3.1 Production Process in Khadi Spinning

Generally in khadi spinning there is a central processing unit where the following power operated machines are located.

Blow room line consisting of about 5 to 6 beating points to clean the raw cotton that arrive in the bale form. Generally cotton is transported to the blow room in the form of compressed bales, (bale weight 170 kg each). Here the cottons are thoroughly opened and cleaned and wound into a lap (sheet form). Carding machine then converts tap into sliver form (rope form). Draw frame is the next machine which paralyses all fibers in the sliver into a more uniform sliver.

The last machine in the central processing unit is the speed frame, which drafts the sliver into a thin roving (the size of a pencil lead) and wound on to a bobbin weighing approximately 1.50 kg. These roving bobbins are then delivered into spinners homes and serves as a raw material for spinning yarn on the charkha.

The roving bobbins are fixed on to the creel of the charkha and the spinning charkha converts the roving (pencil lead size) into a yarn by the process of drafting, twisting and winding on to a bobbin. All
these operations are performed simultaneously on the spinning charkha.

The next step is to weave the cloth. For this we require two sets of threads one perpendicular to the other. The warp yarns (vertical) and the weft yarns (Horizontal). The process to achieve this is to again convert the spinning bobbins into hanks (840 yards) by the process called reeling. One sets of hanks goes for weft winding (Pirn winding). The other sets of hanks goes for a process called warping and sizing. After these process the warp beam is ready and put on the hand loom for weaving and the process of weaving begins and cloth is thus produced.

Exhibit 3.1

Flow Process Chart and Details of Processing Khadi

Mixing Room
   ↓
Blow Room
   ↓
Carding
   ↓
Draw Frame
   ↓
   90
3.2.0 Khadi Spinning Tools And Its Specifications

3.2.1 The History of Development of the Charkha

Charkhas have been in existence ever since the beginning of civilization. The takli in Plate -1, page - 2 as revealed in the Vedas
existed during the Aryan period where hand spun and hand woven material was being used. It was considered most sacred besides the plough. The Greek traveler Megasthenes testifies to the fact that fine muslins of 300s count were hand spun and woven in India at that time. The word khadi came to be known much later.

3.2.2 The spinning wheel

The spinning wheel is a simple form of primitive spinning wheel with a spindle fixed to it, and rotated by handle in plate -6 page - 12. The spindle was narrow and the eccentric spindle would cause thread breakage and uneven yarn.

3.2.3 Two Pots Charkha

This charkha was developed before 1947. The material is drafted by a set of rubber covered drafting rollers and then twisted and wound on the pots. The pots are driven by a wooden pulley drive. Here the production is doubled when compared to spinning wheel. Great effect is required to turn the hand wheel.

3.2.4 Two Spindle Hand Operated Charkha

This is the development over two-pot charkha in plate - 13, page- 32 shows the charkha. This charkha was soon replaced by Four spindle charkha as the production rate of Two Spindle Charkha was less than the Four Spindle Charkha for the same effort of rotating the handle.
3.2.5 Four Spindle Amber Charkha

This machine can be seen in Figure in plate - 8, Page -26. This charkha was an improvement on the muslin charkha and completely made of wooden parts. The speeds were limited due to the wooden parts used to drive the wrought iron spindles. This charkha was developed in Gujarat and made popular by KVIC during the 1960’s.

3.2.6 Six Spindle muslin charkha

This Charkha has been illustrated in plate - 9, page 27. This charkha was developed during the Mughal era of Akbar the Great and was used to spin very fine counts up to 300 s count.

3.2.7 Box Charkha

Plate - 4 and 5 in page - 11 and 12 shows the box type charkha, which was used by Gandhiji, who used to take it with him during his travel in India. He used to daily spin his requirement of yarn using the box charkha and set example to people to boycott the Manchester mills cloth and produce their own requirement of cloth khadi by Hand spinning and Hand weaving. Box charkha is a portable charkha made of wooden pulley and a handle.

3.2.8 Eight Spindle Amber Charkha

This development took place during period 1996 and there was tremendous growth in the khadi sector as this charkha got popularity. The plate -10 in page- 28 illustrates this most popular charkha in use,
particulars in the states of Gujarat, Maharashtra and Tamilnadu. The machine can give a production rate of up to 20 Kg/shift for 8 spindles. The spindle can achieve a speed exceeding 6000 rpm if operated by motor.

