
- ❖ Use of sodium / mercury / metal halide lamps for outer lighting.
- ❖ Use of dimmers wherever required.
- ❖ Proper use of natural light.
- ❖ Proper grouping if the lights.

Comparison between the Copper ballasts and electronic ballasts in flourescent lamps²

Particulars	40 W tube light with Copper ballasts	40 W tube light with Electronic ballasts
Power consumption (choke + tube)	54 –55 W	41-42 W
Savings	-	25 %

The electronic ballasts cost Rs 250 more than the copper ballasts and the saving obtained is nearly double than the above in a year that and has the following features.

- Operates at high frequency
- Low loss 1- 2 watts per choke
- High power factor
- Instant start up
- Operates at low voltage
- Low heat dissipation.

CII² recommend the usage of Energy Efficient 36W tube lights which gives the required illumination with enormous power saving. CII also recommend the usage of Compact Fluorescent lamps for corridors and Administrative buildings where upto 50% energy saving is possible.

Aim & Scope

4.AIM & SCOPE :

The aim of the project is :

- To study the influence of few parameters like Spindle speed, spindle Inserts, spindle oil , cleaning cycle on power consumption in a modern ring frame. This study is limited to the facilities & opportunities provided by the mills.
- To study the various systems prevailing in the spinning mill with Regards to Energy Management through a survey. The survey is limited to six mills only, who have provided the necessary data.
- To suggest a system from the above studies for efficient and effective energy management.

Methodology

5. METHODOLOGY :

5.1 Study of influence of certain parameters on Energy Consumption in Ring Frame

As stated in the Aim studies are carried out on Ring Frame to determine the influence of

- Spindle speed
- Cleaning cycle
- Spindle inserts
- Spindle oil

The Methodology of studying the influence of the above factors on energy consumption involve the work of comparing the average Units per Kilogram (UKG) derived from the recording of energy consumed in a full doff before and after change using load manager. This is apart from studying other related details such as Hours per doff, production, waste, etc. The Ring frame selected for the study is LR G5/1.

The total units (KWh) consumed per doff along with the total material delivered including the wastage is tabulated (See Results & Discussion) and the UKG is found out. The above process is repeated for 3 doffs. The Two UKGs of different conditions are compared to determine the result. Other details of study are tabulated in section 5.1.2.

5.1.1. Quality of measuring instrument

Very accurate Load measuring instrument is necessary to make sure that any marginal deviation is properly recorded. Fortunately we could get one such Load Manager manufactured by Krykard in the mills, where we have conducted our studies. The details that a load manager gives are

- Voltage & Current

- Powerfactor
- Total KW & hours per doff .
- Units consumed (KWh) per doff

5.1.2. Details of study

Influence of Spindle speed on power consumption :

Study :1

Ring frame LR G5/1 (frame7)

Count 30s

TPI – 18.6

Average Speed – 14015.7 rpm

Cop content - 50 gms

Device used – 3 phase Load manager (Krykard EA 0018)

(NIPTEX Control system is used to vary the speed)

S.No	Step Speed (rpm)	Length(m)
1	10620	50
2	11070	100
3	11520	150
4	11970	200
5	12420	250
6	12870	300
7	13320	350
8	13770	400
9	14400	2434
10	14220	2535

Study 2

Ring frame LR G5/1 (frame 7) Count – 30 s TPI → 18.6

Average speed – 15573 rpm Cop content – 50 gms

S.No	Step speed(rpm)	Length (m)
1	11800	50
2	12300	100
3	12800	150
4	13300	200
5	13800	250
6	14300	300
7	14800	350
8	15300	400
9	16000	2434
10	15800	2535

Comparison between SKF and Suessen Spindle Inserts

This study is to compare the power consumption between Suessen (HPS 68) insert and SKF (HF 21) inserts.

