ISLAMIC DEVELOPMENT BANK

**NPO
PAKISTAN**

NATIONAL PRODUCTIVITY
ORGANIZATION

BENCHMARKING STUDY ON "PRODUCTIVITY ENHANCEMENT IN COTTON SPINNING SECTOR IN PAKISTAN"

Dhul Qada 1428H (November 2007)

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CONTENTS

P R E F A C E

Cotton is one of the most important cash crops in many IDB member countries. It plays a vital multi-sectoral role in their economies, earning foreign exchange and providing employment for millions of people in the agricultural and related processing and textile sub-sectors. Out of 56 IDB member countries, 29 countries produce cotton. These countries share about 30% of world cotton area and 28% of world cotton production. Due to the importance of the cotton sector, the IDB has recently embarked upon supporting initiatives aimed at enhancing productivity and international competitiveness of its cotton producing member countries.

In Safar 1426H (March 2005), the Bank organized the first Expert Group Meeting (EGM) on "Enhancing Production Efficiency and International Competitiveness in IDB Cotton-Producing Member Countries" in Jeddah to discuss the main issues and challenges faced by the Bank's cotton-producing member countries and propose concrete actions to tackle the issues. The EGM suggested several actions at national, regional and IDB/international levels to promote cotton production efficiency and competitiveness. In light of the outcome of EGM, the Bank developed a Three-Year Programme for Cotton Sector:1426H-1428H. One action in this Programme was to "*collect, compile and disseminate information about best practices on productivity enhancement in the spinning sector in Pakistan*".

As a follow-up action, the Bank obtained from the National Productivity Organization (NPO) in Pakistan a "*Benchmarking Study in Cotton Spinning Sector*". The Study has been undertaken by the NPO, Ministry of Industries & Production, in close collaboration with a number of organizations in Pakistan.

The NPO Study provides useful information on applying benchmarking in spinning companies and inducting best practices for minimizing costs and improving efficiency in IDB cotton-producing member countries. The Study contains the following elements which may help other IDB cotton-producing member countries take more suitable actions for the improvement of productivity and enhancement of their capacity in spinning sector:

• A Textile Vision;
• Necessary steps to introduce benchmarking practice in spinning sector;

• Identification of 80 best practices in various areas of spinning sector such as cleaning and picking, storage of bales, cleaning of the bales, blowing room, handling of laps, carding, drawing, roving and winding;

• A method to assess the productivity in spinning sector in three steps: (i) spinning process analysis, (ii) identification of various productivity parameters, and (iii) ensuring of data compatibility; and

• A definition of a "Standard Mill" for performance comparison.

Through the dissemination of this benchmarking study, the IDB hopes to sensitize and raise awareness on how to effectively design and implement the spinning productivity enhancement program in cotton-producing member countries through (i) developing in-depth understanding, and application of benchmarking in companies; and (ii) identifying and encouraging the implementation of best practices so as to minimize costs, improve efficiencies and productivity.

The Islamic Development Bank presents its compliments to NPO-Pakistan for granting permission to publish this study and thereby giving the opportunity to cotton-producing member countries to learn more from the productivity enhancement experience in the spinning sector of Pakistan.

Finally, I would like thank colleagues in the Policy Development and Implementation Division, particularly Dr. Nosratollah Nafar, Economist for contributing to and coordinating this publication.

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I.   TEXTILE INDUSTRY IN PAKISTAN

The share of textile industry in the economy along with its contribution to exports, employment, foreign exchange earnings, investment and value added makes it the single largest manufacturing sector in Pakistan. It contributes around 8.5 percent to GDP, employs 38 percent of the total manufacturing labour force, and contributes between 60-70 percent to total merchandise exports. Indeed, with textile exports reaching about $9.4 billion in 2004-05, Pakistan is one of the largest textile exporters in the world. The variety of textile products ranges from cotton yarn to knitwear. Garment made-ups and bed wear are the most important export products with an export value of about $1.35 billion each. Knitwear, readymade garments and cotton yarn also have important shares in total exports. Textile industry is based on locally available raw cotton in the country, and the development of a textile industry making full use of its abundant resources of cotton has been a priority area towards industrialization in Pakistan.

At the time of independence in 1947, there were only 6 textile units with 80,000 spindles and 3,000 looms, which could only supply 8 percent of the domestic demand of its 76 million population. The Government set the objective of promoting textile industry first as an import substitution industry and later as an export oriented industry. This led to positive results as the spinning and weaving sector exhibited rapid growth during 1950's & 1960's, which by the end of 1950's made Pakistan virtually self sufficient in cloth requirement and since then acquired surplus quantities to export yarn and cotton fabrics.

Textile production is comprised of cotton ginning, cotton yarn, cotton fabric, fabric processing (grey-dyed-printed), home textiles, towels, hosiery & knitwear and readymade garments. These components are being produced both in the large-scale organized sector as well as in the unorganized cottage / small & medium units. The number of textile mills now exceeds 400 with about 10 million spindles and 140,000 rotors installed. In 2004-2005, there were 1,221 ginning factories in Pakistan with the total capacity of approximately 20 million bales per year (assuming a 100 day ginning season). Against capacity, the total production of ginned cotton is 14.6 million bales suggesting an excess capacity of ginning in the country. The spinning sector is comprised of 458 textile units (50 composite units and 408 spinning units) with 8.5 million spindles and 75 thousand rotors in operation with capacity utilization of 87 percent and 49 percent respectively, in 2004-05. The number of power looms stand at about 225,000 at present, with only 190,000 operating at full capacity.

There is a fierce competition amongst the low cost producers to take up the share being lost by high cost producers. These market changes have been developing pressure on Pakistan's textile industry and the industry needs to be re-structured to regain competitiveness. In this context, the Government of Pakistan constituted a working group headed by a leading industrialist in the private sector in January 2000 to develop a strategic approach "Textile Vision-2005" to revamp Pakistan's textile industry in light of the global changes in the textile market. The main objective was to create an environment in which firms can upgrade competitive advantages by introducing more sophisticated technology and production processes and penetrate more advanced segments. The Vision aimed at overcoming the major current challenges and develop future thrust of the textile industry by upgrading quality of products, switching over to value addition, using quality raw materials, balancing, modernization and replacement of obsolete plant and equipment, professional & business ethics, meeting schedules and reducing delivery times, maintaining price competitiveness, and promoting international joint ventures.

II.   THE TEXTILE VISION 2005

The Textile Vision 2005, announced in 2000 by President General Parvez Musharraf, envisaged an increase in textile exports and investment in the sector to the tune of US$13 billion and US$6 billion, respectively, by 2005 under a planned development and investment strategy (High Road Scenario). The Vision statement highlights the key drivers of the textile sector growth and also sets a target for the textile industry under the following three scenarios.

a) *Low Road Scenario* represented a situation where only the historic export growth rates in textile sub-sectors were maintained. The overall average export growth for the textile sector after analysis was finalized at 6 percent per annum.

b) *Do-Able Scenario* envisaged increase in unit price realization of yarn, fabric, textile made-ups and garments with an attempt to maintain the market share in each individual market. It also suggested penetration in the non-quota markets along with increased share of synthetic and blended yarns, fabrics and garments. The overall export growth in this scenario was estimated at 12 percent per annum.

c) *High Road Scenario* the most ambitious of the scenarios that not only adopted the apparel sector as the engine of textile export growth but also

recommended diversification in products that hold greatest potential but unfortunately have been neglected e.g. woven garments, sports wear, specialized industrial garments, and women wear. Besides broadening of export portfolio with focus on synthetic and man-made fibers, fabrics and garments, it was based on achieving higher market share of unexplored, non-traditional textile markets. The export growth in this case was estimated at 16 percent per annum with the assumption of 20 percent and 21 percent growth in garments and made-ups segments, respectively.

The program of Vision has been divided into eight sectors with separate investments, namely stitching, knit-processing, woven processing, knitting, weaving air jet looms, weaving waterjet, and polyester fibre. According to the break-up of the total investment of Rs 333 billion[1], Rs 39 billion investment would be spent for the stitching machines, Rs 62 billion for weaving, Rs 29 billion for knitting, Rs 40 billion each for water jet and air jet looms, Rs 87 billion for spinning (spindles), Rs 7 billion in processing (Knit) and Rs 29 billion for the polyester fibre.

Textile Vision 2005

An open, market driven, innovative & dynamic textile sector which is:
- Internationally Integrated
- Globally Competitive
- Fully equipped to exploit the opportunities created by the MFA phase out

and which enables Pakistan to be amongst the top five textile exporting countries in Asia

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Spinning is the first process in the cotton value chain that adds value to cotton by converting into a new product i.e. conversion from ginned cotton into cotton yarn. Since spinning is in the beginning of value chain, all the later value added processes of weaving, knitting, processing, garments and made-ups are dependent upon this process. The effect of a sub-standard yarn production by spinning goes right across the entire value chain. Pakistan's spinning sector caters not only to the requirements of domestic industry but about one third of the total production of yarn is also exported. Pakistan is the fourth largest producer of cotton yarn in the world and the second largest exporter with a market share of about 27 percent. However, according the Textile Vision, the spinning sector faces following issues where sectoral interventions are required:

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[1]Exchange rate as at 10 February 2007 was US$1=Pak Rs 60.10.

1. Low Unit Price Realization

Average unit price realization of Pakistani cotton yarn in the international markets is very low compared to that of its competitors. There are two major reasons for this. First is the cotton quality; deterioration in cotton quality occurs during unsatisfactory storage and handling of seed cotton by growers. Most of the ginners indulge in malpractices involving a mixture of varieties and grades, low standards of ginning and addition of excess moisture just before pressing lint into bales. This results in production of contaminated yarn that sells for a lower price. The poor quality of ginning led the International Textile Manufacturers Association to place Pakistani cottons under most "Contaminated Description" in their 1999 Survey Report.

The foregoing deficiencies create problems for the spinners who have to make special arrangements to deal with Pakistani cotton with high percentage of trash content usually above 7.5 percent, and presence of foreign fibre contamination and consequently incur higher conversion costs.

Second reason for low unit value realization is the product mix of Pakistani cotton yarn. More than 70 percent of the total yarn production is that of coarse and medium count yarns. In yarn exports, this percentage is about 99 percent. Coarse and medium counts fetch a lower price compared to fine and super fine counts that ultimately manifests in low unit value realization. Moreover, the share of other high value added yarns like dyed yarns is also very small in total exports. There is a need of intervention in this sector by providing incentives to the exporters of high value added yarns. These incentives can be in the form of providing export refinance only to exporters of high value added yarns.

2. Lack of Balancing, Modernization and Replacement (BMR)

Pakistani spinning industry showed a high rate of growth till 1994 when the total number of installed spindles reached 8.4 million. After this period, there were successive cotton crop failures in the country that resulted in an over-capacity situation in the industry. Many units were closed and total number of spindles in 1999 decreased to 8.3 million. This situation resulted in inhibiting the flow of investment in this sector. This decrease was not limited to new investment only but also for BMR investment. Currently, major portion of the spinning industry requires investment for BMR. It was, therefore, proposed that the Government should facilitate provision of credit for BMR to spinning industry on concessional terms as well as provide

relief on import duties on machinery for BMR purposes.

3. Low Capacity Utilization

Out of the 8.4 million total installed spindles, only 6.6 million were working which translates into a capacity utilization of 79 percent. The remaining spindles were closed due to a variety of reasons. There was hence a need to improve capacity utilization. According to an estimate, of the total 1.7 million closed spindles, about 0.5 million could be revived. The government has established an organization for revival of industrial units in distress, which would also help in improving capacity utilization in the spinning sector.

4. Low Share of Manmade Fibers

In today's textile world, the incremental demand created each year due to population growth is being met through manmade fibers, since cotton production is finite. Although Pakistani spinning industry is also moving in this direction, it is heavily dependent on local cotton and needs to increase the share of manmade fiber yarns in its total production. Currently, the spindle utilization for manmade fibers is 18 percent, which is much lower than those of its competitors. Moving to manmade fibers will decrease the dependence of spinning industry on cotton thereby reducing its vulnerability to bad cotton crop. One of the major reasons for low share of manmade fiber yarns is the protection given to the polyester industry in the shape of relatively high import duties. There is a need to rationalize this duty structure. Along with polyester, there are many fibers that are not produced in Pakistan. Imports of such yarns would help the industry to improve capacity utilization and increase export earnings.

Along with the spun blended yarns, share of filament yarn also needs to be increased. There is a need to diversify the product mix of yarn exported from Pakistan and increase the share of yarns other than cotton yarn in total yarn exports. Not only in exports, but also from domestic garment industry's point of view, filament yarn is very important for uplifting the women apparel sector.

Five years after the adoption of the Textile Vision 2005, the performance of the textile industry has been satisfactory. The production of yarn and cloth increased annually by 6.4 percent and 5.4 percent over the period 1999-2005, respectively. Table 1 compares the performance of Pakistan textile industry over the period 1999-2005. The textile exports increased by 16.4 percent annually over the last five years reaching US$9,378 million in 2004-05. However, it is still less than the target of the Vision 2005 under the planned development and investment strategy (High Road Scenario) by about 28 percent. To accelerate the investment in the textile sector, the Government set up a high level "Federal Textile Board" in 2002, which introduced the following vital incentives for investment in the sector, particularly foreign investment: (i) Investment in all sub-sector of textile industry became permissible without any Federal Government permission/sanction/intervention as well as no permission of Provincial Governments is required for locating the unit in any area, (ii) Foreign investment is permissible at 100% equity or joint venture, (iii) Full repatriation of capital and dividends along with technical & franchise fee payments was allowed, (iv) Duty free import of machinery for value added export industries has been allowed, and (v) Import duties are repaid to companies in the form of duty drawback rebates scheme.

As a result, the textile sector attracted increased capital during the recent years. The market capitalization in the sector increased from Rs43.7 billion in 2000 to Rs103.5 billion in 2005 (Table 1). Moreover, the accumulated investment in the sector reached to US$6 billion over the period 1999-2006, of which

Table 1 Performance of Pakistan Textile Industry, 1999-2000				
	Unit	1999-2000	2004-2005	Annualized Growth (%)
Capacity (spindles)	Thousand	8,477	10,485	4.34
Consumption of Raw Material (Cotton & Fibre)	Million kg	1,970	2,588	5.61
Production of cotton	Thousand Tonnes	11,240	14,265	4.88
Production of Yarn	Million kg	1,679	2,290	6.40
Production of Cloth	Mill sq mitre	4,987	6,480	5.38
Textile Exports	Million US$	4,384	9,378	16.43
Market Capitalization of Cotton and other Textile Companies listed on the Karachi Stock Exchange	Billion Rupees	43.7	103.5	18.82

US$175.3 million came from FDI. As shown in Table 2, the bulk of investment has gone to the spinning sector accounting for 47 percent of total investment followed by weaving (26 percent), textile processing (11 percent), made-ups (8 percent) and knitwear & garments and synthetic textile (5 percent each). Higher investment in improving production, quality, and value addition is evident from US$2.8 billion worth of import of textile machinery during the same period. Massive investment in this sector has also enhanced their capacity to consume about 14 million bales of cotton, up from 9.0-9.5 million bales in the late 1990s. Enhancement of capacity also resulted in approximately 450,000 job creation.

