

# A Review of Selection Process for Sewing Machine Operator

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**Abstract-** The garment industry in India has an overwhelming presence in the economic life of the country and it plays a pivotal role through its contribution to employment generation, industrial output and the export earnings of our country. The garment manufacturing industry has varied product range. To manufacture such various categories of products, the trained work force is required. Sewing machine operations convert a garment into three-dimensional shapes. It is one of the most important departments of any garment manufacturing unit due to maximum work content among all processes, dependency on skilled manpower in manufacturing and high capital investment. The majority of skilled manpower of a garment manufacturing unit require in the sewing section. The selection criteria are effective enough to be able to help the recruiters in selecting the trainees with correct dexterity and ability to perform the job at a required level. This review paper discuss about the different selection process of sewing machine operators.

**Keywords:** Garment manufacturing, Sewing machine operations, Selection criteria

## 1. INTRODUCTION

A sewing machine operation is any stitching or seaming activity that can be performed without taking out the fabric or cut panels from under the needle, so in this case if the operator stops sewing in between while keeping the needle in the fabric or cut panel and begins sewing operation again without losing the stitch, the entire process of sewing is known as an operation (Solinger, 1988). He has further mentioned that a sewing machine operator has to perform different types of tasks like an operation, a job, or a process. While Glock & Kunz has explained the sewing machine operation as one of the steps in garment manufacturing process that must be completed to convert material (fabric or cut panels) into stitched garments (Glock & Kunz, 2004). He has also added that the job consists of two or more sewing machine operations that are performed successively on the same machine.

The sewing machine operation is a sedentary occupation and the body parts used during sewing is fingers, wrist, forearm, upper arm, foot & ankle, knee & thigh and thoracic region (Solinger, 1988). The minimum leg requirements for sewing machine operation area right leg capable of doing the following: (1) right foot flexion; (2) right foot extension; (3) right thigh abduction. Stohlman (Stohlman, 1986) has mentioned total ten basic MTM motions i.e. reach, move, turn, apply pressure, grasp, position, release, disengage, eye travel & eye focus and body, leg & foot motions relevant for sewing machine operators.

The AAMT (Advance Analytical Methods of Training) training manual mentioned that training the operators who do not have the necessary aptitude for

the job is not viable and also it is not always possible to select sufficient operators of the desired caliber (KSA Technopak, 2008). It is essential that the selection criteria are effective enough to be able to help the recruiters in selecting the trainees with correct dexterity and ability to perform the job at a required level.

## 2. SELECTION PROCESS

The selection parameters for sewing machine operator are physical requirements, vision requirements, color blindness, spatial relationship, test of spatial relationship, physiological aspects, muscular movement, muscle tone, principles of posture, physical fitness, psychological aspects of sewing machine operation, the effect of emotion on muscle tone, time sense, sight reading & the pattern concept of sight reading (Solinger, 1988). Out of these seventeen parameters, some can be further clubbed, having similar attributes, i.e., vision requirements & color blindness, time sense & sight reading. Stitch world (Stitchworld, 2011) has combined several parameters under 3A's; Aptitude, Ability and Attitude to evaluate operator selection. Test for communication ability, numerical ability, spatial ability and shape test are part of aptitude test. While under ability test, there is two popular version of pegboard tests- PBDA & PBDB, ball & tube test, two arm coordination test, Purdue pegboard test, visual ability test, color perception test and threading needle exercise test. Attitude is tested through trainability test. Technopak (KSA Technopak, 2008) and IL&FS (IL&FS, 2014) also did mention manual dexterity tests- Pegboard (KSDA), Finger dexterity test- Peg Board (KSDB), Pinboard, Manual dexterity test- Ball & Tube/ Marble & tube, two arm coordination test-

Purdue peg board test, hand-eye coordination-Needle board, & sewing test.

While machine control and trainability falls under the category of physical requirement (Solinger, 1988), KSP - Visual accuracy & speed and color blindness test (KSA Technopak, 2008), (IL&FS, 2014) color perception test (Stitchworld, 2011) all can be put under the category of vision requirement and color blindness. The importance of spatial ability test are conducted in production, technical and design jobs where plans and drawings are used, and the purpose of the shape test is to analyze the intelligence and ability to establish spatial relationships (Solinger, 1988), (Stitchworld, 2011). Time sense & sight

reading test is a work cycle activity of anticipating, visualizing and planning the next phase of activity cycle in sufficient time (Solinger, 1988) while communication and numerical ability test (Stitchworld, 2011) talks about reasoning tests, designed to measure the candidate's problem-solving abilities and communication skills while numerical ability tests assess the mathematical abilities, as also the ability to use numbers in a logical and rational way. The selection tests can be categorized under the following chart, and each test is explained further in detail.