Study Details

Ring frame LR G5/1 (frame 42) Count – 40s Spindle speed – 19230 rpm

Study1: Sussen HPS 68 insert with M19VN

Study2: SKF HF21 insert with M19HD spindle

Influence of cleaning on power consumption :

The purpose of this study is to determine the difference in power consumption in a ring frame before and after the cleaning cycle. The cleaning is done once in 2 weeks.

Study Details:

Ring frame LR G5/1

Count 30s Spindle speed – 15900 rpm (avg)

Comparison between Mineral oil and Synthetic oil :

The purpose of this experiment is to determine the power consumption using a mineral based spindle oil and a synthetic based spindle oil and hence compare the UKG values keeping all the other parameters constant.

Study Detail: Count 32s' Avg Spindle speed = 14850 rpm TPI –19.5

Study1: With Machospin (Mineral based oil)

Study2: With Mosil (Synthetic based oil) :

5.2. Study of the systems prevailing in various mills

To study the systems prevailing in the mills a suitable **questionnaire** was Prepared & sent to various types of spinning mills. From the data collected from the mills the different systems used in the industry are summarized and highlighted.

Results and Discussions

6. RESULTS & DISCUSSIONS

6.1 RESULTS OF STUDY UNDERTAKEN

6.1.1 Influence of Spindle speed on power consumption :

The tables below shows the result of a study on the influence of spindle speed on power consumption. In the first study (Table 1) the ring frame is run at normal speed (14015.7 rpm) and in the second study (Table 2), the ring frame is run at 10% higher speed keeping all other parameters like lift, ring dia, spindle weight and spindle wharve constant

Table 1

Specific Energy Consumption at Lower speed

Ring frame LR G5/1 (frame7)

Count 30s

TPI – 18.6

Average Speed – 14015.7 rpm

Cop content - 50 gms

Doff No	Hours run	Units per doff	Yarn wt (kgs)	Waste (kgs)	Total weight (kgs)	UKG	Units per hour
1	2	40.614	46.288	0.64	46.928	0.865	20.307
2	2.02	40.421	45.948	1.52	47.468	0.852	20.01
3	2.01	40.526	46.054	0.95	47.004	0.862	20.16

$$\text{Average UKG} = 2.579 / 3 = 0.86$$

Table 2

Specific energy Consumption at 10 % Higher speed :

Ring frame LR G5/1 (frame 7) Count – 30 s TPI – 18.6

Average speed – 15573 rpm Cop content – 50 gms

Doff No	Hours run	Units per doff	Yarn wt (kgs)	Waste wt (kgs)	Total weight	UKG	Units per hour
1	1.51	42.117	47.928	0.72	48.648	0.866	22.79
2	1.52	40.336	47.328	1.22	48.548	0.91	23.75
3	1.51	42.1	47.93	0.8	48.73	0.864	27.88

$$\text{Average UKG} = 2.64 / 3 = 0.88$$

The increase in the UKG for 10 percent increase in spindle speed is 2.3 % and this result correlates with the study done by Kunal Spindle Manufacturers.

6.1.2. Comparison between SKF and Suessen Spindle Inserts :

The tables below shows the results of the comparative study between Suessen spindle inserts and SKF spindle inserts with respect to the Specific Energy Consumption. Table 3 shows the results of the study done using Suessen spindle inserts with M19VN spindles and Table 4 shows the results of the study done using SKF spindle inserts with M19HD spindles. All other parameters like lift, ring dia, spindle wharve & spindle speed are kept constant.