3.2.9 Conventional Metal Charkha

Plate -11 in Page -31 illustrates the conventional metal charkha. It is a simple charkha and was used by people to spin in homes, their daily requirement of cloth. Conventional metal charkha is a four spindle all metal charkha which is having a handle to turn and spin the khadi yarn. Due to heavy moving parts, the speeds were limited and human drudgery was more. Hence this charkha did not become popular.

3.2.10 12 Spindle Pedal Operated Charkha

Plate -15, Page - 45 shows the once popular pedal operated charkha this produces great drudgery to the operator who has to continuously pedal the machine in order to rotate the 12 spindles. There is lot of spindle speed variation and the twist flow in the yarn is not uniform. More over ladies who operated this machine have the problem of miscarriage or do not conceive and hence quit the work after working for two years to raise a family. The production also steadily drops from morning towards evening due to fatigue of the spinner. Due to continuous pedal operation for eight hours, the feet of the spinner get swollen and hence the absentism rate increases.
3.3.1 16 Spindle motorized Charkha, Appropriate Technology tools

Plate -16 and 17 page 46 and 47 respectively shows the 16 Spindle Motorized Charkha developed by the researcher. This is the narrow width high-speed spinning frame that could be used in rural households for spinning khadi yarn. The following are the appropriate technology tools used in the charkha.

3.3.2 Creels

Umbrella type creel has been used which are in existence in the textile spinning mills, but hitherto not used in the charkha spinning. These umbrella creels with bobbin holder can hold large diameter roving bobbins up to 6 Yz” and 12” height weighing up to 1.5 kg each. These bobbins can supply roving hank continuously for more than 15 days. Making the work of frequent creeling operation redundant. There by the khadi spinner has more time to attend other works.

3.3.3 Drafting system

The popular SKF-PK-225 drafting system was adopted with 45°-angle roller stand. This 3 roller double apron drafting system helps in better control of fibers and contributes to good and even drafting of fibers. This drafting which is popular in high speed ring spinning frame has been successfully adopted in the 16 spindle charkha with suitable modifications to arm bar and roller stand.
design. The draft-gearing unit had also to be modified suitably by using helical cut gears as helical gears give noise free high speed smooth running in the machine.

3.3.4 Spindles and Rings

The textile mill spindles and rings which are available freely were used to enable the charkha spinner to go for higher lift of spindles 180mm and larger diameter rings 42/48mm diameter. This means that the spindles can hold bigger package bobbins weighing up to 60 grams for each bobbin. These spindles are placed in a bolster with oil damper to enable the spindles to rotate freely without any vibration what so ever. The spinning rings are also highly polished to enable the ring traveler to move around smoothly. The traveler used was elliptical traveller, silver coated which is the one used in textile mills regularly and is freely available. The silver coated traveller dissipates the heat generated due to rotation and gives better quality yarn. The width of the spinning charkha has been kept at 21.5" and the height is fixed at 56" to enable the machine to enter in to the huts of village people, so that they can spin yarn at their homes itself. As the lintal of the huts is only 5 1/2 feet the height of the charkha machine was kept at 4 1/2 feet. The driver pulley shaft is extended to fix the VS Hp motor on a motor bed. The motor is driven by A section belt with single groove pulley.

3.3.5 Problems identified with the existing spinning tools

It can be inferred from the data provided, that in addition to
human drudgery in rotating the handle of the spinning charkha, mostly the women folks who are employed are put to lot of physical strain. Many women are not able to conceive due to 8 hours of physical strain. Also it has been seen that women who do conceive, have had abortion due to working the 8 spindle manually operated charkha. There is migration of spinners to other jobs.

The new model 8 spindle all metal charkha (1996 model) also called the Coimbatore or Rajkot model charkha was developed during the year 1996. Ever since that time, there has been no improvement in the machine design or ergonomic design change with the result that the poor khadi spinners are forced to earn meager wages and suffer physical drudgery.

The researcher had conceived the idea of increasing the number of spindles from 8 to 16 and also made some changes in machine design and ergonomics so that the spinning frame can take up higher speeds without much vibration. “If motorized, the wages earned will be higher and quality will be comparable to mill yarn”. Hence the researcher Introduced fraction HP. single phase motor for driving the spindles of the 8 spindle charkha and 16 spindle charkha that could replace the drudgery of rotating the spindles by hand power or by foot power.