<b>Selection Attributes</b>	<b>Test Attributes</b>	<b>Prescribed test</b>
<b>Physical Requirement</b>	Manual dexterity (Speed of hand movements)	Peg Board- Kurt Salmon Dexterity test- A
	Finger Dexterity (Speed of finger movement)	Peg Board- Kurt Salmon Dexterity test- B
		Use of paper napkin
		Move on edges and points
	Hand and eye co-ordination test	Paste the parallel lines
		Marble & tube / Ball & Tube
		Pin boards
	Two arm co-ordination test	Needle Board
Sewing Test (If the operator is experienced)	Purdue pegboard test	
		Trainability tests
<b>Vision requirement and color blindness</b>	Visual accuracy, speed & color blindness test	Kurt Salmon Perception test- KSP
<b>Spatial relationship</b>	Distinguish the variations in geometric forms	Spatial Ability Test
<b>Shape test</b>	Analyze the intelligence and ability	Shape Test A
		Shape Test B
<b>Time sense &amp; Sight Reading</b>	Tempo, rhythm and sight reading	Sight reading
<b>Communication ability test</b>	Measure the candidate's problem-solving abilities and communication skills	Verbal critical reasoning test
<b>Numerical ability test</b>	Assess the mathematical abilities	Arithmetic operations
		Numerical reasoning tests
<b>Other factors</b>	Tracing the star	Trace the star pattern test
	Cut the number	The group embedded figure tests
		The arrow span test

Table 1. Selection tests (Source: Author's tabulation)

## **2.1 Physical requirements-**

There are two classes of physical elements- sight and body movements (Solinger, 1988) in which body areas used during the sewing operation cycle are- finger, wrist, forearm, upper arm, foot & ankle, knee, thigh and thoracic region. Flexion, extension, abduction and adduction are the movements that used mostly in sewing machine operations (Solinger, 1988). Technopak (KSA Technopak, 2008) in AAMT (Advance Analytical Methods of Training) has mentioned that dexterity tests in assessing finger dexterity and hand dexterity to check the speed of hand and finger movements respectively. It is further referred to by that these tests must be conducted and administered through a recognized and standardized procedure. The dexterity tests carried out for the operators are:

- Peg Board - KSDA (Hand & arm co-ordination, two-hand coordination)
- Peg Board - KSDB (Finger and wrist dexterity, two-hand coordination)

The peg board, pin board, marble and tube, needle board test as a part of the selection of sewing machine operators (IL&FS, 2014). The Marble and Tube test consist of an apparatus, which has a box with two compartments and a circular opening over the box. A tube is fitted to the box such that the opening of the box and the tube is in a straight line. There are 30 marble and 60 permissible cycles, so the slider of the box has to be moved after one cycle of 30 marbles. In needle and thread test, there is a board that has 15 needles the needles are separated by a distance of 4 inches apart. The eye of the needle is threaded such that the threading is guided through a pre-decided path. The target for each candidate is that he has to complete the threading of all 15 needles. These selection tests follow by personal interview and counseling session.

Keeping the above basic skills required in mind it becomes important to test the presence of these basic skills through some simple tests, which can be administered to both experienced as well as fresh candidates.

### **2.1.1 Manual dexterity (Speed of hand movements)**

#### **Peg Board- KSD-A**

This peg board test (also called Kurt Salmon Dexterity –A Type) is a board having 240 holes total with 30 holes in each row. Total 120 numbers of metal pegs are already inserted in holes of top four rows, away from the operator and bottom four rows (row number five to eight) of holes are empty. Board is placed with the long side facing operator and

operator has to pick two pegs by two hands simultaneously from extreme left and right of the first row, and insert the pegs in same columnar positions of the eighth row. The operator has to repeat same moving to next two pegs of the same row till the pegs in the first row are emptied onto the eighth row. Similarly, an operator has to complete the exercise emptying the pegs of 2<sup>nd</sup> row to 7<sup>th</sup> row, 3<sup>rd</sup> row to 6<sup>th</sup> row and 4<sup>th</sup> row to 5<sup>th</sup> row. If an operator completes the test within 75 sec, he/she secures the highest grade and if he/she takes more than 90 seconds candidate is considered lowest grade. The cut off time for a candidate to be selected should be between 81-86 seconds.