Table 2 Sectoral Share in Total Investment Growth in the Textile Sector (US$6 Billion, 1999-2006)			
Spinning & Fibre	47%	Knitear & Garments	5%
Weaving	26%	Made-Ups	8%
Textile Processing	11%	Synthetic Textile	5%
Source: Pakistan Economic Survey 2005-06, Page 29			

Addressing the structural weaknesses of the Pakistani textile and clothing industry may take time. The government and industry have, however, recognized the challenges that they face, and have started to implement reforms. Given the fact that the spinning sector is the most important segment in the hierarchy of textile production, this benchmarking study will provide necessary measures and plans for further productivity enhancement in the textile sector.

III. BACKGROUND OF THE STUDY

With the dawn of the new millennium, Pakistan like all developing countries is facing a major challenge of a free and borderless, global market. Not only does it need to improve the range and quality of its products, innovation and creativity are equally imperative crux to consider becoming competitive in the world arena. **Value addition** has therefore become the buzzword of economic policies and agendas.

Textile is one of the main industries in Pakistan. The spinning sector comprises of 445 spinning mills in the country (50 composite and 395 spinning units) with 8.6 million spindles and 145 thousand rotors installed. Out of this, presently 7.2 million spindles and 64 thousand rotors are in operation. The capacity utilization has stagnated at 87% in spindles and 45% in rotors[2]. Pakistan stands at number four in world cotton yarn production with 8% share. The available raw cotton is best for making lower count yarn i.e. 20s.

[2]Economic Survey 2001-2002.

During the last one decade, spinning industry went through serious operational problems due to increased cost of production. This had a negative impact on the replacement and modernization of technology installed. Hence, the overall productivity of the mills and quality of the yarn deteriorated. Today, most of the mills are not equipped with modern machines and are therefore handicapped and unable to produce yarn of the *required quality at competitive prices*.

Keeping in view the forthcoming challenges of the free global trade regime, a number of large textile groups have embarked upon modernization programs. Formerly, spinning units were based on Chinese/ Japanese machinery, being cost-effective. Now a number of mills are shifting to German technologies. Pakistan has so far invested US$ 400 million in replacement of machinery and another US$ 500 million is in the pipeline. The government has also allowed duty-free imports of machinery and plants by export-oriented industries subject to an increase of 40% value-addition in their products and 50% of their total sales income in the form of export earnings. The textile industry, which contributes 65% to the total foreign exchange earnings of Pakistan, is taking full benefits from this decision of the government.

Nevertheless, it has been felt that the implementation of the replacement/modernization plans will not automatically lead to manufacture of quality yarn at competitive prices unless standard levels of process conditions and machinery/labor performance are achieved at each stage. Considering the importance of enhancing productivity and quality in this specific sector of the textile industry, and also its significant contribution to the exports and foreign exchange earnings of the county, NPO-Pakistan decided to undertake a process and result benchmarking. The proposed survey on benchmarking was the first of its kind in Pakistan. The exercise was based on a similar example of benchmarking carried out in the jute industry in Bangladesh, jointly by Asian Productivity Organization (APO) and the country experts. NPO-Pakistan has adopted the NPC Model of benchmarking of the Malaysian Perbadanan Produktiviti Negara (National Productivity Corporation).

1. Objectives of the Study

The exercise was designed around the following objectives:

• To develop in-depth understanding, and application of benchmarking in companies;

• To identify and encourage the implementation of best practices so as to minimize costs, improve efficiencies and productivity;

- To collect information on best practices in different production process/sections of the mills under the survey and to develop comparative data amongst the local mills as well as similar projects in other Asian countries. (The idea was to identify functions and processes in each department of a spinning unit, and the related results being obtained. Subsequently, overall results of the departments would to be linked and evaluated, and reasons for differences in various mills would be assessed. Simultaneously, the practices in use would be determined).

The benchmarking methodology adopted was intended to assist in ascertaining best practices, which need to be adopted in Pakistani mills. It was decided that necessary guidelines, concrete action plans and recommendations based on the observations and empirical findings from the exercise would be made. The Government of Pakistan, with the assistance of NPO-Pakistan, and the APO can then together take necessary measures and plans for its implementation and further development in order to enhance the overall productivity in the sector.

2. Scope of the Study

The study was carried out for enhancing the productivity of the textile spinning sector. In Pakistan, there are mainly two types of mills – average size of up to 25,000 spindles, and large mills having more than 25,000 spindles. Within these mills, despite of the fact that same machinery is installed (Chinese/Japanese/German origin), there is a combination of yarn counts being manufactured. It was learnt, the available raw cotton is best for making lower count yarn i.e. 20s. Most of the mills have now upgraded their facilities to produce 40s count yarn.

Based on its discussions with APTMA and Spinning Machinery Company (Pvt.) Ltd., NPO decided to focus on that particular segment, the product of which is mainly exported. Pakistan is presently exporting coarse quality of yarn. As a short-term goal, NPO decided to benchmark these mills so that an increased productivity in this segment will directly and immediately affect our exports earnings and GDP. Subsequently, since benchmarking is a *continuous learning process*, benchmarking will study improving other areas of concern e.g. energy consumption in the textile sector.

3. Steps of the Benchmarking Study

The NPO-Pakistan followed the NPC Model for conducting benchmarking exercise. The procedure adopted is indicated in Table 3.

	Table 3 Benchmarking Steps
1	What to benchmark
2	Plan benchmarking project
3	Understand & analyze the current business practices that have been targeted for reform
4	Collect data and information of processes to be benchmarked
5	Analyze data/information to determine best practices
6	Determine best practices to be adopted
7	Implementation of Results

(a) What to Benchmark

In July 2001, NPO was entrusted with the task of evaluating the productivity of the textile spinning sector. A preliminary study was undertaken at NPO, and data on textile spinning sector of various Asian countries as available on the web, which was quite limited, was taken to compare the performance. Based on this initial study, the NPO submitted its preliminary report on September 17, 2001 to the Ministry of Industries & Production which recommended the undertaking of the BENCHMARKING exercise in the textile spinning sector by NPO with the assistance of Asian Productivity Organization (APO), APTMA, spinning mill-owners and other consultants. A work plan was also conveyed in the report.

Subsequently, APTMA was contacted to identify a balanced sample for conducting the study. However, no response was received. None of the mills were willing to cooperate in the exercise due to secrecy and confidentiality reasons. In February 2002, NPO arranged a presentation on Benchmarking at APTMA for the mill-owners, in order to apprise them of its process and benefits; the assurance of maintaining confidentiality of information was also given. As a result, almost 14 mills gave their consent for cooperating in this exercise. However, since NPO was unable to impose the study on mills, the credibility of an efficient sample could not be confirmed. It was evident, the mills which were willing to participate in the study were average-size mills performing better than the average performing mills of the country.

(b) Plan the Benchmarking Project

The benchmarking team at NPO comprised of three officers. This team visited a spinning unit in Mirpur, AJK to identify and understand the basic processes. On the basis of the information gathered, NPO designed a work plan for the project as indicated in Table 4.

Table 4			
	Activity	**Time Schedule**	
		Commencement	Completion
1	Identification of Benchmarking Exercise	February 2002	February 2002
2	Select Processes to be benchmarked	February 2002	April 2002
3	Form Benchmarking Project Team- Identification of Benchmarking Partners and initial meetings and selection of benchmark mill	February 2002	April 2002
4	Prepare Benchmarking Plan	February 2002	February 2002
5	Designing of Questionnaires (follow-up surveys)	March 2002	May 2002
6	Collection of Data /Project visits	March 2002	June 2002
7	Analysis of the Data	June 2002	July 2002
8	Completion of Report by NPO and determination of Best Practices		August 2002
9	APO Expert Visit for comments and suggestions on the Report	August 2002	September 2002
10	Completion of Benchmarking Exercise		October 2002
11	Implementation of Best Practices	November 2002	As required

(c) Understand & Analyze the Current Business Practices that have been Targeted for Reform

The main processes of a spinning unit include:

1. Blow Room
2. Carding
3. Drawing
4. Roving
5. Ring
6. Winding
7. Humidifying
8. Packing

Discussions with the mill owners indicated that results in each department are measured against preset standards of each count of yarn as per the demand of the customer. Final results are measured against Standards specified in Uster Statistics. It was also noted that results would vary according to the type of raw cotton used since contaminated cotton is the main problem of the cotton industry. Other factors influencing quality and productivity of the mills are the knowledge and expertise of the management, expertise of the laborers, basic shop floor management, good housekeeping techniques, level of technology installed and its maintenance, etc.

Based on this basic information, NPO then designed an initial questionnaire. The same was prepared in-house by NPO staff, based on their own personal information of spinning units. The initial questionnaire was sent out to all the benchmarking mills for their comments and suggestions for modification. Based on the response from all the mills by May 2002, the questionnaire was revised.

(d) Collect Data and Information of Processes to be Benchmarked

The NPO team together with the local expert visited all mills during July 2002 to collect primary data as per the questionnaire. General discussions were held with all the Mill Managers.

(e) Analyze Data/Information to Determine Best Practices

With the assistance of the local expert, the NPO team was able to draw preliminary analysis of the data collected. NPO had decided to secure full support of APO for the benchmarking exercise. Under the Technical Expert Service (TES) program of APO, NPO arranged for a foreign expert to visit Pakistan at the conclusion of the data collection phase in order to complete the first phase of the study. Experts under the TES program are available free of cost to the APO member countries. In this particular case also, NPO had to bear very nominal charges for arranging the consultant.

On recommendation of APTMA, Mr. Geert de Clercq, a Belgian consultant was approached by NPO and was requested to assist in the exercise. A detailed Terms of Reference was forwarded to him together with a copy of the questionnaire and the results of the analysis so that he becomes aware of the base work undertaken by NPO. Mr.Clercq subsequently visited Pakistan from August 26-September 4, 2002 to finalize the study and give his recommendations.

4. Conclusion of the First Phase of Bench-marking Study

A detailed presentation was made by the APO expert at the College of Textile Engineering, Faisalabad at the conclusion of his 10-day visit. During the visit, the APO expert visited nine mills and identified the various best practices being practised.

It was concluded at the closing session that both labor and machine productivity is influenced by different yarn parameters i.e. blend (cotton type, synthetic, waste, etc), count, twist, slub, nep, core yarn, etc. The data therefore needs to be made comparable (the production / labour values etc. have to be adjusted for comparison). In order to formulate a basis for comparison, the concept of **A STANDARD MILL** needs to be developed. With the help of conversion tables, mills would then be in a position to convert their values on a comparable basis and measure their performance and productivity. The report of the APO expert was submitted to NPO in October 2002. Based on his recommendations and the preliminary analysis undertaken by the benchmarking team, the First Report on the Benchmarking Study was submitted to the Ministry of Industries and Production in November 2002.

5. Second Phase of the Benchmarking Study

It was hence determined, that in the second phase of the benchmarking study, NPO would undertake the formulation of the Spinners' data as done in Europe and India. This information is based on assessing labor productivity, machine productivity, and cost structures, as well as comparing quality data with the Uster Statistics.

Keeping in view the task of setting productivity measurement and assessment technique, following steps were followed:

- making the spinning mills comparable (i.e. make tables to convert to standard "**Standard Spinning Mill**")
- expressing the results in a standard way
- bringing the individual results together and making a summarizing report with all participants blinded
- comparing mill results against those of the others in the group
- identifying the performance gap(s)
- setting best practices and productivity assessment technique for the spinning sector

Although detailed data was collected during the field surveys, data on cost structure was not available with NPO. It was decided that the second phase would take another three months and the final report would be finalized by March 2003.

IV. PRELIMINARY BASE WORK

The benchmarking study undertaken by NPO was based on the processes and results in each department of a mill, in the cotton-spinning sector of Pakistan. The aim of this exercise was to determine best practices to improve efficiencies in this pertinent export-based sector.

Accordingly, a detailed questionnaire was prepared and finalized with the assistance of the benchmarking partners. Subsequently, the NPO team together with the local Expert, Dr.H.R.Shiekh collected detailed primary data on the processes and results being obtained in each department of every mill under survey.

Summarized findings from the data are given in Table 5.

1. Yield of Cotton

Table 5			
Non-Lint %		**Manufacturing Waste**	
Mill	**%**	**Mill**	**%**
A	7.95	A	17.55
B	10.2	B	15.8/34.8
C	8.3	C	15.1
D	11.5	D	14.3
E	10.75	E	16.15
F	9	F	17.35
G	8.15	G	13.52
H	10.25	H	16.55
I	9.85	I	15.35
J	10	J	13.9
K	8.63	K	15.99
L	9	L	13.9

Yield of Cotton –
Range : 82.45 – 86.48%

It was observed that some mills could obtain higher yields starting with high non-lint cotton; on the other hand, some mills start with lower non-lint cotton, but still get relatively lower yields.

2. Uniformity and Fibre Growth

The cumulative fiber growth of one mill is 6.66%. This mill is able to:

- Supply the client with higher quality yarn for a given count, or
- Economize on the purchasing of cotton by 6.66% lower in 2.5% S.L. staple for the same count

Cotton Uniformity Ratio: 46 - 51.32%

One mill obtained highest Uniformity Ratio of 51.32%; this particular mill has highly organized and efficient cotton procurement department with daily testing and a well-equipped quality assurance laboratory as indicated in Table 6.

Table 6			
Uniformity Ratio		**Comm. Fibre Growth**	
Mill	**%**	**Mill**	**%**
A	49.1	A	7.6
B	50	B	3.178
C	48	C	2.5
D	48.5	D	3.275
E	47	E	n.a
F	46	F	1.08
G	50.01	G	6.667
H	50	H	1.6
I	51.32	I	1.52
J	49	J	3.52
K	48	K	n.a
L	48.25	L	5.11

Fiber Growth 2.5% S.L
Ra :Range: 1.08 – 6.667%

3. Raw Material Utilization

Range :
Weight loss %: -0.1 to – 2.5%
Weight gain %: 0.24 to 0.75%

Although most of the mills have good air-conditioning of yarn packages, but in 1-2 cases, arrangements are unsatisfactory which results in weight loss on account of moisture content in packed yarn to the extent of –2.5% as compared to cotton bales as indicated in Table 7).