3.3.6 Fibre properties of Cottons used

Generally 2 or 3 different cottons are mixed together in order to
produce a good yarn. The advantage of mixing is to improve fibre properties and also to bring down yarn cost and production cost. The most popular cottons that are used to spin the khadi counts are given in the Table no 3-I The cotton varieties shown are cultivated in south India except for variety J34, which comes from Punjab. The Table - 3.1 gives the important fibre properties like length, strength, fineness, and uniformity for spinning a good quality yarn. Higher the values of fibre properties, higher is the price of cotton.

3.4 Design of the improved Spinning Tool and Specification

The khadi centers have popularized the 8 Spindle all Metal Hand Operated Charkha and there after introduced a modified 12 Spindle all Metal Foot Operated Charkha. The researcher has conducted extensive study on both the types of charkha and found that women spinners who operate the pedal charkha do not conceive and there is drudgery of constant body movement and exertion. More over the machine design has certain in built drawbacks. It is not amenable to higher spindle speeds. The spindle and rings are of small sizes and here the package sizes are limited. The draft gearing and pulley drive were primitive and there was slippage in spindle drive resulting in more human effort on the past of the spinner, besides health problems.

Therefore the researcher has by conducting study in rural homes which have a small room and low LINTEL in the huts, come to
the conclusion that 16 spindle machine with low height and narrow width would suit the requirements of rural homes such a charkha would give good moveability. This gives good measurability and easily the machine may be brought inside or taken out of huts for repair. The height is also less so it can be easily enter in to doorway. It is a higher version of the 12 spindle foot operated machine (Plate - 15 in Page - 45).

This improved Charkha has bigger diameter spinning rings 42mm and larger spindles 180mm to accommodate bigger bobbins and ultimately more yarn when compared to 8 Spindle Hand Operated or 12 Spindle Foot Operated Charkha. The SKF PK 225 top arm drafting system ensures uniform pressure on the bottom rollers and hence better yarn quality.

The small diameter spindle wharve saves energy. This new improved design of charkha is powered by a 0.25 hp single-phase motor which can easily be worked with domestic power. The creel has been designed with an umbrella shape to accommodate larger diameter of simplex bobbins up to $6 \frac{1}{2}$ inches in diameter. The height of the creel has been kept low 4 $\frac{1}{2}$ feet to enable the machine to be taken inside the huts. Normally skewer type creels are used in khadi charkha. But in the new improved designed charkha, ball bearing bobbin holders are used in place of skewers. This will reduce the roving stretch between creel and drafting zone. The helical cut gears reduce the noise and also conserve energy while working.
<table>
<thead>
<tr>
<th>SL. No</th>
<th>Count</th>
<th>Cotton Variety</th>
<th>2.5% Span length (mm)</th>
<th>Fibre strength Stelometer (3mm G) (Gms/tex)</th>
<th>Micronaire value (g/inch)</th>
<th>Trash Percentage</th>
<th>Uniformity ratio (U%)</th>
<th>Maturity ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10^s</td>
<td>Desi and Bonda waste</td>
<td>18.0</td>
<td>14.5</td>
<td>6.0</td>
<td>7</td>
<td>49.8</td>
<td>0.80</td>
</tr>
<tr>
<td>2</td>
<td>33^s</td>
<td>J34 and V797</td>
<td>23.5</td>
<td>18.5</td>
<td>4.4</td>
<td>9</td>
<td>45.3</td>
<td>0.85</td>
</tr>
<tr>
<td>3</td>
<td>64^s</td>
<td>MCU5 / Shankar4 and 1007</td>
<td>28.0</td>
<td>20.0</td>
<td>3.8</td>
<td>5</td>
<td>46.1</td>
<td>0.90</td>
</tr>
<tr>
<td>4</td>
<td>72^s</td>
<td>H4 / MCU5 and Shankar6</td>
<td>27.5</td>
<td>17.0</td>
<td>3.7</td>
<td>5</td>
<td>49.0</td>
<td>0.88</td>
</tr>
</tbody>
</table>
3.5 Technical Specifications Of 16 Spindle Improved Charkha