Technopak's peg board test KSD-A has 120 metal pegs, (KSA Technopak, 2008), whereas IL&FS peg board test has 100 pegs in a 10 by 10 grid hole. The Peg board test suggested by (IL&FS, 2014) is a square shaped board, divided equally into 4 square colored zones, each having space for 25 holes there are in all 100 holes. There are 100 pegs, which are bi-colored. 50 pegs are with 2 colors (Red & yellow) and the balance 50 with 2 colors (green & white). The colored part of the peg inserted into the respective color zone a straight-line pattern is followed that means if there is a peg which has red and green color the red colored part will go into the red part of the peg board. The insertions of the peg have to be one line wise; there has to be a line-wise order and are not supposed to be put randomly. The total time given for this test is 100 seconds, and the total number of pegs inserted is counted. Scoring is done, and each peg is given a certain weightage.



Fig. 1- Peg Board- KSD-A & B {Source- (KSA Technopak, 2008)}

### **2.1.2 Finger Dexterity (Speed of finger movement)**

#### **2.1.2.1 Peg Board- KSD-B**

This peg board test (also called Kurt Salmon Dexterity–B Type) is also having the similar configuration as Kurt Salmon Dexterity–A Type. The candidate has to follow the similar steps as Kurt Salmon Dexterity–A Type. The only difference is a half length of the pegs are painted red and while

picking the candidate to have to use thumb and index finger, flip the peg using the middle and index finger (in the air) and place the peg upside down in the same column as earlier. The peg board test procedure in this variation is same as the earlier one, only the candidate should turn the pegs in their hands before inserting them into the holes in the other half of the board; now red end of the peg should be inserted in the hole so that colour of top portion of the peg (which is white) is opposite of the color of the board (which is red). The number of pegs in the board is either 50 or 120. There is a minimum cut-off score for selection in this test.

#### **2.1.2.2 Use of paper napkin –**

Saini & Jana (Saini & Jana, 2012) has mentioned a total of 5 test for the selection of sewing machine operators. Out of 5 tests, use of paper napkin is one of them. The main aim of this test to check the ability is to separate fine plies, finger dexterity, visual accuracy, and speed. Two-dimensional fabric joined to form a three-dimensional garment. In the sewing operation, the first step is to pick up the two plies to be joined, aligning them in a position so that they can be joined and stitching them. These steps may vary from design to design but picking up the ply remain the same in one way or other. The characteristics checked for the ability is to check the separation of fine plies, finger dexterity, visual accuracy, and speed. In this test, the candidate has to pick 2 paper napkins separately and align it one over another. At last, candidate must complete the task by separating, aligning and placing the napkin. This test is time bound.

#### **2.1.2.3 Move on edges and points-**

The approach of the job training program set up by the war department in WW2, known as TWI (Training Within Industry) (Dinero, 2005). The sewing exercises have marked off sewing lines and have the operator trace them with the sewing machine. These don't have to be done on fabric at the outset; paper is a better medium so one can enlarge and photocopy these sheets. These practice sheets are designed for different functions. Some are designed specifically to teach positioning tempo, rhythm, and fluidity. Once the operator measure the success with these exercises, then training to specific jobs on fabric starts (Saini & Jana, 2012)

A total of 6 exercises has been developed. The first exercise is to check the accuracy in straight sewing lines, treadle (foot pedal) and braking control and to overcome from the fear of the machine. The second exercise reinforces the skills above and helps with coming to an accurate stop, manipulating the hand

#### **2.1.2.3 Paste the parallel lines-**

Saini & Jana (Saini & Jana, 2012) has also mentioned the selection test for paste the parallel line. The long-standing challenge was that a single piece of paper, no matter the size, cannot be folded in half more than 7 or 8 times. Although the maximum number of fold allowed in one direction is also more than 12, but the alignment and the evaluation process get hampered.

The graph paper is used for the purpose of the folding test. The small size, as well as large size graph paper, is used so that the ability to work on alignment with larger WIP as well as smaller WIP can be evaluated. During this test a candidate has to fold the ply using the given template and candidate has to repeat the process three times for each template. Time for the same is checked and recorded. Score sheet and weightage against this is assigned on the scale of 1 to 5 where 5 given for maximum point.