Table 7	
Weight Loss/Gain %	
Mill	**%**
A	-0.1
B	-1
C	2.4
D	1
E	-2.5/0.75
F	n.a
G	0.72
H	n.a
I	n.a
J	n.a
K	0.75
L	1.25

4. Atmospheric Conditions

- In couple of mills, the readings on the humidifier register are found to be incorrect
- Humidity levels in blow rooms and carding departments were generally higher than standard values
- Temperature in preparatory departments (dry bulb) were low compared to general practices which is not favorable to extraction of trash

5. Human Resource – Operative Per Spindle

Production Operators

In most of the cases, the operative (production) Workers per 1000 spindles per shift were around 5 as indicated in Table 8.

Table 8	
Worker/1000 shift	
Mill	**Nos**
A	6
B	6
C	6.7
D	5
E	5.26
F	4
G	4
H	4.79
I	6.6
J	4.5
K	5.2
L	3.4

6. Quality of Carded & Combed Yarn

Data of the test results pertaining to the U%, CV%, neps in the back process departments, thick and thin places, hairiness in the ring and autocone winding were collected. Most of the mills are achieving the standard as per 5% Uster. In preparatory departments, in general, for U% and C.V.%, the results are at par with 25% Uster Statistics.

6.1 Sliver and Roving Quality

The data shows that most of the mills are not achieving U% of carded sliver up to the standard of Uster Statistics at 5% level. However, at the finished sliver, roving stages, U% is comparable to the 5% Uster Statistics standard values.

6.2 Ring Spun Yarn and Wound Yarn Quality

Most of the mills are providing ring spun carded/combed yarn and final yarn package with quality parameters either comparable to 5% Uster Statistics or better. However, the results of the tests show that hairiness of ring spun yarn and wound yarn of three mills (B, K and L) is very high.

6.3 Quality Control Laboratories

Almost all the mills surveyed were adequately equipped with textile testing and quality control laboratories. Moreover, lots of machines have on-line quality control system thus enabling 100% quality control and assurance at these points. Most of the mills were certified under the ISO 9000 Quality Management System, though some of these were not maintaining documentation of quality required, and not updating "kaizen" display boards (which represented a relaxed implementation of the quality control circles).

It was noticed that except for one or two mills, all mills displayed their "Quality Policy" conspicuously in Urdu in almost all departments. The policy read as follows:

"Our prime objective is to maintain satisfaction of the customer by utilizing our resources in the best possible manner and to produce products which not only conform to the specifications stated by him but also meet specified performance criteria. In other words, we utilize our capabilities to produce best quality of yarns, fabric and always strive to make continuous improvements".

7. Counts

Mill	Counts Produced						
A	20CM	20 CD	30 CD				
B	10 CD	16 CD	20 CM	24 CD	30 CM	32CM	40 CM
C	12 CD	14CD	16 CD	20 CD	21 CD	24CD	
D	10 CD	16 CD	30 CD	31 CD			
E	20 CD	30 CD	30 CM	36 CD			
F	16 CD	20 CM	30 CD	40 CM			
G	16CM	20 CM					
H	20 CD	26 CD	30 CD	31 CD			
I	1OCD (W)	10 CD (H)	12CM (W)	14 CD (W)	16 CD (W)	16CM (W)	
J	7 CD						
K	19CM	20 CM	24 CD	30 CD			

Table 9

8. Spinning Potential

Based on the results of 2.5% S.L., Pressley Strength and fineness of cotton, it was observed that spinning potential of the cottons being used by the mill with reference to the fibre properties is from 21 ne to 30 ne. But due to market considerations, some mills are spinning coarse counts in the range of 10 to 20 ne, hence under-spinning the cotton.

9. Machinery

The mills visited by the benchmarking team were considered above average performing mills. Most of the mills were either in the process or had already undertaken modernization in the machinery installed, particularly in the preparatory departments and auto cone winding.

In the Mixing and Blow room, it was noticed that some of the mills have already installed Maxiflo machinery from Trutzschler, Germany. Loptex Sorter, and Uni Clean B11, which provides excellent results in the blow room are also available at some mills. In the blowing room, the machinery is a mix of European with Chinese, with Trutzschler having the biggest share, followed by Rieter. Although most of the machinery brand in each mill dates back to late 80s or early 1992, however some replacements have been made in 2001. For detection and removal of foreign fibres in Pakistan, trends towards the installation of sophisticated devices such as Loptex Sorter in blow rooms was gaining momentum.

Latest models of the Trutzschler cards, DK 903 have been acquired by some mills. It was noticed that Chinese cards have been replaced by the European ones; in the last decade, replacement has been made with Crosrol and then Trutzschler. Since Crosrol

Ltd. of United Kingdom is no longer manufacturing carding machines, the spinning mills are concentrating on the procurement of Trutzschler or Rieter cards.

Likewise, in the drawing section, latest model of single delivery draw frames from Rieter # RSBD 30 were seen. The latest model of double delivery Toyoda frames # DYH 600 were also seen during the visits at some mills. The machinery mix is Chinese, Japanese, and European frames; however, tendency for the latest investments seems to be towards Rieter.

Combing sets installed in the mills were a mix of Chinese, Japanese, and European machines whereas the latest investments seems to be all for Rieter.

Comparatively, there were older machines in the Simplex department. The simplex mix is Chinese and Japanese, and no European simplex machines were seen. Only a few of the simplex are of recent date, so no tendency in recent investments can be seen. The mills have not acquired latest innovations for this section. The latest machine PK 5000 with pneumatically loaded pendulum arm which maintains uniform pressures on the drafting system rollers should be acquired to replace SKF PK1500 which have spring weighted pendulum arm. Older models were also noticed in the Ring section, where Chinese machines are still giving the requisite results. No European machines are installed.

The modernization trends noticed in the autocone winding section were the replacement of existing Japanese Murata manual winding machines by the Schalfhorst autocone winder model 338. In some mills, Savio, and Orion Auto Coner of Japan were also noticed. Almost all the winding machines have electronic yarn clearer either from Uster or Loepfe installed, or both.

In some mills, it was noticed that although the machinery was old, it was well maintained and the operations were organized. In some mills having Chinese machinery, the European ones of higher technological level replaced some of the original machine components. It was noticed that quite a few mills tend towards this solution as it provides the best compromise between price, machine productivity and yarn quality.

In various mills, a mix of different machines for the same department could be noticed. In some cases, 4 different brands of machines and models were found in the same department. This is considered rather negative for the productivity and for total costs being incurred. Operators in these departments have to be trained to work with different machines. Having a variety of machines for the same operation (e.g.

carding and drawing) also requires higher stocks of spare parts and technicians trained to maintain different machines, which complicates the machinery maintenance work. These mixes of machines should thus be avoided where possible.

10. Machine Speeds and Settings

In general, machine speeds and settings between the functional parts of respective machines were found to be optimum and compatible with the type of fibres/fibre blends being processed. Where comparatively old machinery prevented the use of high speeds required for achieving competitive machine productivity, the concerned mill concentrated on production of hosiery yarn, which is produced at speeds lower than those used for weaving yarn.

11. Waste Removal/Dust Filtration and Humidification Plants

About 50% of the mills surveyed were operating LUWA waste removal/dust filtration and humidification plants. The environment in the blow rooms and cards in these mills was worker-friendly. Moreover, optimum conditions of temperature and Relative Humidity (R.H.) were being maintained. However, in the remaining mills, locally made humidification plants were being operated and therefore neither the production department air was clean, nor were the atmospheric conditions of temperature and R.H. up to the standard levels.

Most of the mills are kept very clean – lots of labor is employed to sweep the floors. Machines are also kept very clean, which is a good sign to produce quality products.

12. Workshop and Fire-Fighting Equipment

Well-established workshop facilities were found in most of the mills to cater for small parts repair and replacement requirements. Fire-fighting arrangements were also adequate and in accordance with the rules and regulations of Insurance Association of Pakistan (IAP) applicable to the issue of Fire Insurance Policies covering stock of cotton, yarn, stock in process, stores, etc.

13. Relevance of Results

The analysis of the data collected and the results being obtained by each mill indicates that results are directly related to :

• Ability and expertise of the management (to manage the operations)

• Employee training, morale and motivation

- Material handling
- Age and make of technology
- Quality assurance techniques and equipment
- Basic housekeeping techniques
- Efficient shop floor management

14.   General Observations

The spinning technology is evolving, and more particularly as application of electronics, robotics, etc is evolving very fast; the newer machines need trained people to get the most out of them. Therefore, two needs are to be met on rather short term:

1. Regular education to form better skilled technicians, not just textile technicians, but also technicians with specialization in electronics, mechanics, etc;

2. Training Centers should be set-up to provide regular refresher training for the employees and managers already working in the textile industry, like in other European countries. Such refresher courses can assist in imparting knowledge on new technologies and machines. It was observed by the APO expert, that investment in new technologies only takes place when someone else has invested in it and has obtained better results. In the second phase, some more mills would follow in investing in that technology; but eventually when the news of better results spread fast, more and more mills will invest in top technology. Hence the result is that majority of the spinning industry risk to be one step behind of the leading spinning industries, while it has the potential needed to be at the leading edge.

Due to CONFIDENTIALITY reasons, the data may not be available in this report.

V.   BEST PRACTICES

The aim of the study was to determine best practices, which can be adopted in spinning mills to improve their productivity, reduce material and conversion costs, and thereby, enhances profitability. During the visits, a number of good practices were noticed in the mills. These practices are summarized below:

1.   Cleaning and Picking

It was observed that contamination of raw cotton is one of the major problems of the Pakistani cotton thus resulting in lower quality yields and products (Chart 1). Ginners should improve the ginning quality to meet the needs of the spinners so that higher value added yarns can be produced, suitable for conversion into high value added finished products. According

to Rieter, the potential quality problems of Pakistani cotton are high foreign content, high short fibre content, and damaged bales.

Chart 1

Evaluation of potential quality problems
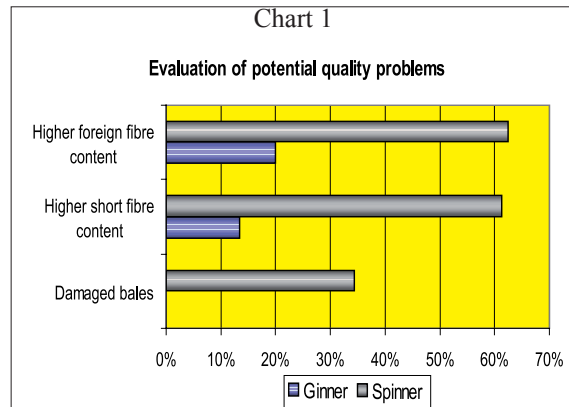
Since the ginning process is still inefficient in Pakistan, spinners have to undertake the responsibility of cleaning and picking of cotton themselves before the actual spinning process. In most of the mills, a large number of daily wagers are employed only for the purpose of cleaning the raw cotton and picking out contamination. As compared to the cotton obtained from the U.S., Central Asian States and Australia, there is also a high content and variety of contamination found in raw cotton such as toffee wrappers, jute pieces, threads, pieces of cloth, hair, etc. Hence, manual picking is necessary. Some mills have employed according to the ratio of one labor per bale for cleaning.

2.   Storage of Bales

Most of the mills do not have sufficient storage area for the raw cotton purchased. This is likely since the total annual requirement is not purchased at one time and hence the storage area is alotted keeping in view the probable requirement of three months or so. In most cases, raw cotton is stored in open area, and are covered to protect from dust and rain.

In order to protect the bales for better yields and quality of yarn it is important that **bales are not be stored outside**. Rain makes them wet if they are not properly covered which can result in fungus; additionally, sun can yellow the fibres at the exposed sides of the bales, and the UV from sun can also damage fibres at the outside. Moreover, bales can get dusty / dirty which can lead to more picking and cleaning than required, hence leading to reduced time efficiency. The ginners should be advised not to have a metal strip around the bales to hold the cotton together. This metal strip oftens gets rusty and destroys the raw cotton. Strong plastic strips should be used as is done with the foreign cotton imported by the mills.

3. Cleaning of the Bales

The first process in the cleaning of bales should commence before the bales are opened and broken down for picking and mixing. A labourer should clean the bales from outside to remove dirty and rusty cotton. Rust must be removed as it can make holes in the cloth during bleaching. Major reason of the rust is the steel/metal ribbons/strips used to pack the bales. An alternative packing material can be galvanized "quick-links".

4. Blowing Room

The blow room process includes picking, mixing, and blending of raw cotton. Different practices were noted in each mill.


There was no standard picking process; every mill uses a different way of picking. It was noted that picking process is environmentally unfriendly because of high fibre content in the air. It was noted that 50% of the mills surveyed were operating LUWA waste removal and dust filteration plants as well as LUWA humidification plants for keeping departmental air clean, and for maintaining standard conditions of temperature, R.H.; hence, the blowing and carding proceses in these mills were not environmentally unfriendly. It was also a very labor-intensive department. However, considering that the labor is cheap in Pakistan as compared to Europe, picking may be continued to be done manually than with modern equipment to be more cost-efficient. The various practices in use for cleaning are evident in the pictures:

Mixing and blending of raw cotton is an important aspect of the spinning process. A good blending and mixing policy and labeling is needed to avoid stripes in cloth after bleaching and dyeing. The proporation of mixing different types of cotton yields different qualities of yarn. Spinners should therefore:
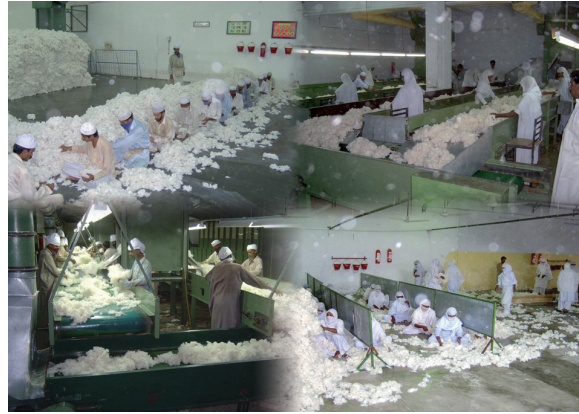
- Use different lots and maximum of bales;
- Not change all lots of bales at the same time;
- Try to avoid a change over or lot break when new harvest comes in;
- Print the production date on the label in order to keep track of the ages of cotton being used;

Various technologies are being used in the blow rooms. Most of the mills have recently switched to German technology, which is more expensive but give better quality. However, there was low fibre content in the atmosphere with the European linear line. In terms of technology, blending heaps can be be reduced with the use of European technology. The machines can blend more efficiently as indicated in the diagram below:
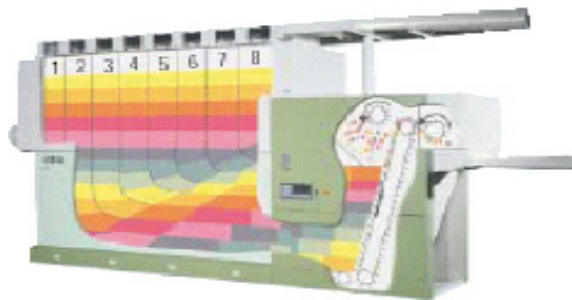
Most of the mills use the Pocupine machines in the blow room. These should be replaced by B11/Axiflow for better opening, no rattails, and less fibre content in waste. This will also ensure less breaks in ring spinning frames and improve overall productivity of the machines. Another important machine to use is the Loptex, which extracts colored particles from the raw cotton. German technologies are better in removing heavy and colored particles and better blending in the blow room. Pakistani mills should therefore consider upgrading their blow rooms.