**Application**: Staple fibre spinning up to 60mm

**Max number of spindles**: 16

**Counts Spun**: 4s to 140s Ne

**Mode of spindle drive**: 4 spindle tape drive obtained through motor drive

**Power rating**: 0=25 hp single phase motor electrically driven

**MACHINE DATA**

Machine Length : 1118mm (44")

Machine width : 550mm (21 1/2")

Machine height : 1372mm (54")

Spindle gauge : 70mm

Spindle Lift : 180(7")

Ring diameter : 42mm (or) 1 5/8"

Range of twist : 250 - 2550 turns/meter

Tin roller diameter : 190mm

**Spindle wharve diameter**: 13mm

Front roller diameter : 25.4mm

**Top arm type**: SKF PK 225

**Drive**: Electrical motor driven

**Motor Specifications**: Single phase 1440 rpm, 0.25 hp/220 V, 50 cycle TE FC Motor.
Trials were taken on the newly designed machine for $10^s$, $33^s$, $64^s$ and $72^s$ Nm counts at 5500 rpm, 6500 rpm and 7500 rpm. But it was observed that the machine vibration and quality of roving (Raw material) was not suitable to work at speed beyond 6500 rpm as the yarn breakage was high. There is scope for conducting further studies in this area with better quality raw material.

3.6 Modifications Suggested In The Spinning Charkha

The all-metal 8-spindle Coimbatore or Rajkot charkha was taken as the sample. The main driving shaft was extended with suitable Aluminum pulleys (190mm dia) to drive the spindles. The spindle beam and drafting roller beam were extended suitably to add another 8 spindles. So, also the ring rail was extended to add another 8 rings. The machine is built up in units of 8 spindles per staff length. That is the difference between 2 roller stands, which hold the drafting system. So the ring frame design has to be in multiple of 8 spindles. The researcher has tried to fix 24 spindles, but the length of the machine increases nearly 5 1/2 feet causing difficulty to accommodate in the huts of the spinners. The height and width of the spinning machine has been redesigned to save space. The height was been reduced to 4 14 feet from earlier 5 feet. So also the width has been reduced from 28 “ to 21 1/2 “. So that 2 machines can be accommodated inside the huts opposite to each other with a 2 feet alley in between, so that the spinner can easily look after 2 machines (16 spindles) with the same effort and by incorporating motor drive using fraction Hp motor.
The draft-gearing units were replaced with helical cut gears to enable smoother and noise less rotation. The spindle lift has been increased from the present 4” to 7” lift. So also the ring diameter has been increased from 32 mm to 42 mm to hold more yarn and increase the running time of the spinning machine. To keep the cost low, the easily available spindles & rings of the textile mills are used here. So also the SKF-PK 225 double apron drafting system which is used in textile mills has been adopted on the charkha spinning. This could be done by using the arm bars and roller stands, and fluted rollers taken from the Textile mills. This not only brings down the cost of the charkha, but also the spares are easily available in the market.

3.7 Summary

The researcher has made a detailed study of all the existing spinning charkhas by visiting several places in Tamil Nadu, Gujarat, New Delhi, Mumbai and discussing with, Sarvodaya sanghs, KVIC and KVIB centres. Also library services of khadi centres were reached to know the developments in the spinning charkha since 1900 to the present status. The most popular cotton khadi yarns spun and the cottons used to spin these counts are stated. The raw cotton characteristics are also mentioned. Keeping the 8 Spindle all Metal Charkha as a base, the researcher has tried to develop a new 16 spindles all metal charkha, which used to help the khadi spinner to earn more wages besides producing a yarn with uniform twist flow and better quality. Thereby it could fetch a higher yarn price in the market. The machine design of the ring frame of textile' mills scaled
down and wherever possible adaption has been made taking the
drafting system, rings and spindles of the Textile mill industry and
adopting it for the cause of millions of rural spinners.

Thus, the hypothesis stating that the design specifications of
the charkha tools could be modified or improved by increasing the
number of spindles per charkha; increasing the height of the spindle
blade, increasing the diameter of the ring; fitting modified drafting
rollers and improved top arm and power driving tool (Motor) could be
attached and increase of spindle speed has been proved through
methodological design modification as discussed in this chapter.