#### **2.1.3 Hand and eye co-ordination test**

##### **2.1.3.1 Marble & tube / Ball & Tube**

The Marble and tube test prescribed by IL&FS (IL&FS, 2014) consists of an apparatus, which has a box with 2 compartments and a circular opening over the box. A tube is fitted to the box such that the opening of the box and the tube is in a straight line. There are 2 sections in the box for the marbles. Marbles are placed in one section picked up and are inserted in the tube with one hand and guided to the opening of the box with the other hand such that the marbles should go into the hole on the top of the box and fall into the box. There are 30 marble and 60 permissible cycles, so the slider of the box has to be moved after one cycle of 30 marbles and here are 60 possible cycles. (KSA Technopak, 2008)'s ball & tube test has 25 balls of 11/16: diameter. During the test, these 25 balls should be placed on the right-hand side, and the left-hand side should be empty and covered with a perforated cover. The inverse applies for LH. Ability developed in this test are simultaneous use of hands and coordination of simultaneous movements. This test is frequently used by apparel industry to measure manual co-ordination together with finger dexterity. As mentioned by (Stitchworld, 2011) for this test 25 balls are kept in a tray alongside a vertically mounted hollow pipe of a slightly bigger diameter than the balls. The candidate is supposed to pick up the balls and drop them through the pipe with one hand and catch them with the other. The target time for this test is 25 seconds and tests should be carried out by the right hand and left hand separately. Here candidates are encouraged to use both hands simultaneously; while one hand is waiting to catch the ball, the other hand can be used to pick up the next ball. The minimum cut-off score for selection is 2-3. One somewhat similarly test also used is called the Box and Block Test (BBT), which requires moving

the maximum number of blocks, one by one, over the middle wall from one compartment of a box to another of equal size, all within the time frame of one minute. When testing begins, the candidate should grasp one block at a time with the dominant hand, transport the block over the partition and release it into the opposite compartment. The same should be repeated with the non-dominant hand, and after the completion of a minute, the blocks should be counted for recording the score.

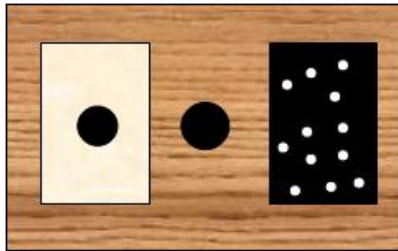


Fig-2 Ball & Tube {Source- (KSA Technopak, 2008)}

### 2.1.3.2 Pin boards

The Pin Board suggested by Technopak (KSA Technopak, 2008) & IL&FS (IL&FS, 2014) have a

series of holes, there are 5 holes in a row and there are 10 columns of such holes. Overall there are 50 holes. The candidate has to pick up 3 pins at a time and insert it in the hole. The candidate has to use only one hand for this purpose, and he cannot use both his hands. The candidate has to carry out the process step by step in a straight line. There are 50 possible cycles and the Time per cycle is 2.5 seconds. The total time given for this test to the candidates is 125 seconds and the weightage given is 0.5. (Stitchworld, 2011)'s pin board test is used to assess the ability of the candidate to do fine work with fingers to test the ability to make rapid finger movements, neatly, accurately and sensitively. Commonly known as the O'Connor Finger Dexterity Test after its developer and requires hand placement of 3 pins per hole. This test has been used successfully as a predictor for rapid manipulation of small objects, common in any assembly line work. The pin board has the total of 135 holes arranged in 9 rows and 15 columns. All the pins are placed in a small recess on one side of the board. The candidate should use only one hand and put all  $135 \times 3 = 405$  pins in the holes in the target time of 180 seconds.



Fig. 4- Pin Board (Source- { (Kurumer, Karabay, & Sever, 2011)}

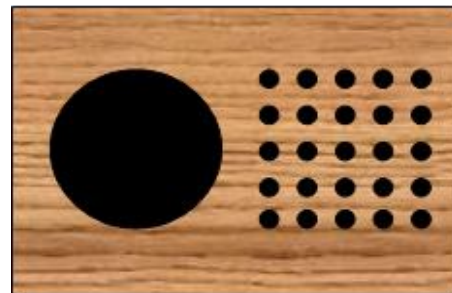


Fig. 5- Pin Board {Source- (KSA Technopak, 2008)}

### 2.1.3.3 Needle Board

Threading Needle Exercise Test is conducted to evaluate the candidate's hand steadiness of operator and eye-hand coordination, which are critical for quality performance 12 needles are positioned 6 inches apart on a rectangular base. The candidate must thread all 12 needles with one thread in such a way that three needles are threaded front to back, four needles are threaded right to left, and five needles are threaded left to right. This test is sometimes modified to put all needles in one direction. While different direction simulates different threading direction in different sewing machines (e.g. single needle lockstitch, overlock, and double needle lockstitch, etc.), left to right being the most important direction (Stitchworld, 2011).