The blow room is equipped with three different types of pipes – one for transferring mixed cotton to the series of machines, one for transferring dust and contamination out of the machines, and the third for transferring air. It is recommended to have different color piping for each of this use; also, the colors should be preferably light colors to prevent darkness in the room. In one of the mills it was noted that there were hydrant pipes fitted from outside the walls (through small openings at regular intervals) of the blow room in order to blow water into the room in case of fire. This was an alternative arrangement in addition to the fire fighting equipment inside the factory.

Plastic caps/headgear and masks should be worn by the laborers and workers in the blow room to prevent hair from falling into the raw cotton and from cotton fibre to damage their lungs. Additionally, this will also be better for the laborers to keep their hair clean due to high fibre content in the atmosphere.

5. Handling of Laps

The product of the blow room are laps. Laps require proper handling to prevent wastages. It is recommended that laps:

• Must not be compressed;
• Must not be rubbed;
• Must not hang on an axle;
• Must be protected;
• Must be handled with care;
• Must be used in the manner of First In First Out;

Good practices noted in a mill are shown:

However, if the mills are using German technology which has the chute feed system, the handling of laps does not remain a problem. Chute feed is direct from the opening line, hence there is no lap waste (first meter), no problem of damage to the lap, no left over, and no labour involved. It is a relatively easy machine giving high production. This is also essential if the mill uses high production cards.

6. Carding

Before the raw cotton can be made into yarn, the remaining impurities must be removed, the fibres must be distangled, and they must be straigtened. The process of detangling the fibres in a parallel fashion is done on carding machines.

Speed of the carding machine determines the quality of the yarn as well as the cost of production. A spinner needs know that:

• Low Speed gives better quality, lower energy consumption, lower production, and uses more machines;
• High speed gives lower quality, higher energy consumption, higher production, and uses less machines;

In most of the mills, carding machines were recently upgraded. The newest generation card machines can utilize cotton up to 100 kg/h and more depending upon the condition of cotton. Grinding of the flats and the cards clothing has to be done at certain intervals to keep the quantitiy of the neps in the card sliver under an acceptable level. The newer cards dispose integrated grinded systems, which can also grind automatically during production, which is not usual with the old card machines. The newer versions of card machines from Europe like **Card C 51 IGS of Reiter** gives the facility of integrated grinding systems which ensure constant quality over lifetime of the cylinder wire.

Cards should be maintained against dust. A curtain may hang between the drawing and carding section to prevent the fibre from flying into the card machines. Cards should be cleaned with compressed air.

In the carding section, if the sliver breaks for some reason, the whole can should be changed or else the manual handling of the sliver will affect layers of the sliver in the drum and hence the quality of yarn produced.

Placement of carding machines should be in a manner that 2 cards face each other. This would result in lesser human resource requirements to mind the machines and would hence result in high labor productivity.

Proper storage area for empty cans needs to be earmarked. In some mills it was noted that the empty can close to the machine did not have a marked area, while in some mills, it was noted that a circular yellow strip was present to assist the worker in placing the can at a right place. This also assists in free gangways and no hindrance for movement of cans. A card cleaning schedule needs to be maintained.

7. Drawing

In the drawing section, combining of several silvers eliminates irregularities that would cause variations. It is recommended that:

- in the drawing section, spinners should have a sliverwatch done manually or with Barco Sliverwatch to take out contamination;

- for improving the blending, every worker should be given a number and his designated cans should also have numbers on them;if different cans are being used then identification of the can should be done by a coloured strip. Helpful instructions should be placed on the walls for the labor to follow this system; blending of sliver at the feeding of the frame is necessary for good quality yarn, especially with regard to dye-ability;

- Proper areas may be marked for storage of empty and full cans. In some mills, it was noticed that numbers and color coded areas were earmarked for specific can which also carried the same color and number. Parallel metal pipes were also placed near to the floor to ensure placing of can in a straight line and prevent hitting with each other;

- Waste bins with identification for reusable and other waste needs to be placed near to every drawing frame. This needs to be done in simplex and ring department also;

- The correct working of the autoleveller has to be checked very regularly. The best practice is to take away one sliver in the feeding, bring it back and then add one. Checking the produced sliver with a regularity tester will show if the settings are correct or not;

8. Roving

Long bobbins are produced on the roving frames where the sliver is drawn and twisted until it becomes a diameter of pencil lead. Spinners should consider:

- The speed of the simplex is also important; belt transmission is now more and more replaced by frequency inverters which makes the settings of a simplex a lot easier;

- Rubber tops are to be replaced regularly as they affect the productivity of the machines and thus require high twist multiplier. Also the height of the tops have to be adjusted so that the angle in which the roving is leaving the drafting zone is the same for the first as for the second bobbin row; height adjustment at the right time with the correct type would reduce twist multiplier to 20%;

- If the sliver length is not under control, sliver cans can run out and this can result in wastage. It is therefore advised that spinners should adopt block creeling;

- Every spindle should be given a number;

- For improving doffing, empty bobbins should be placed under the machine to reduce time in doffing;

- Reduce stand still for doffing by almost 50% by:
  - Fix a plank with bobbin holders on the machine; 1 holder for each spindle
  - Put empty bobbins on the holders when machine is almost ready for doffing

- Doffing = pull full bobbin of spindle, take empty from holder, put full on holder and empty on spindle
- Start machine
- Take away full bobbins
- *While handling of bobbins, avoid rubbing and avoid hard handling and heavy impacts*
- For storage of bobbins, avoid contamination, rubbing, impacts, and storing for long periods. Plastic curtains may be used to cover the stored bobbins. Moreover, storage racks need to be properly labeled for the specific type of bobbin. Color coded bobbins may also be used for easy and quick identification;

9.   Ring Spinning

The twist multiplier in almost all mills was observed to be rather high. This could be due to the fibres used in our mills. It was also learnt that the mills use Uster Satistics 2001 as a borderline between knitting and weaving yarn. The twist multiplier for Carded cotton yarn was 3.9, while for combed cotton yarn was 3.7 on an average. Some of best practices noticed were:

- Use spindle brake, 1 color of pipes (identification);
- Protect rovings from dust with "dust Caps";
- Have third row with spare bobbins; Third row should be covered with plastic to prevent floating fibre;
- Use of inverters makes different speed possible, thus the mill does not have to compromise anymore between end down, maximum spindle speed, full use or partial use of the lift;
- To improve the drafting system rubber rollers must be kept smooth, bottom rollers must be stiff, bearings should not be worn-out or vibrating, and roller settings must be accordingly to fibre length;
- To improve ring spinning settings, ensure that thread guides are at the same height and correct
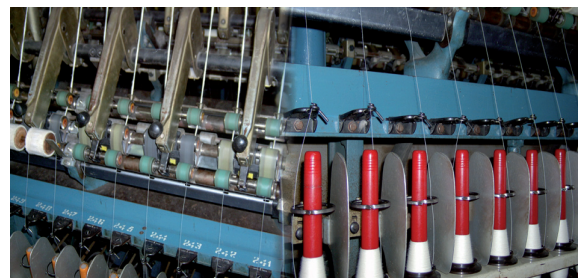
centred, spindles are correct centred (for longer lifetime and better yarn/hairiness). Use anti-balloon to control yarn tension and decrease contact with separators;

- Avoid bad shaped cones by end down piecing fast;

- Use Rollerpicker instead of stick for cleaning of ring frames;

- Consider auto doffing than manual doffing to increase life of spindles, better yarn quality (less handling) especially when the linked to coner. Auto doffing reduces doffing time and production costs (compressed air and spare parts costs). With autodoffing, there are fewer thread breaks, less wastage, no spindle cleaning is required, and reduction in fly;

- Consider a new technology, i.e. **Compacspin**, a new but fast growing technology which gives better yarn characteristics for most end uses;

- Small trolleys should not be used for transferring bobbins as they are labour-intensive and dangereous in use (high speed);

- Ear plug must be enforced to be worn in the ring section to prevent damage to ear of the workers;

- Colored bobbins should be used for different counts of yarns being produced for easy identification;

- For the bobbin stock on the same frame, it is quality-wise better to have a spare row of hangers than to place the bobbins on the top of the rails, which is better for labor productivity;

10. Winding

Winding of yarn on to small cones is best when it passes through three devices namely, splicer, clearer,

and waxing device. Splicers should be under clearer so that splice must be checked and if out of range, it should be cut and remade. Waxing should be on top, if not, then the particles tend to deposit on splicer and/or clearer thus deteriorating their function. Some of the practices, which will improve efficiency, are:

- Take more than 1 cop for yarn supply to the winder to improve labour productivity. Feeding the reserve can be done by taking 3-4 cops in one hand, stripping the underwinding and putting them in one move into the supply;
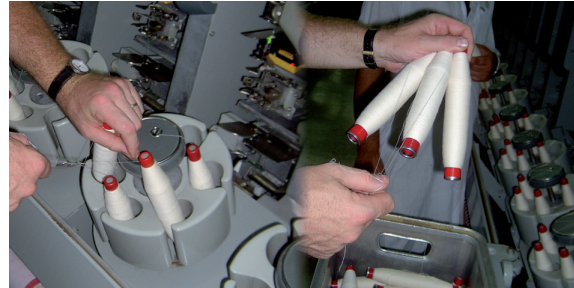
- Use Classimat to check your settings, and make splice profile, and check for drift and calibrate the setting periodically (preferably fortnightly);

- Tension control is very important since tension differs from top to bottom of cop while unwinding the cop. This tension changes have impact on the quality of winding and waxing and in some cases on length control. A good tension control is very important if the mill intends to produce quality cones at high speed;

- *If autodof is adopted in winding, it would save labor cost, reduce excessive use of spare parts + technicians, and more reliable yarn is expected*;

- Each cone should be weighed and checked with UV lamp to ensure high quality. Instructions for the workers should be placed for easy weighing.

- At one time, a worker should pick only two finished cones and put them on the trolley. This will ensure proper handling of the cone and the maintenance of quality of yarn. In some mills, it was observed that the workers try to grip and carry more than two cones at a time, which was affecting the quality results of the yarn and the shape of the cone. A conveyor belt behindthe machine for empty bobbins is also recommended for transferring the bobbins till the end of the autoconer machine and then lifting on to the trolley;

- Low fences, rod pipes, or blocks need to be placed around the autoconing machines to prevent hitting of the machines by the trolleys. In some mills it

was noted that rod pipes were attached close to the floor around the machine to stop collision of the trolleys with the machines; these fencing can also be placed near ring frames;

11. Humdification of the Cones

In order to achieve the desired weight of cones, cones need to have 8.5% water (commercial mass). This can disappear in less then 24 hours. Hence, moisture intake needs to be checked and added mathematically.

Cones should be left for humidification overnight, preferable for more than 12 hours. Moreover, the placing of cones in the humidified room should be such that each cone can intake the requisite moisture.

12. Quality Lab

Quality assurance and quality tests are required in each department of the spinning unit to ensure delivery of a quality order to the customer. Most of the local mills lack in quality due to nonavailability of the testing equipment which is expensive investment of the spinning unit. However, most of the mills visited have quality assurance laboratories and qualified personnel. Sophisticated equipment was also seen during the visits.

In order to ensure quality production, it is important that:

- Quality test are conducted on raw material samples to be purchased for operations. The spinners should not rely solely on the ginners' tests. Lots of bales should be inspected and checked at arrival;

- Quality tests are conducted on random samples of the finished product of each department as per a time schedule;

- Qualified personnel should man the laboratory;

- Calibration should be done very often; manuals should be consulted;

- If new equipment is not affordable, second-hand equipment may be purchased;

- If a Pressley is used, a Stelometer should also be used: Pressley measures cotton strength, Stelometer fibre strength;

- The conditions of outgoing trucks transporting finished goods packs should be inspected to ensure prevention of damage to the cones during transportation;

- Uster Statistics should be followed as standards; however spinners need to be aware of the revision in the statistics from time to time;

13. Good House-Keeping Techniques

In most of the mills, generally good house-keeping practices were noticed. Some good practices which need to be followed are:

- Work Instructions for the workers should be placed in each department and should be easy to read and understand; if color coded, numbers, lights are used to organize the work flow, the same should be included in the instructions

- Instructions in case of fire should be conveyed through bold posters

- Use of fire fighting equipment should be practised and drills should be held. Moreover, workers should be informed to keep the fire fighting equipment free of hindrances e.g. trolleys, etc.

- Yellow lines may be drawn on the floor to earmark the machine area, gangways, and storage areas

- Air changes for maintaining a healthy environment should be regular as per international standards

- Trolleys used should be of a size which is easy to push around and the wheels should be kept greased. The laborers tend to swing around on small trolleys at high speed which can result in accidents and damage to the machines

- Each department has its own maintenance room equipped with spare parts. The maintenance room needs to be kept organized under the principle of 5S, and adequately labeled for quick identification

14. Employee Morale and Training

In Pakistan, one of the major problems is mistrust amongst the employees, low morale which results in high employee turnover. This affects labor productivity and efficiency of the mills. For example in Mill C, workers were being paid their salaries on the 16th of the month. It was also reported to the Benchmarking Team that Jobbers and Time Keepers operated rackets to deny workers 50% of their earned overtime amount. On the other hand, it was observed that in Mill E, the management ensured payment of salaries to the workers on time and especially overtime payments were made on the same day before the

concerned workers left the mill. Thus turnover in Mill C was very high and the workers were demoralized. The workforce in Mill E was stable, motivated and putting in their best efforts.

In most of the mills visited, it was noticed that employee turnover was comparatively less. In one or two mills where it was high, the productivity of the mills and the profitability was adversely affected. For maintaining high employee morale for consistent growth and sustainability, it is recommended that management should introduce reward and incentive schemes for high performers, issue bonuses etc to keep the employees commited. Regular training programs should also be organized for the employees for skill development. Most of the workers are trained on-the-job and with the induction of new technologies, training should be imparted. This may be done in collaboration with the machinery manufacturers. It is recommended that each worker should be electronically trained to understand and perform his job better. Workers need to be sent on regular training programs to improve their skills. Likewise, middle management must also be trained to manage the work in an efficient manner.

In this highly competitive local as well as export market, it is absolutely essential to utilize human resource to the best possible advantage for achieveing best output rate. This objective can only be achieved with the establishment of Human Resource Development and Human Resource Management Departments under adequately qualified and experienced personnel. It was noticed that HRD/HRM departments were fully functional in Mills G, H. And I.