Ring frame LR G5/1 (frame 42) Count – 40s Spindle speed – 19230 rpm

Table 3

Suessen HPS 68 insert with M19VN Spindle

Doff No	Yarn wt (kgs)	Waste wt (kgs)	Total wt (kgs)	Power (KWh)	UKG	Doff time (mins)
1	45.436	1.26	46.696	70.926	1.519	143
2	45.736	1.2	46.936	71.468	1.523	143
3	46.056	1	47.056	71.259	1.514	143
4	45.636	1.18	46.816	71.415	1.525	143
5	45.416	1.3	46.716	71.306	1.526	143

Average UKG = 1.522

Table 4

SKF HF 21 insert with M19HD spindles

Doff No	Yarn wt (kgs)	Waste wt (kgs)	Total wt (kgs)	Power (KWh)	UKG	Doff time (mins)
1	45.756	1.36	47.116	70.35	1.493	143
2	45.796	1.06	46.856	69.997	1.494	143
3	45.936	1.04	46.976	70.166	1.494	143
4	45.636	1.14	46.776	69.727	1.491	143
5	45.516	1.1	46.616	69.704	1.495	143

Average UKG = 1.493

The Suessen inserts with M19VN spindles consume 2 % more power compared to an SKF HF21 insert with M19HD spindle. This may be due to the difference in the basic design characteristics, lubrication, etc

6.1.3 Influence of cleaning on power consumption :

The tables below show the influence of cleaning cycle on power consumption. The Table 5 shows the Average UKG for a ring frame which is run without cleaning and Table 6 shows the Average UKG for ring frame which is run after cleaning with all the other parameters kept constant.

Ring frame LR G5/1 Count 30s Spindle speed – 15900 rpm (avg)

Table 5

Before Cleaning

Doff No	Yarn wt (kgs)	Waste wt (kgs)	Total weight (kgs)	Power (KWh)	UKG	Doff time (mins)
1	54.538	1.020	55.558	54.503	0.981	128
2	55.098	0.92	56.018	54.979	0.981	128

Average UKG = 0.981

Table 6**After Cleaning**

Doff No	Yarn wt (kgs)	Waste wt (kgs)	Total wt (kgs)	Power (KWh)	UKG	Doff time (mins)
1	54.258	1.42	55.678	54.558	0.98	128
2	54.038	1.680	55.718	54.027	0.97	128

Average UKG = 0.975

The ring frame after cleaning consumes 0.66 % less power than an unclean Machine, which is not cleaned for 14 days which is expected because a cleaner machine reduces the resistance to motion because of the removal of fluffs and other dirt particles.

6.1.4 Comparison between Mineral oil and Synthetic oil :

The study below shows the result of the comparative study between Mineral based spindle oil and Synthetic based spindle oil. In Table 7 shows the study is carried out using Mineral based Spindle oil and in Table 8 shows the study carried out using Synthetic based spindle oil in the same Ring frame keeping all other parameters constant.

Count 32s Avg Spindle speed = 14850 rpm TPI –19.5

Table 7

With Machospin (Mineral based oil)

Doff No	Hours per doff	Units per doff (KWh)	Total wt (kgs) (yarn + waste)	UKG
1	3.03	96.346	64	1.5
2	3.04	96.474	64	1.5
3	3.05	95.947	64	1.49
4	3.04	96.270	64	1.5
5	3.03	95.589	64	1.49
6	3.05	98.862	64	1.54

Average UKG = 1.50

Table 8

With Mosil (Synthetic based oil)

Doff No	Hours	Units per doff (KWh)	Total wt (kgs) (yarn +waste)	UKG
1	3.03	89.733	64	1.4
2	3.03	88.572	64	1.38
3	3.05	87.34	64	1.36
4	3.03	88.155	65	1.37
5	3.03	88.615	64	1.38
6	3.04	88.968	64	1.39

Average UKG = 1.38

Thus the Synthetic based spindle oil consumes lesser energy compared to Mineral based spindle oil. The power saving achieved using synthetic based spindle oil is 8.6 % which may be due to special additives in the oil, better transfer of heat or lesser friction to spindle rotation.

6.2 SUMMARY OF RESULTS OF SURVEY UNDERTAKEN :

Following are the summary of the results of the survey conducted. As said in the methodology a questionnaire was sent to 6 mills of which 2 are modernised mills, 3 are partially modernised mills and 1 mill is a conventional mill.