VI. HOW TO ASSESS YOUR PRODUCTIVITY?

A total number of 14 mills in Punjab consented to become benchmarking partners, out of which 12 mills shared their data. However, as has been mentioned before, since the prerogative to chose a balanced sample for study did not rest with NPO, most of the mills which chose to participate in the exercise turned out to be above average mills. As such the differences amongst the mills were minor.

Although NPO had specified its criteria, it was also learnt during the visits that most of the benchmark mills are producing different counts of yarns and different varieties e.g. combed, carded, slub, core-spun,lycra, polyester-cotton, etc. The count varied from 20 ne to 40 ne during one shift. Both labor and machine productivity is influenced by different yarn parameters i.e. blend (cotton type, synthetic,

waste,etc), count, twist, slub, nep, core yarn. Hence, although the best practices were noted during the visits, but the aim to set Productivity Assessment Technique and Productivity Standard for the Spinning Sector could not be finalized in the first phase.

It was hence determined, that in the second phase of the benchmarking study, NPO would undertake the formulation of the Spinners' data as done in Europe and India. This information is based on assessing labor productivity, machine productivity, and cost structures, as well as comparing quality data with the Uster Statistics.

The procedure entailed three steps:

- Process analysed (classical break down of spinning process)
- Process measured
- Data made comparable

Detailed data was collected by NPO. However, in order to compare the data, the production / labor values etc. have to be adjusted for comparison. In order to formulate a basis for comparison, the concept of A **STANDARD MILL** was developed. With the help of conversion tables, mills' data can then be converted on a comparable basis to measure their performance and productivity.

1. The Comparable Function

This section describes the method of assessing productivity in spinning. Briefly, the method consists in adjusting the various parameters to 20 ne count so that a mill can compare its productivity and also judge its performance against the standards regardless of the differences in the counts produced. The standards for HOK and OHS are given in Table 10.

Table 10		
Department	**HOK**	**OHS**
Blow Room	5.11	1.95
Carding Room	2.75	1.05
Drawing and Simplex	4.71	1.8
Ring	17.29	6.6
Total	**29.86**	**11.4**
Production per spindle per 8 hours adjusted to 20s (g)	305.33	

Note: The level of modernization assumed is as follows- single process blow room with automatic or otherwise lap doffing, high production cards, high speed draw frames (two passages), high speed inters and high speed ring frames (new and converted)

2. Pakistan Standard Mill

The basic characteristics of the Standard Mill are determined in Tables 11 and 12.

Table 11	
Count	**20s**
Number of Spindles	**20,000**
Spindle speed	**16,500 rpm**
Twist Multiplier	**4.0**
Twist per inch	20 x 4 = **17.89**
Production inch per min	$\frac{16,500}{17.89}$ = **922.30**
Inch per shift	922.30 x 60 x 8 = **442,705**
Yards per shift	$\frac{442,705}{36}$ = **12,297**
Lbs per spindle shift	$\frac{12,297}{20} = \frac{614.85}{840}$ = **0.73**
Ounces per spindle shift at 100%	0.73 x 16 = **11.72**
Actual production per spindle shift taking 92% capacity utilization	11.72 x 0.92 = **10.77**
Lbs per shift	$\frac{10.77 \times 20,000}{16}$ = **13,463**
Lbs per day	13,463 x 3 = **40,389**

Standard Number of Operative per shift:

Table 12	
Blow Room	13
Carding Room	7
Drawing and Simplex	12
Ring	44

Number of production workers/1000 spindles/shift = **4.3**

Standard OPS in grams:

$\frac{10.77}{16}$ = 0.673 x 453.6 = 305.329 g

Note: 1 lbs = 453.6 grams

3. Data Needed for Productivity Assessment

The mill's HOK, production per spindle, and other productivity parameters are assessed based on data with respect to operative engaged, ring spinning production and spindle shifts worked.

4. Operatives

Operatives hours actually engaged in different departments irrespective of whether the operatives are permanent, temporary, apprentice, or daily wagers. The categories of operatives to be included for the calculation of HOK are as follows:

Machine tenters, back attendants, reserve and interval relieving tenters, head jobbers, doffing jobbers, line jobbers, oilers, sweepers, doffers and interval relieving doffers, mixing coolies, card tenters, grinders, fly-carrier-cum-sweepers, lap carriers, belt stitchers, roving bobbins carriers, tape stitchers, and doff carrier-cum-conditioning men.

As an example, suppose that the operatives hours in different departments and ring spinning production and spindle shift for a mill are as given in Tables 13 and 14.

Table 13 Operative Hours	
Department	**Operatives Hours per day**
Blow Room	1,008
Card	648
Drawing and Simplex	864
Ring	2,880
Total	**5,400**

Table 14 Production and Spindle Shifts in Ring Spinning	
Count	**Production (kg)**
20s	5,936.01
20s	6,561.00
30s	3,645.00
Spindle Shift (8 hours)	**37,440**

A Standard Spinning Mill should achieve at least process productivity and product quality parameters as outlined in Table 15.

The definitions of the various productivity parameters, the calculation of which are illustrated and explained in this report are given in Table 16.

5. Production Per Spindle (P) Adjusted to 20s

To obtain a combined converted production for all the counts produced in the ring spinning departments, the production for each count may first be converted to 20s. Then each of these converted figures may be multiplied by the respective spindle shifts, and finally a weighted average is taken. It is also possible to

Table 15				
For Top Class Process Conditions				
Department	**Particulars**	**Production Targets**	**Particulars**	**Quality Factors**
Blow Room	Production Efficiency Lap Weight – lbs Lap length – mtr Lap roll – rpm	85 to 90% 40 to 50 40 to 50 10 to 15	Cleaning Efficiency Nep formation Lap C.V.% Lap Rejection	70% or higher Less than 50% 0.75 or lower Less than 2%
Carding	Cylinder – rpm Doffer –rpm Taker-in rpm Revolving flat in/min Production per hour-lbs	350 to 500 75 to 100 900 to 1200 4 to 8 100 or above	Cleaning Efficiency Break/card/hour U% of sliver C.V.% of sliver Neps removal	90 to 95% Nil 2.0% or lower 2.5% or lower 75% or higher
Drawing Finisher Head	Delivery speed-mpm Grains per yard Operating efficiency %	450 or higher 60 to 70 85 or higher	Sliver U% Sliver CV % (wrapping) Ends break/del/hour	2.0 or lower 1.5 or lower less than 1.0
Simplex	Flyer speed –rpm Operating efficiency %	1100 or higher 85 to 90%	Roving U% Roving CV % Wrapping CV% Break/sp/8 hours	3.5 to 4.0 4.0 to 4.5 0.7 to 1.0 1 to 2
Ring	Spindle rpm Operating efficiency %	upto 20,000 94 or higher	Yarn Quality Ends down per 1000 sp/hr	Up to 5% Standard of Uster Statistics less than 20
Cone Winding	Speed mpm Operating efficiency %	1200 90 or higher	Pound wraped per break Tachibana daisen std Offending faults Ends breaks/cone (4.166 lbs)	150 to 200 Nil less than 2.0

arrive at this combined figure without first finding out the converted production per spindle for each count, as described below. The production in each count is multiplied by the respective conversion factor for that count (Table A in the Annexure). The products so obtained are totalled up, and this total is divided by the total number of spindle shifts worked during the day. The calculation for the data in Table 14 is illustrated below:

Adjusted P = $(1,978.67 + 2,187 + 1,215)$

Adjusted P per day = $(1,978.67 + 2,187 + 1,215) \times 3$

$= (5,936.01 + 6,561 + 3,645)$

$= (5,936.01 + 6,561 + (3,645 \times 1.78))$

$\dfrac{\text{Adjusted Production} \times 1000}{\text{Spindle Shift}}$

$= \dfrac{18,985.01 \times 1000}{37,440}$

$= 0.507$ kgs or 510 grams (rounded)

6. Adjusted HOK

In most cases in the Europe, the production in each department varies considerably. Besides, a number of different yarn counts are being produced ranging from 6s to 90s. Hence, in order to find the adjusted HOK,

the first step is to calculate the standardized production for different departments using different conversion factors as given in Table B in the Annexure. The ring frame production in each count is multiplied by the corresponding conversion factor appropriate to that department and the sum is taken. However, in most of the Pakistani mills, the yarn count varies between 6s to 40s. Additionally, the variations in back-processes i.e. ounces per lap, hank roving, linear density, grains, etc, is very little. Hence, in case of Pakistani mills, the calculation of adjusted production for each department is not necessary. Thus, to work out the standardized production for the mixing and blow room, the conversion factors as given in (Table A in the Annexure) would be applied. The standardized production for the mixing and blow room department for the above data would be:

Adjusted P = $(1,978.67 + 2,187 + 1,215)$

Adjusted P per day = $(1,978.67 + 2,187 + 1,215) \times 3$

$= (5,936.01 + 6,561 + 3,645)$

$= (5,936.01 + 6,561 + (3,645 \times 1.78))$

$= \mathbf{18,985.01}$

Adjusted HOK = $\dfrac{\text{Operative Hours} \times 100}{\text{Standardized (adjusted) Production}} = 5.31$

Table 16	
HOK	Operatives hours to produce 100 kg of yarn
Adjusted HOK	The HOK (that is, the operative hours engaged to produce 100 kgs of yarn) is adjusted to a common count of 20s by multiplying the actual production in different counts by relevant conversion factors. The production so converted is termed as "Standardized Production". Thus the adjusted HOK is calculated from: $$\frac{\text{Operative hours} \times 100}{\text{Total of the standardized ring spinning Production in individual counts}}$$
Conversion Factors for HOK	The conversion factors are the ratios of the HOKs of individual counts to that of 20s count: $$\frac{\text{HOK for a given count}}{\text{HOK for 20s count}}$$ These HOKs have been worked out taking the production rates, work assignments, etc. that correspond to those of standard mill. The conversion factors are different for different departments, and for the count of 20s, it is unity for all departments. Another major practical advantage of the method is that it is not required to obtain a break-up of the operatives according to each count.
Standard HOK	HOK for 20s count under the specified conditions. Standard HOKs for different departments are given in Table 1 and the conditions under which these standards can be attained are given in the footnote to this table. As can be seen, the total standard HOK for these conditions is 29.86
Composite Productivity Index (CPI)	A measure of productivity calculated by expressing the standard total HOK of 29.86 as a percentage of the mill's total HOK adjusted to 20s count and reflects the effect of both labor and machines
P	Production per spindle per 8 hours shift adjusted to 20s in grams
Conversion Factor for P	These conversion factors are the ratios which the standard production per spindles in 20s count (i.e. 305.33 g) bears to the production per spindle in the standard mill in the respective counts. That is: $$\frac{305.33 \text{ g}}{\text{Std. Production per spdl per 8 hour (g) in the given count}}$$
OHS	Number of operatives per 1000 spindles adjusted to 20s count obtained by dividing the products of adjusted HOK and adjusted P by 800. For standard OHS for different departments, reference may be made to Table 1. As can be seen, the total OHS is 11.4.
OHSAM	OHS modified to allow for valid comparison of a mill's OHS with the standard OHS of 11.4 taking into account the deviation of the mill's production per spindle from the standard production per spindle.
SH	A measure of spindle utilization calculated by dividing the average spindle hours worked per day by the installed spindles
OPS	Ounces per spindle shift are calculated by: $$\frac{\text{Total actual production (ring frame) in ounces per day}}{\text{Total spindles per day}}$$
MPI	A combined measure of production per spindle and spindle utilization. It is calculated by expressing the product of production (P) adjusted to 20s count and spindle utilization (SH) as a percentage of 7,328 = (305.33 * 24.0). The index would be reduced by 1/7th if the mill works only 6 days a week.

By making similar calculations for other departments, HOK figures in Table 17 can be arrived at.

7. Operatives Per 1000 Spindles (OHS)

It would also be useful to assess separately to what extent the differences in productivity are explained by the production per spindle and the number of operatives engaged. The number of operatives engaged per 1000 spindles adjusted to 20s (OHS) can be calculated by using the formula:

$$OHS = \frac{HOK \times P}{800}$$

Where P is the production per spindle per 8 hours in grams, and both HOK and P have been adjusted to 20s count on the lines explained earlier.

For the example considered, the adjusted production for 20s per spindle shift per day (3 shifts) in grams is calculated below:

$$\frac{18,985 \times 1000}{(12,480 \times 3)} = \frac{18,985 \times 1000}{37,440} = 510 \text{ grams (rounded)}$$

The total OHS as obtained from the formula is:

$$OHS = \frac{5.31 \times 510}{800} = 3.385$$

The OHS figures for individual departments (Table 4) can be worked out similarly from the corresponding HOKs.

8. Modified OHS (OHSAM)

From the definition of OHS given above, it follows that OHS is a function of production per spindle (P), although for small deviations in production per spindle, say, less than 5%, the workers complement engaged in different departments can be expected to remain practically unchanged. However, for any large increases in production per spindle, the OHS would increase significantly. This is because operatives such as number of ring frame doffing boys and the preparatory department operatives would require to be engaged in proportionately larger numbers to cope with the higher volume of ring spinning production.

The OHSAM can be worked out from the expression:

OSHAM=

(Standard OHS x OHS)/(Standard OHS – 0.014229 x (Standard OPS in gm – P^))

where P^ is the production per spindle for the mill in grams.

For the example, OSHAM is calculated as:

$$= (11.4 \times 18.14)/(11.4 - 0.014229 \times (305.47 - 431.02)$$
$$= 206.796/(11.4 - 0.014229 \times -125.55)$$
$$= 206.796/(11.4 + 1.786)$$
$$= 15.68$$

Table 17 HOK and OHS for the Data given in Tables 10 & 16			
Department	Operative Hours	HOK	OHS
Blow Room	1,008	6.24	3.39
Card	648	4.00	2.18
Drawing and Simplex	864	5.35	2.90
Ring	2,880	17.84	9.67
Total	5,400	33.43	18.14

9. Composite Productivity Index

Composite Productivity Index is calculated by expressing the standard total HOK of 29.86 as a percentage of the actual HOK. For example:

Composite Productivity Index (CPI) =

$$\frac{29.86 \times 100}{33.43} = 89.32$$

10. Hours Worked Per Spindle Per Day (SH)

$$SH = \frac{\text{Spindle shift (8 hours)} \times 8}{\text{Working days in the month} * \text{installed spindles}}$$

The spindle shift figure used in the above calculation is inclusive of the spindle shifts stopped due to routine maintenance, cleaning and count change. These stoppages should not ordinarily be far in excess of 1%. In cases of abnormally large percentage of stoppages due to these causes, a flat allowance of 1% may be applied. That is, the total worked spindle shifts (8 hours) figure is to be multiplied by 1.01 and the figure arrived at should be taken for SH calculation.

Suppose, in this example, the mill has an installed spindle age of 12,480 and it has worked for 30 days in the month. Assuming that the spindle shifts (8 hours) figure of 1,123,200, with normal stoppage of 1%, thus making it 1,111,968 then the SH figure works out to:

$$\frac{1,111,968 \times 8}{30 \times 12,480} = 23.76 \text{ hours}$$

11. Machine Productivity Index (MPI)

$$MPI = \frac{\text{Mill's adj. Prdn per spindle}}{\text{Std. Production per spindle}} \times \frac{SH}{24} \times \frac{\text{days in a week}}{7} \times 100$$

In the above, days in a week is either 6 or 7 depending on whether the mill is scheduled to work 6 days in a week or 7 days in a week. Assuming that the mill considered in the example worked 7 days a week, then :

$$MPI = \frac{510}{305.33} \times \frac{23.76}{24.0} \times \frac{7}{7} \times 100$$

MPI = 165.36

12. Production Per Frame Day (PFD)

As PFD is equal to 1.25 x MPI, for the example, PFD = 1.25 x 165.33 = 206.66.

13. Ounce Per Spindle (OPS)

The total ounces per spindle shift can be expressed by the formula:

Total actual production (ring frame) in ounces per shift for a given count divided by Total spindles

For the example:

Total production per day

= 16, 142 kgs	*per shift = 5,380.67 kgs*
= 35,586 lbs	*11,862.22 lbs/shift*
= 569,376 ounces	*189,795.48 ounces/shift*

$$OPS = \frac{569,376}{12,480 \times 3} = 15.20$$

14. Average Count

For the example taken, three different counts are being produced. In order to find the average count being produced by the mill, the production per count per shift is multiplied with the respective count, and then their sum is divided by the actual total production. This is reflected in Table 18.

Table 18		
Count (a)	**Production (b)**	**a x b**
20	1,978	39,560
20	2,187	43,740
30	1,215	36,450
Total	5,380	119,750
Average Count		**22.25**

So far, definitions and procedures for working out the various productivity parameters have been explained. The following section explains some more uses of conversion factors.

15. How to Find Out Standard Production Per Spindle in Different Counts?

The production per spindle conversion factor for a given count is:

Standard production per spindle per 8 hours in 20s count (g) divided by Standard production per spindle per 8 hours in the given count (g)

To illustrate, the conversion factor for the production per spindle for 40s combed hosiery is 2.626; then the standard production per spindle in 40sC is obtained as follows:

$$\frac{305.33}{2.626} = 116.26 \text{ g}$$

16. How to Find Out Standard Total HOK for a Given Count?

Sometimes, for costing purposes, it might be required to get a quick estimate of the total actual HOK for a count under mill's conditions. This can be done by assuming that the HOK for all the counts in the mill will be uniformly higher or lower in the ratio of the extent to which the CPI for the mill is less or more than the standard of 100.

Total HOK estimated for a given count

$$= \frac{\text{Standard total HOK for the count}}{\text{CPI for the mill}} \times 100$$

Standard total HOK for a count can be obtained from the respective conversion factor from the relation:

Standard total HOK = Standard total HOK for 20s x Respective conv. factor in a count

= 29.86 x respective conversion factor

For example, let us consider 40s carded yarn. The total HOK conversion factor for 40s carded is 2.4268 (Table B), which gives the standard total HOK for this count as 72.46 (29.86 x 2.42). Suppose that the composite productivity index for a mill is 80. then, the estimated actual total HOK in 40s count in this mill is:

$$\frac{72.46}{80} \times 100 = 90.58$$

## VII. FIRST PRODUCTIVITY SURVEY

The method for assessing productivity as determined by the benchmarking team consisted in adjusting the various parameters to 20s count so that a mill's productivity can be compared; additionally, the calculations can assist in judging the performance against the NPO standards regardless of the differences in the counts produced.

On the basis of the data collected during the survey, various parameters were calculated for each of the 11 participating mill (data of one mill was incomplete). Table 19 conveys the findings of the survey.

1.   Labor Productivity

Labor productivity is measured in terms of the HOK. It refers to the number of operative hours taken by a mill to produce 100 kg of yarn. **The lesser the number of operatives, the more productive and efficient is the mill's labor.** According the parameters of the Standard Mill, the total HOK adjusted to the 20s count is 29.86. The Standard Mill figure in the following graphical representations is indicated by a line. As can be seen, most the mills surveyed have HOK figures close to the Standard Mill's HOK (Chart 2).

Chart 2: Total HOK
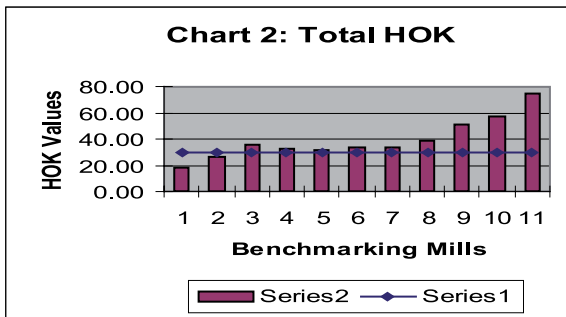
The OHS reflects the number of operatives per 1000 spindles adjusted to 20s count obtained by dividing the products of adjusted HOK and adjusted P by 800. Since the OHS takes into account the number of operatives employed per 1000 spindles, therefore, lower OHS reflects better overall efficiency (Chart 3).

Chart 3: Total OHS
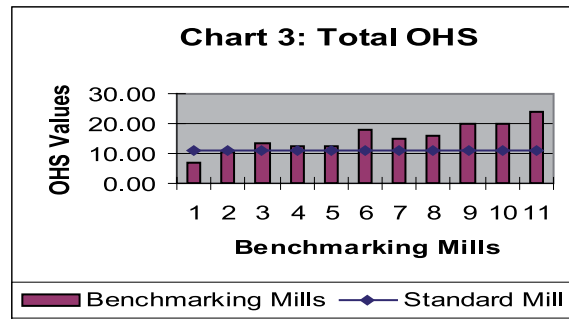
In order to compare the total production of the mills under survey, the conversion of the various counts to one comparable count is essential. Since the average count for the Pakistan mills is 20s. Chart 4 indicates the total adjusted production per spindle per 3 shift per day in grams.

OHS is a function of production per spindle (P), although for small deviations in production per spindle, say, less than 5%, the workers complement

Table 19
NPO's First Productivity Survey in Cotton Spinning for 2002
Total Participating Mills :12

Mill	HOK					RTH	OHS					RO	PA	RP	OM	ROH	AC	OPS	CPI	CPS Rs
	B R	C	DS	R	TH		BR	C	DS	R										
8	2.0	2.7	4.0	9.7	18.4	1	0.8	1.0	1.6	3.8	7.2	1	311.7	5	8.4	1	28.6	6.7	162.0	
11	4.8		4.5	17.9	26.8	2	1.7		1.7	6.9	10.3	2	307.6	8	11.4	2	24.2	8.2	111.3	
9	7.5		9.2	18.9	35.6	7	2.9		3.5	7.3	13.7	5	309.3	7	11.8	3	11.3	15.4	84.0	
7	2.2	2.2	5.5	23.3	33.3	4	0.8	0.8	2.2	8.8	12.5	4	300.0	9	12.2	4	18.7	11.3	89.6	8.27
6	11.4			20.3	31.7	3	4.4			7.9	12.3	3	310.8	6	14.0	5	25.2	7.4	94.0	
1	6.2	4.0	5.3	17.8	33.4	5	3.4	2.2	2.9	9.7	18.1	8	510.0	1	15.9	6	22.2	15.2	89.3	7.97
4	2.8	2.4	7.4	21.1	33.7	6	1.2	1.1	3.3	9.4	15.0	6	356.7	2	16.4	7	25.9	8.4	88.5	
5	2.7	4.1	10.2	22.4	39.5	8	1.1	1.6	4.0	9.0	15.8	7	321.3	3	17.7	8	26.1	7.7	75.8	
12	9.6	3.2	11.2	27.3	51.3	9	3.7	1.2	4.4	10.6	20.0	9	311.8	4	19.8	9	20.0	11.0	58.2	
3	6.0	6.5	9.0	36.4	57.9	10	2.1	2.3	3.1	12.7	20.1	10	278.1	10	20.1	10	17.9	10.7	51.5	
2	11.6	4.3	10.4	48.8	75.0	11	3.7	1.4	3.3	15.6	24.0	11	256.3	11	25.0	11	17.7	9.7	39.8	8.50
ST	5.1	2.8	4.7	17.3	29.9		1.9	1.0	1.8	6.6	11.1		305.3				20.0	10.8		

Note: BR= Blow Room, C= Card, DS= Drawing & Simplex, R= Ring, TH= Total HOK, RTH=Rank for Total HOK, BR= Blow Room, TO=Total OHS, RO= Rank for Total OHS, PA= Prod/sp adjusted to 20s (P) in gms., RP= Rank for P, OM=OSHAM, ROH= Rank for OHSAM, AC= Average Coun

The HOK is a composite index by which both the operative and machine efficiencies of any spinning mill can be assessed. Accordingly, **lower the HOK, better is the overall performance**. The HOK data reported above is self-explanatory.

engaged in different departments can be expected to remain practically unchanged. However, for any large increases in production per spindle, the OHS is expected to increase significantly. This is because
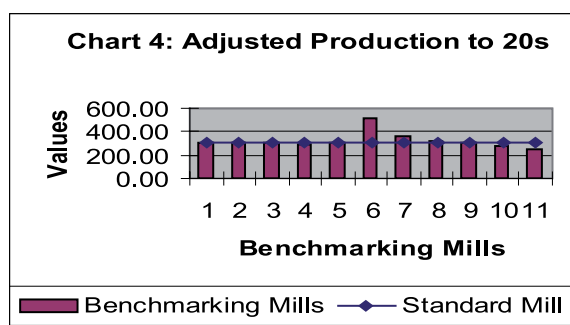
Chart 4: Adjusted Production to 20s

Chart 4: Adjusted Production to 20s — Values vs Benchmarking Mills (1–11); series: Benchmarking Mills, Standard Mill

operatives such as number of ring frame doffing boys and the preparatory department operatives would require to be engaged in proportionately larger numbers to cope with the higher volume of ring spinning production.

OSHAM is modified OHS to allow for valid comparison of a mill's OHS with the standard OHS of 11.4 taking into account the deviation of the mill's production per spindle from the standard production per spindle. Hence, lower the OSHAM, the more efficient is the mill (Chart 5).

Chart 5: OSHAM

Chart 5: OSHAM — Values vs Benchmarking Mills (1–11)
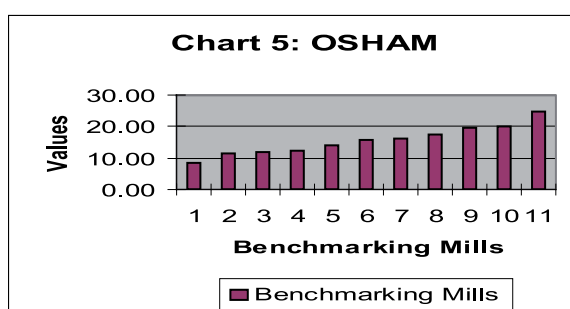
The OPS represents ounces per spindle/shift produced by a mill. In this case, the Standard Mill would produce 10.77 ounces per spindle shift (Chart 6).

Chart 6: OPS

Chart 6: OPS — Values vs Benchmarking Mills (1–11); series: Benchmarking Mills, Standard Mill
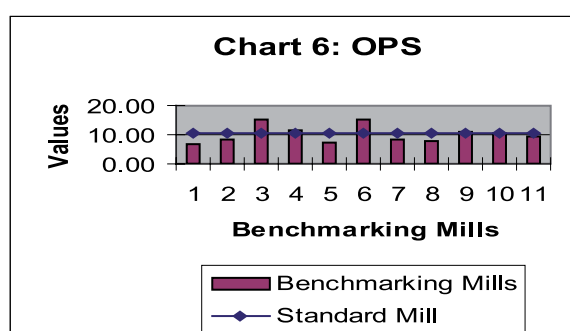
2. Cost Comparisons

The cost of raw cotton is the major cost in the total yarn cost. It comprises from 65% to 70% of the cost. Maximum possible yield from cotton should be achieved for which waste extracted at each stage should be effectively controlled.

In addition to the cotton cost, there are a number of other fixed costs. Hence, for calculating the conversion cost, the first step is to calculate the fixed cost. Cost heads of the various monthly fixed costs of typical mill is given in Table 20.

#	Table 20 Cost Heads
1	Mark-up on outstanding loans such LT-TFC, LMM, etc
2	Interest on cotton finance
3	Salaries and wages at the factory
4	Salaries at the Head Office
5	Overheads at the factory (establishment expenses)
6	Utilities, electric power, gas, water, etc.
7	Interest on running finance
8	Insurance of plant, vehicles, building, stock-in-process, and cash in transit
9	Cotton cess
10	Loading, unloading, packing, contractors
11	O.H. expenses at head office
12	Stores, spares, lubricants

The cost per spindle shift (CPS) is calculated by dividing the monthly fixed cost by the number of shifts worked per month. Packing cost pertains to the expenses incurred on the packing material, which are higher if the goods are packed for export. For the goods packed for local market, the packing cost heads are given in Table 21.

#	Table 21 Cost Heads
1	P.P. bag (35 x 46 inch)
2	Paper cones
3	Polythene bags (14 x 18 inch)
4	Plastic stopper (plain type)
5	Jute twine
6	Marking ink and label

Sales tax is also leviable on the sale price of yarn. Sales tax differential is calculated by deducting the sales tax paid on cotton from the amount of sales tax leviable on the sales price of yarn.

The total yarn production cost per pound of yarn is equal to the sum of raw cotton, conversion cost, packing cost and sales tax, less the recovery from the sale of non-usable manufacturing waste.

Although NPO had requested all the mills to provide their conversion cost, in order to calculate and compare how much cost effective each mill is, but information was only received from 3 mills.

The Conversion cost for these 3 mills on the basis of OPS values for 20s count works as indicated in Table 22).

Table 22			
Mill #	CPS in Rs.	OPS (20 CD & 20 CM)	Conversion Cost/lbs
7	8.27	10.615 (20 CM)	Rs.12.465 (say Rs.12.47)
1	7.97	11.35 (20 CM) 11.15 (20 CD)	Rs.11.235 (Rs.11.24) Rs.11.437 (Rs.11.83)
2	8.5	11.5 (20 CM)	Rs.11.826 (Rs.11.83)

The foregoing calculations clearly indicate the effect of fixed costs on conversion costs and underline the necessity of keeping fixed cost low in order to produce yarns at competitive prices.

VIII. INTERVENTIONS REQUIRED IN TEXTILE SECTOR

The country has the advantage of abundance of cotton and a large base for the manufacturing of textiles and clothing. The country also has the largest ceilings in various categories up to the year 2004 and the competitive advantage — though this advantage has eroded to a large extent, it could be regained.