- In well organized sector mills it was found that the mill has an Energy cell headed by either the Electrical engineer or the Energy Manager.
- The cost of 1 unit from the TNEB mains ranges between Rs 4 – 4.25 and that of the generated energy is between Rs 4.5 – 4.6 .
- The Power factor of the mills taken for survey ranges between 0.92 – 0.99. The mills use capacitors (paper type) to correct the power factor. It was observed that the power factor before correction was 0.85.
- The modernized mills are provided with departmentwise power meters but in other mills the power meters are provided only at the power house.
- The weight of the spindles have been reduced from 320gms to 260 gms in 2 of the six modern mills who have participated in the survey. The partially modern mill and conventional mill use spindles weighing 280 to 320gms.
- The wharve of the spindle used in the industry is 19mm in the modern mill, whereas the spindle wharve in the partially modern mill and conventional mill ranges between 20.2 mm and 25 mm.
- The optimum ring diameter used are 38mm for coarser counts and 36mm for finer counts in places where the Automatic cone winding machines with individual splicers are used. In partially modernised mills and conventional

- The number of blades used for pneumafil fans is 9 or 12.
- Modern mills prefer to use Energy Efficient motors as the return on the high investment towards the same is very appreciable.
- Modern Mills do a periodic diagnostic checks on the motor efficiency and keep track of the number of rewindings carried out.
- The Modern mills use screw type compressors and aftercoolers are incorporated in the compressors.
- Both water and air cooled compressors are used.
- For departments 36W flourescent lamps with electronic ballasts are used in the modern mill, but the partially modern and conventional mill still use 40W bulbs with copper chokes.
- In general all mills have gone for sodium vapour lamps for road lighting.
- In general the mills have gone for automatic switching off for road lights and manual switching off for department lighting.
- In modern mills air type of circuit breaker is used.

These are some of the findings of the survey undertaken.

7. CONCLUSION & RECOMMENDATIONS

From the study and survey undertaken, we conclude the following

7.1 THROUGH EXPERIMENTS :

From the study on LRG5/1 with 1008 spindles 180mm lift, 38mm ring dia & 263 gms spl wt one can conclude that

- For 10 % increase in speed the corresponding increase in UKG is **2.3 %**
- The energy saving obtained using SKF HF21 spindle insert with M19HD is **2% (Rs 26000 / yr @ Rs 4.5 /unit for 1008 spls)** compared to Suessen HPS 68 inserts with M19VN
- The energy saving obtained by cleaning the machine after doff is **0.66 %**
- The energy saving obtained using synthetic based spindle oil instead of Mineral based spindle oil is **8 % (Rs 1.3 lakhs / year @ Rs 4.5 / unit for 1008 spls)**

7.2 THROUGH SURVEY :

- There is a separate energy cell to look after the Energy Audit programme.
- Energy meters are kept departmentwise in modern mills.
- The power factor maintained is 0.93 to 0.99 using paper capacitors to reduce the transmission & distribution losses and also Maximum Demand.
- During modernization the V belt drives in ring frame have been replaced using flat belt drives.
- Spindle wharves upto 19mm are in use instead of 25mm and spindle weights have been reduced from 320 gms to 220 gms to go for higher speeds.

- Ring diameters have gone as low as 36mm in places where autoconers with individual splicers are installed and correspondingly the lift has been reduced to 160mm for finer count spinning to reduce package power on ring frame.
- Synthetic based spindle oils have found increased usage to save energy.
- Energy Efficient Motors are preferred because the payback period is very short.
- Axial fans are used for humidification and centrifugal fans are used for Pneumafil to conserve energy.
- The mills have started using Electronic choke instead of Copper choke in lighting.
- Compact flourescent lamps have found its application in the corridor and administrative building lighting.
- The use of 36W tube lights instead of conventional 40W tube lights has become a common practice.