The first and the most necessary step is to increase production of raw cotton in the country — Pakistan is capable of producing 20 million bales of raw cotton — and double the output from the area presently under cotton cultivation. This could be achieved through use of better quality seed offering higher yield and also resistant to CLV, balanced used of fertilizer, timely spray of pesticides, ensuring larger availability of irrigation water, and better crop management. Efforts should also be made to produce medium and long-staple fibre varieties of cotton.

One of the biggest problem for Pakistani spinning mills is the contamination of raw material (i.e. bales of cotton fibres). Spinners are loosing time and money by "picking" the cotton manually in order to be able to process it in an acceptable way. The picking moreover is a very unhealthy work. Hence, ginners have to be educated to meet quality standards of the spinners. Ginners need to understand these quality requirements, and adjust their organization to meet them. Efforts should also be made to establish modern ginning factories in the country. Cotton experts say that, since ages old ginning technology is used in the country, cotton fibre is damaged during the ginning process — an 'A' quality produced at the farms become 'B' when it comes out of ginneries. Not only does it contain foreign materials, it has higher than normal percentage of moisture and often lower grades of cotton are mixed with higher grades. Unless very strict quality standards are maintained at the ginning stage, the country cannot produce superior quality of fabrics.

The financial institutions must ensure liquidation of closed spinning units. Since most of them have become technologically obsolete and are beyond redemption. At least 20 per cent of the spinning units should be scrapped to allow continuation of only efficient and technologically modern units. The units producing coarse counts are not making any positive value-addition. On the one hand, due to poor value-addition, they are not able to earn profits equal to the opportunity cost, and on the other hand if the quantity of cotton used by these mills is made available to the units producing higher counts and dyed cones, it would not only improve the profit margins, but also result in exportable surpluses fetching higher prices.

The objective of higher value-addition in textile industry just cannot be achieved without creating a very strong weaving and processing base. It may be true that the power-looms sector can meet the indigenous requirement of fabrics but for overseas buyers the country needs to install at least 20,000 additional modern shuttleless/airjet looms. It is also necessary to produce better quality fabrics to produce made-ups of international standard. There are two major complaints about Pakistani fabrics: there is no consistency in colors/shades; and the dye bleeds out in the first washing. While poor selection of cotton is responsible for inconsistency in dyeing, the bleeding is due to use of substandard dyes. The poor finishing may also be attributed to the facts that the textile processing units are operating mostly in the unorganized sector, at small scale, without modern processing facilities, and there is inconsistency in the hardness of water used in the processing process. Thus, the overseas buyers prefer to buy yarn or grey fabrics from Pakistan. Modernization of processing is the key to higher value-addition. The made-ups manufacturing is still done at small scale for want of credit facilities. The disadvantage of smaller units is that they are not able to produce quality made-ups. Due to stringent customs procedure (for bonded warehousing facility) these units are not able to import

superior quality fabrics and have to remain contented with whatever they can get locally.

Another factor which has been discouraging production and export of quality products is the quota allocation policy of the government. The present policy still encourages volume export over quality and higher unit price realization. The bad implementation has also made quota a tradable commodity — as the premium on quota is more than the cost of the product itself. Pakistan has to redefine its quota allocation policy to encourage production and export of quality products. As the bulk of Pakistan's textiles falls under quota restrictions, one of the ways to earn more is to improve unit prices. The exporters have failed to reap the profits that could have been derived from the devaluation of currency. As they were able to get more in rupee terms, they should have concentrated on improving quality standards, but they lowered the FOB prices (in dollars) to attract more buyers. In turn, the unit price realization has gone down further.

There is a need to remove the tag that Pakistan is a source of low-quality, low-price products, hence the Trade Development authority of Pakistan (TDAP) has to play the key role. It should encourage local manufactures to exhibit only high-quality products. Lately, the TDAP has allowed 'Spot Sales' during fairs which attracted more 'seasonal exporters' rather than manufacturers of quality products. The TDAP must arrange participation of Pakistani exporters in more and more fairs and international exhibitions. However, selection of an exhibitor should be only on merit.

The government has been trying to provide various incentives through textile packages, economic and tariff reforms, export refinance facility and lowering of interest rate. There is an obligation on industry in general and textile sector in particular to reciprocate through improved productivity and quality standards. The effort should not only be to increase volume, but, more importantly, to improve the image of the country. In line with the Quaid-e-Azam's express desire, the 'Made in Pakistan' label should be a sign of quality.

It is also imperative that the government should remove all the small irritants. The government often announces very good policies, but poor implementation, delay in issue of amended SROs and subsequent changes distort these. The country must try to achieve a competitive advantage in textile sector which has been the largest foreign exchange earner, and its growth on solid grounds can help Pakistan double its exports in less than five years. Since Asia (excluding Japan) is emerging as the new textile manufacturing base, Pakistan could become to largest source of supply. However, offering low prices alone cannot help in exporting more. Pakistan mainly supplies textiles and clothing to developed countries. Efforts should be made to sell only high quality products in the years to come, as these countries have the highest purchasing power and the buyers are also willing to pay good premium.

IX. CONCLUSION

As has been mentioned before, Benchmarking is a relatively new terminology - a new concept of knowledge sharing; it refers to a continous learning process, which encourages improving one's own performance by learning from best practices of other enterprises in the similar industry. In Pakistan, NPO has been the pioneer to introduce this concept. Recognizing the importance of enhancing productivity and quality in cotton spinning, National Productivity Organization, Ministry of Industries & Production undertook this study. The main objective of this exercise was to identify functions and processes in each department of a spinning unit and the related results being obtained, in order to establish linkages between the two and identify the practices which result in the performance gaps in various mills. However, as the exercise progressed, it was determined that there is as such no technique or information to assess productivity of individual mills and then make comparisons with other mills in the same sector. Hence, it was decided that in addition to the identification of best practices, a technique to assess productivity of a mill would also be established and the establishment of a formal comparable data would be initiated by NPO. At the conclusion of this study, NPO has therefore established the following:

* Identification of **80 BEST PRACTICES**; it is expected that with the adoption of the best practices identified, overall productivity of the spinning sector will improve between 2-5% which would result in reduction in material handling and conversion costs by Rs.7.500 million per annum in an average mill. This will thus ensure susbtantial increase in profitability of the mills.

* **A TECHNIQUE TO ASSESS PRODUC-TIVITY OF A MILL**; this entails calculation of labor and machine productivity of each mill

* **A STANDARD MILL** for comparing the performance of each mill

* **COMPARABLE DATA** to measure the performance of each mill with other mills in the same sector

It has been established that good performance in the mills is a result of efficient use of available

27

resources like raw material, finance and human resources, superior quality of products on the basis of implementation of Total Quality Management (TQM) system, effective marketing, and continuous modernization and up-gradation of production facilities and customer oriented manufacturing. The practices mentioned in this report would address some of these factors.

The objective of this exercise would not be complete if the best practices and the Productivity Measurement System identified are not implemented. It is therefore recommended that all the stakeholders get together under the supervision of APTMA to:

• Discuss the findings of this report
• Set goals for process change
• Plan agenda for process change
• Implement the plan, and then
• Measure Customer satisafaction

It is important that the National Productivity Organization and the Ministry of Industries & Production be also fully aware of the steps taken for implementation of this plan. The Survey Data needs to be expanded in terms of number of mills, and also needs to be updated as new technologies, and products are introduced. In order to play an important part in this change towards value addition and innovation, NPO will be maintaining and including the comparable data of the mills at its secretariat. More mills are therefore invited to join in this exercise. And finally, it needs to be reiterated here, all information shared by the Benchmarking Mills has been kept purely confidential, and would never be divulged to any other public or private organization, for any purpose whatsoever. Benchmarking is a continuous process, and develops as it progresses. It is a tool for becoming a **World Class Organization**. It provides an understanding of the practices, which would assist in giving organizations a competitive advantage with its customers. As Lord Kelvin said.

"…when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind …."

Annexure

Table A		
Conversion Factor for Calculating Standardized Production in Spinning		
Count	**Calculation**	**Conv. Factor**
10s	10.4/20.90	0.5
12s	0.5 * 12/10	0.6
14s	0.5 * 14/10	0.7
16s	10.4/13.15	0.79
20s		1
21s	1 * 21/20	1.05
24s	10.4/7.8	1.33
30s	10.4/5.83	1.78
31s	1.78 * 31/30	1.84
36s	1.78 * 36/30	2.14
40s	10.4/3.73	2.78

Method to Calculate Conversion Factor:

Conversion Factor = (OPS as per Standards of Uster Statistics for the Standard Count I.e. 20s) / (OPS as per
Standards of Uster Statistics for the other count)
and
Conversion Factor = (Coarse Count Conversion Factor) x [(Finer Count)/ (Coarser count)]

Table B
Conversion Factors for Calculating Standardized Production for Spinning

Count	Spindle	Mix & Bl Rm	Cards	Drg	Fly Frames	Ring Spg	Total
5s	0.3228	2.3540	2.2569	1.8444	2.6937	1.3347	1.6988
5s HO	0.2791	2.3540	2.2569	1.8444	2.6937	1.2134	1.6260
6s	0.3179	2.3540	2.2569	1.8444	2.6937	1.1406	1.5774
6s HO	0.3131	2.3540	2.2569	1.8444	2.6937	1.1163	1.5532
6s C	0.2815	2.7908	2.6937	1.8444	2.4511	1.0678	1.5774
7s	0.3713	2.3540	2.2569	1.8444	2.6937	1.2619	1.6502
8s	0.4028	2.3540	2.2569	1.8444	2.6937	1.3105	1.6988
8s HO	0.4101	2.3540	2.2569	1.8444	2.6937	1.3347	1.6988
8s CHO	0.3495	2.7908	2.6937	1.8444	2.4511	1.2134	1.6745
10s	0.4805	2.3540	2.2327	1.8444	2.6937	1.1891	1.6017
10s HO	0.4538	2.3540	2.2327	1.8444	2.6937	1.1649	1.5774
10s C	0.4611	2.7908	2.6695	1.8444	2.4511	1.1649	1.6502
10s CHO	0.4320	2.7908	2.6695	1.8444	2.4511	1.1163	1.6260
12s	0.5703	2.3297	2.2327	1.8444	2.6695	1.3347	1.6988
12s HO	0.5363	2.3297	2.2327	1.8444	2.6695	1.2862	1.6502
12s C	0.5242	2.7908	2.6695	1.8444	2.4511	1.2619	1.7230
12s CHO	0.4878	2.7908	2.6695	1.8444	2.4511	1.2134	1.6745
14s	0.7111	2.3297	2.2327	1.8444	2.6695	1.5532	1.8201
14s HO	0.6674	2.3297	2.2327	1.8444	2.6695	1.4803	1.7958
14s HT	1.3881	2.3297	2.2327	1.8444	2.6695	2.5724	2.4996
14s C	0.6528	2.7908	2.6695	1.8444	2.4511	1.4561	1.8444
14s CHO	0.6067	2.7908	2.6695	1.8444	2.4511	1.3833	1.7958
15s CHO	0.6674	2.7908	2.6695	1.8444	2.4511	1.4803	1.8444
16s	0.8106	2.3783	2.3055	1.8444	2.6695	1.4561	1.7958
16s HO	0.7717	2.3783	2.3055	1.8444	2.6695	1.4075	1.7473
16s C	0.7208	2.8394	2.7423	1.8444	2.4511	1.3590	1.7716
16s CHO	0.7062	2.8394	2.7423	1.8444	2.4511	1.3347	1.7716
17s	0.8834	2.3783	2.3055	1.8444	2.6695	1.5532	1.8444
17s HT	0.8008	2.3783	2.3055	1.8444	2.6695	2.6452	2.5481
18s	0.9246	2.3783	2.3055	1.8444	1.8686	1.6017	1.7958
18s HO	0.8834	2.3783	2.3055	1.8444	1.8686	1.5532	1.7473
18sC	0.8251	2.8394	2.7423	1.8444	1.7473	1.4803	1.7958
18s CHO	0.8033	2.8394	2.7423	1.8444	1.7473	1.4561	1.7716
19s	0.9974	2.3783	2.3055	1.8444	1.8686	1.6988	1.8444
19s HO	0.9513	2.3783	2.3055	1.8444	1.8686	1.6260	1.8201
20s	0.9998	2.3783	2.2812	1.8201	1.8444	1.6017	1.7958
20s HO	0.9246	2.3783	2.2812	1.8201	1.8444	1.5289	1.7473
20s HT	2.0045	2.3783	2.2812	1.8201	1.8444	2.5967	2.4268
20s C	0.8785	2.8151	2.7180	1.8201	1.7473	1.4803	1.7958
20s CHO	0.8203	2.8151	2.7180	1.8201	1.7473	1.4318	1.7473
21s	1.0751	2.3783	2.2812	1.8201	1.8444	1.6745	1.8444
21s HO	0.9950	2.3783	2.2812	1.8201	1.8444	1.6017	1.7958
22s	1.1527	2.3783	2.2812	1.8201	1.8444	1.7473	1.8929
22s C	1.0071	2.8151	2.7180	1.8201	1.7473	1.6017	1.8686