7.3 RECOMMENDATIONS

1. Spinning Mill should concentrate on Energy Conservation aspects. Energy Conservation programme should be a continuous and regular activity.
2. Systematic and Comprehensive Energy Audit should be carried out to chalk out the ECP. A separate Energy cell should be constituted to conduct Energy Audit, awareness about Energy Saving and also to carry out Energy Conservation Programme.
3. Maintain departmentwise energy meters instead of one meter for easy

Management and control.

4. Maintaining the power factor always above 0.95 by appropriate installation of capacitors should be given importance.
5. Since ring frame consumes maximum amount of energy, during modernization care has to be taken to install Energy efficient devices. Concentration should also be towards saving energy in Humidification and Compressors which are next highest contributors towards energy cost.
6. Replace the V belt drives in ring frame by flat belt drives.
7. Replace mineral based spindle oil with synthetic based spindle oil.
8. Use spindles with lower wharve diameter and lesser weight in places where higher spindle speeds are required for better productivity.
9. Use lesser ring diameter in cases where automatic winding machines with individual splicers are available so as to reduce package power.
10. Use Energy Efficient motors and make sure that the loading in these motors is always above 80% for better efficiency.
11. Avoid idle running of motors.
12. Replace the 40 W tube lights with the new 36W tube lights and fit an Electronic ballast instead of Copper choke.
13. Proper grouping of lights is a must for energy saving and natural light must be used wherever available.
14. Use CFL for corridor lighting and Administrative buildings.
15. Use Sodium and mercury vapour lamps for road lighting.

16. Use Axial flow fans for humidification and Radial flow fans for Pneumafil.

Replace the aluminium fans with Fibre Reinforced plastic fans for Pneumafil and Humidification.

The above are few of our recommendations based on our survey and study.

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ANNEXURE

9. ANNEXURE :

9.1 FORMULAE TO DETERMINE THE UKG OF A MILL :

Units (KWh) consumed in different departments for 100 Kg of yarn in ring frame :

$$= A \times B / (C \times D)$$

Where ,

A is the Number of units for 8 machine running hours (KWh).

B is the Waste factor given by (100 + waste).

C is the Production in Kgs per delivery.

D is the Number of deliveries.

The units for each department are added up to get the Total units consumed to produce 100 Kgs of yarn. The above figure is then divided by 100 to get the Units consumed to produce 1 Kg of yarn.

9.2 FORMULAE TO DETERMINE THE POWER CONSUMED IN WATTS/SPINDLE IN A RING FRAME :

There are various formulae used to determine the power per spindle in a ring frame.

❖ Soliman's formula :

$$N_{pt} = d^{7/2} h n^{3.1} z 10^{-9} \text{ (Total package power in KW)}$$

$$N_{st} = 4.25 z G^{0.87} D^{1.7} n^{2.4} 10^{-8} \text{ (Mean spinning power in KW)}$$

$$N_{nt} = 3.33 z g^{1.9} h n^{1.4} 10^{-7} \text{ (No load power in KW)}$$

$$\text{Total power} = N_{st} + N_{nt} + N_{pt}$$

$$\text{Mean power} = N_{st} + N_{nt} + 0.53 N_{pt}$$

Where , z is the number of spindles , g is gauge (mm) , h is lift (mm)

D is the ring diameter (mm) , **d** is package diameter (mm)

G is traveller weight (gms) , **n** is spindle speed in 10000's

❖ SITRA's formula :

$$P = (7.5 + 80 / C + 500 / t^2) n^2$$

Where ,

P is the power consumption in watts per spindle , **t** is turn per inch

C is the count in Ne , **n** is spindle speed in 10000's

❖ ATIRA's formula :

$$P = (1.88 \times 10^{-14} n^2 [h \times d^{2.75} + 8.6 h^2 d / C]) + (9 \times 10^{-7} n / C^{0.5})$$

Where, **n** is spindle speed , **h** is lift , **d** is ring diameter , **C** is count in Ne

Both lift and ring diameter are in inches.