Table B (Continued) Conversion Factors for Calculating Standardized Production for Spinning						
Count	Spindle	Mix & Bl Rm	Cards	Drg	Fly Frames	Ring Spg	Total
22s CHO	0.9416	2.8151	2.7180	1.8201	1.7473	1.5532	1.8201
23s	1.2255	2.3783	2.2812	1.8201	1.8444	1.8201	1.9414
23s HO	1.1333	2.3783	2.2812	1.8201	1.8444	1.7230	1.8686
23s C	1.0751	2.8151	2.7180	1.8201	1.7473	1.6745	1.9172
23s CHO	1.0071	2.8151	2.7180	1.8201	1.7473	1.6017	1.8686
24s	1.2716	2.3783	2.2812	1.9414	1.9657	1.8686	1.9657
24s HO	1.1721	2.3783	2.2812	1.9414	1.9657	1.7716	1.9172
24s C	1.1042	2.8151	2.7180	1.7958	1.8201	1.6988	1.9414
24s CHO	1.0338	2.8151	2.7180	1.7958	1.8201	1.6260	1.8929
25s	1.3517	2.3783	2.2812	1.9414	1.9657	1.9414	2.0385
25s HO	1.2401	2.3783	2.2812	1.9414	1.9657	1.8444	1.9657
25s CHO	1.0945	2.8151	2.7180	1.7958	1.8201	1.6988	1.9414
26s	1.4245	2.4268	2.3540	1.9414	1.9657	2.0142	2.0870
26s HO	1.3153	2.4268	2.3540	1.9414	1.9657	1.9172	2.0142
26s C	1.2449	2.8879	2.8151	1.7958	1.8201	1.8444	2.0385
26s CHO	1.1600	2.8879	2.8151	1.7958	1.8201	1.7473	1.9900
27s	1.5070	2.4268	2.3540	1.9414	1.9657	1.9172	2.0142
27s HO	1.3930	2.4268	2.3540	1.9414	1.9657	1.8201	1.9657
27s CHO	1.2280	2.8879	2.8151	1.7958	1.8201	1.6745	1.9414
28s	1.5920	2.4268	2.3540	2.0870	2.1356	1.9900	2.0870
28s HO	1.4634	2.4268	2.3540	2.0870	2.1356	1.8929	2.0142
28s C	1.3833	2.8879	2.8151	1.9414	1.9657	1.8201	2.0385
28s CHO	1.2886	2.8879	2.8151	1.9414	1.9657	1.7230	1.9900
29s	1.6793	2.4268	2.3540	2.0870	2.1356	2.0628	2.1356
30s	1.6405	2.4268	2.3540	2.0870	2.1356	2.0385	2.1113
30s HO	1.4585	2.4268	2.3540	2.0870	2.1356	1.8686	2.0142
30s C	1.4367	2.8879	2.8151	1.9414	1.9657	1.8686	2.0870
30s CHO	1.3347	2.8879	2.8151	1.9414	1.9657	1.7716	2.0142
31s	1.6745	2.4268	2.3540	2.0870	2.1356	2.0628	2.1356
31s HO	1.5313	2.4268	2.3540	2.0870	2.1356	1.9414	2.0628
31s C	1.5095	2.8879	2.8151	1.9414	1.9657	1.9172	2.1113
31s CHO	1.4027	2.8879	2.8151	1.9414	1.9657	1.8201	2.0628
32s	1.7570	2.4268	2.3540	2.2812	2.3055	2.1356	2.2084
32s HO	1.5823	2.4268	2.3540	2.2812	2.3055	2.0142	2.1356
32s C	1.5823	2.8879	2.8151	2.1599	2.0628	1.9900	2.1841
32s CHO	1.4706	2.8879	2.8151	2.1599	2.0628	1.8929	2.1113
33s	1.8395	2.4268	2.3540	2.2812	2.3055	2.2084	2.2569
33s C	1.6502	2.8879	2.8151	2.1599	2.0628	2.0385	2.2084
34s	1.9245	2.4268	2.3540	2.2812	2.3055	2.2812	2.3055
34s HO	1.6793	2.4268	2.3540	2.2812	2.3055	2.0628	2.1599
34s C	1.7255	2.8879	2.8151	2.1599	2.0628	2.1113	2.2569
34s CHO	1.6017	2.8879	2.8151	2.1599	2.0628	2.0142	2.1841
35s	2.0094	2.4268	2.3540	2.2812	2.3055	2.3540	2.3540
35s C	1.8007	2.8879	2.8151	2.1599	2.0628	2.1841	2.3055
36s	2.0968	2.4268	2.4268	2.2812	2.3055	2.1841	2.2569
36s HO	1.8298	2.4268	2.4268	2.2812	2.3055	1.9900	2.1113

Table B (Continued)
Conversion Factors for Calculating Standardized Production for Spinning

Count	Spindle	Mix & Bl Rm	Cards	Drg	Fly Frames	Ring Spg	Total
36s C	1.8322	2.8879	2.8879	2.1599	2.0628	1.9900	2.1841
36s CHO	1.7449	2.8879	2.8879	2.1599	2.0628	1.9172	2.1356
37s	2.1720	2.4268	2.4268	2.2812	2.3055	2.2327	2.2812
37s C	1.9075	2.8879	2.8879	2.1599	2.0628	2.0385	2.2327
38s	2.2618	2.4268	2.4268	2.4268	2.4268	2.3055	2.3540
38s HO	1.9851	2.4268	2.4268	2.4268	2.4268	2.0870	2.2084
38s HT	3.7421	2.4268	2.4268	2.4268	2.4268	3.3975	3.0578
38s C	1.9875	2.8879	2.8879	2.2812	2.4511	2.1113	2.3055
38s CHO	1.8929	2.8879	2.8879	2.2812	2.4511	2.0385	2.2569
39s	2.3516	2.4268	2.4268	2.4268	2.4268	2.3783	2.3783
39s HO	2.0652	2.4268	2.4268	2.4268	2.4268	2.1599	2.2569
39sCHO	1.9681	2.8879	2.8879	2.2812	2.4511	2.0870	2.3055
40s	2.4268	2.4268	2.4268	2.4268	2.4268	2.4268	2.4268
40sHO	2.1453	2.4268	2.4268	2.4268	2.4268	2.2084	2.2812
40s HT	4.0406	2.4268	2.4268	2.4268	2.4268	3.6159	3.2034
40s C	2.1356	2.8879	2.8879	2.2812	2.4511	2.2084	2.3783
40s CHO	1.9196	2.8879	2.8879	2.2812	2.4511	2.0628	2.2812
40s CHT	3.2568	2.8879	2.8879	2.2812	2.4511	3.0335	2.9122
41s	2.4583	2.4268	2.4268	2.4268	2.4268	2.4511	2.4511
41s C	2.2132	2.8879	2.8879	2.2812	2.4511	2.2812	2.4268
42s	2.4875	2.4268	2.4268	2.4268	2.4268	2.4753	2.4511
42s HO	2.2933	2.4268	2.4268	2.4268	2.4268	2.3297	2.3540
42s C	2.2958	2.8879	2.8879	2.2812	2.4511	2.3297	2.4511
42s CHO	2.0555	2.8879	2.8879	2.2812	2.4511	2.1599	2.3297
43s	2.5748	2.4268	2.4268	2.4268	2.4268	2.5481	2.4996
43s C	2.3783	2.8879	2.8879	2.2812	2.4511	2.4025	2.4996
44s	2.6525	2.4268	2.4268	2.4268	2.6937	2.5967	2.5724
44s C	2.4632	2.8879	2.8879	2.2812	2.4511	2.4511	2.5481
44s CHO	2.2035	2.8879	2.8879	2.2812	2.4511	2.2569	2.4025
45s CHO	2.2788	2.8879	2.8879	2.2812	2.4511	2.1841	2.3540
46s	2.8345	2.4268	2.4268	2.4268	2.6937	2.5481	2.5481
46s C	2.6307	2.8879	2.8879	2.2812	2.4511	2.4025	2.4996
47s	2.9267	2.4268	2.4268	2.4268	2.6937	2.6209	2.5724
47s C	2.7180	2.8879	2.8879	2.2812	2.4511	2.4753	2.5481
48s	3.0214	2.4268	2.4268	2.4996	2.8636	2.6695	2.6452
48s C	2.8054	2.8879	2.8879	2.3540	2.6209	2.5239	2.5967
48s CHO	2.5117	2.8879	2.8879	2.3540	2.6209	2.3297	2.4753
50s	3.1354	2.4996	2.5967	2.4996	2.8636	2.7666	2.7180
50s C	2.9655	2.9607	3.0820	2.3540	2.6209	2.6452	2.7180
50s CHO	2.6695	2.9607	3.0820	2.3540	2.6209	2.4511	2.5724
50s CHT	4.5503	2.9607	3.0820	2.3540	2.6209	3.7130	3.3975
52s	3.3247	2.4996	2.5967	2.4996	2.8636	2.8879	2.7908
52s C	3.1451	2.9607	3.0820	2.3540	2.6209	2.7666	2.7908
54s	3.5189	2.4996	2.5967	2.8151	3.1063	3.0092	2.9122
54s C	3.3296	2.9607	3.0820	2.6695	2.8394	2.8879	2.9122
54s CHO	2.9801	2.9607	3.0820	2.6695	2.8394	2.6452	2.7423

Table B (Continued) Conversion Factors for Calculating Standardized Production for Spinning							
Count	**Spindle**	**Mix & Bl Rm**	**Cards**	**Drg**	**Fly Frames**	**Ring Spg**	**Total**
55s	3.6184	2.4996	2.5967	2.8151	3.1063	3.0820	2.9607
55s C	3.3174	2.9607	3.0820	2.6695	2.8394	2.8879	2.8879
55s CHT	5.0914	2.9607	3.0820	2.6695	2.8394	4.0770	3.6887
56s	3.6960	2.4996	2.5967	2.8151	3.1063	3.1306	3.0092
56s C	3.4097	2.9607	3.0820	2.6695	2.8394	2.9364	2.9364
56s CHO	3.1476	2.9607	3.0820	2.6695	2.8394	2.7666	2.8151
57s C	3.5019	2.9607	3.0820	2.6695	2.8394	3.0092	2.9850
58s	3.8950	2.4996	2.5967	2.8151	3.1791	3.2762	3.1063
58s C	3.5941	2.9607	3.0820	2.6695	3.0092	3.0578	3.0335
58s CHO	3.3174	2.9607	3.0820	2.6695	3.0092	2.8879	2.9122
59s C	3.6887	2.9607	3.0820	2.6695	3.0092	3.1306	3.0820
60s	3.9751	2.4996	2.5967	2.8151	3.1791	3.3247	3.1306
60s HO	3.6960	2.4996	2.5967	2.8151	3.1791	3.1306	3.0092
60s HT	5.7661	2.4996	2.5967	2.8151	3.1791	4.5381	3.9314
60s C	3.6693	2.9607	3.0820	2.6695	3.0092	3.1306	3.0820
60s CHO	3.3830	2.9607	3.0820	2.6695	3.0092	2.9122	2.9364
60s CHT	5.5962	2.9607	3.0820	2.6695	3.0092	4.4168	3.9314
61s C	3.7615	2.9607	3.0820	2.6695	3.0092	2.8636	2.9122
62s	4.1741	2.4996	2.5967	2.8151	3.1791	3.1063	2.9850
62s HT	6.0573	2.4996	2.5967	2.8151	3.1791	4.2469	3.7130
62s C	3.8562	2.9607	3.0820	2.6695	3.0092	2.9364	2.9364
62s CHO	3.5504	2.9607	3.0820	2.6695	3.0092	2.7423	2.8151
63s	4.2760	2.4996	2.5967	2.8151	3.1791	3.1791	3.0335
63s C	3.9484	2.9607	3.0820	2.6695	3.0092	2.9850	2.9850
64s	4.3804	2.4996	2.5967	2.9364	3.5431	3.2276	3.1063
64s C	4.0430	2.9607	3.0820	2.6695	3.0820	3.0335	3.0335
65s	4.4823	2.4996	2.5967	2.9364	3.5431	3.3004	3.1548
66s	4.5867	2.4996	2.5967	2.9364	3.5431	3.3490	3.2034
66s C	4.2348	2.9607	3.0820	2.6695	3.0820	3.1548	3.1063
66s CHO	3.8999	2.9607	3.0820	2.6695	3.0820	2.9607	2.9607
67s C	4.3294	2.9607	3.0820	2.6695	3.0820	3.2034	3.1306
68s C	4.4289	2.9607	3.0820	2.6695	3.0820	3.2762	3.1791
70s	5.0089	2.4996	2.5967	2.9364	3.6645	3.6159	3.3733
70s C	4.6255	2.9607	3.0820	2.6695	3.3004	3.3733	3.2762
70s CHO	4.2615	2.9607	3.0820	2.6695	3.3004	3.1548	3.1306
72s	5.2249	2.5481	2.8394	2.9364	3.6645	3.7373	3.4946
72s C	4.8245	3.0578	3.3975	2.6695	3.3004	3.4946	3.3975
73s C	4.9240	3.0578	3.3975	2.6695	3.3004	3.5674	3.4218
74s	5.4457	2.5724	2.8394	2.9364	3.6645	3.8829	3.5674
74s C	4.9992	3.0578	3.3975	2.6695	3.3004	3.6159	3.4703
75s	5.5549	2.5724	2.8394	2.9364	3.6645	3.9314	3.6159
76s	5.6666	2.5724	2.8394	2.9364	3.6645	4.0042	3.6645
76s C	5.2031	3.0578	3.3975	2.6695	3.3004	3.7373	3.5431
77s C	5.3074	3.0578	3.3975	2.6695	3.3004	3.7858	3.5674
78s C	5.4093	3.0578	3.3975	2.6695	3.3004	3.8586	3.6159
80s	5.9724	2.5724	2.8394	3.0092	4.0770	4.1984	3.8343

			Table B (Continued)			
		Conversion Factors for Calculating Standardized Production for Spinning				
Count	**Spindle**	**Mix & Bl Rm**	**Cards**	**Drg**	**Fly Frames**	**Ring Spg**	**Total**
80s C	5.4773	3.0578	3.3975	2.7423	3.8343	3.8829	3.7130
80s CHO	5.1788	3.0578	3.3975	2.7423	3.8343	3.7130	3.5917
81s C	5.5792	3.0578	3.3975	2.7423	3.8343	3.7373	3.6159
82s	6.1641	2.5724	2.8394	3.0092	4.0770	4.0528	3.7373
82s C	5.6836	3.0578	3.3975	2.7423	3.8343	3.7858	3.6402
84s	6.3898	2.5724	2.8394	3.0092	4.0770	4.1741	3.8343
84s C	5.8923	3.0578	3.3975	2.7423	3.8343	3.9071	3.7130
86s C	6.1034	3.0578	3.3975	2.7423	4.0770	4.0285	3.8101
88s C	6.3194	3.0578	3.3975	2.7423	4.0770	4.1498	3.9071
89s C	6.4262	3.0578	3.3975	2.7423	4.0770	4.1984	3.9314
90s	7.0863	2.5724	3.2762	3.1548	4.4168	4.5867	4.1741
90s C	6.5354	3.0578	3.9071	2.7423	4.0770	4.2712	4.0285
91s C	6.6446	3.0578	3.9071	2.7423	4.0770	4.3197	4.0770
92s C	6.7538	3.0578	3.9071	2.7423	4.0770	4.3925	4.1013
92s CHT	9.4961	3.0578	3.9071	2.7423	4.0770	5.9214	5.0963
93s C	6.8654	3.0578	3.9071	2.7423	4.0770	4.4410	4.1498
94s	7.5643	2.5724	3.2762	3.1548	4.4168	4.8293	4.3440
94s C	6.9746	3.0578	3.9071	2.7423	4.0770	4.5138	4.1984
95s	7.6857	2.5724	3.2762	3.1548	4.4168	4.9021	4.3925
95s C	7.0863	3.0578	3.9071	2.7423	4.0770	4.5867	4.2226
96s C	7.1979	3.0578	3.9071	2.7666	4.3440	4.6352	4.2954
96s CHT	10.1222	3.0578	3.9071	2.7666	4.3440	6.2611	5.3632
98s	8.0521	2.5724	3.2762	3.1791	4.7323	5.1205	4.5624
98s C	7.4260	3.0578	3.9071	2.7666	4.3440	4.7565	4.3925
100s	8.2997	2.5724	3.2762	3.1791	4.7323	5.2419	4.6352
100s C	7.8556	3.0578	3.9071	2.7666	4.3440	4.9992	4.5381
102s C	8.0910	3.0578	3.9071	2.7666	4.3440	5.1448	4.6352