Fig-6- Needle Board {Source- (KSA Technopak, 2008)}

Needle board test mentioned by (KSA Technopak, 2008) is done to test the hand-eye co-ordination of a candidate. The apprentice should sit facing the table at a comfortable height (see figure). The board should be placed in front of the apprentice. The thread is placed at the point of threading. The timekeeper starts the

chronometer. The thread is taken with the right hand. Thread the first needle. Thread the second, third, fourth, and fifth and sixth needles. Stop the chronometer. It has to make sure that make sure that all the needles have no sharp points and all of the eyes face the same direction. The needle protectors should be firm. While (IL&FS, 2014)'s needle board has 15 needles, the needles are separated by a distance of 4 inches apart. The eye of the needle is threaded such that the threading is guided through a pre-decided the path. The target for each candidate is that he has to complete the threading of all 15 needles. The time allowed for this is a total of 60 seconds, and the target is to complete 15 needle eyes. The scoring pattern is as given in Table 1 on page 14. There is a weight age of one mark per cycle.

#### **2.1.4 Two arm co-ordination test**

##### **Purdue pegboard test**

Purdue pegboard test comprises of two tests for testing a candidate's two arm coordination that too for executing intricate operations which require high level of concentration. The candidate has to use both his hands simultaneously and start by picking up a pin from the cup on his right with his right hand and at the same time picks up a pin from the cup on the left with their left hand, while placing the pins down the rows, beginning from the top. At the end of exactly 30 seconds, the numbers of needles inserted are counted, and the score is recorded. In the second test under this test battery, the candidate would have to complete an assembly of a pin, washer, collar and washer, in the same order under a period of 60 seconds. The score is calculated by counting the number of parts assembled. Since there are four parts in each assembly, if the subject made eight complete assemblies, the score is 8 multiplied by 4 (parts), or 32. The candidate would pick up a pin from the right-handed cup with their right hand and place it in the top hole in the right-handed row. As soon as the pin has been placed, pick up the washer with the left hand and place it over the pin. While the washer is being placed over the pin with the left hand, a collar is picked with the right hand and dropped over the pin. After placing the collar over the washer, pick up another washer with the left hand and drop it over the collar. This completes the first 'assembly', consisting of a pin, a washer, a collar, and a washer. While the final washer for the first assembly is being placed with the left hand, the second assembly is initiated immediately by picking up another pin with the right hand (Stitchworld, 2011).

#### **2.1.5 Sewing Test (If the operator is experienced)**

Sewing test is conducted for the candidate having some prior experience in the similar field. Trainability test is done for this purpose. Trainability test is intended to assess the ease with which a candidate can learn the type of skill required by the job. The test has been divided into two parts. The first part of a trainability test which consists of a carefully standardized process of instruction during which the trainer introduces a task, explains and demonstrates each step, for example how to pick up the two parts simultaneously, sewing start and end points, pivot points, number of sewing bursts in between, lifting of presser foot, cutting of thread, and disposing of. The task use to perform by the candidates once or twice while being coached. The second part is the actual test, when the candidate performs the tasks several times without any help.. The trainee will get three attempts and will be evaluated in the third try only. The trainer observes and uses a structured checklist to record errors. Towards the end of the performance period, the instructor rates the overall trainability of the candidate. Trainability tests are not only used as pass/fail selection instruments but it may also enable applicants to get the clearer understanding of the job in question. Separate trainability tests should be designed for specific skills, as it was seen during validation that no single test could predict for all skills (Stitchworld, 2011).

D'Alessandro (D'Alessandro, 1972) has also suggested the machine control test to test the experienced operators. This test is conducted to check how a candidate runs the machine during certain period. .

#### **2.2 Vision requirement and color blindness:**

Vision requirement and color blindness have explained that the ability to read and differentiate among variations in color- hue, value and intensity, geometric forms- linear, plane and solid contours-area and spatial relationships are important for sewing operators. Color blindness should differentiate color-hue, value and intensity (Solinger, 1988). The test to check the color blindness is KSP (Kurt Salmon Perception) test - Visual accuracy and speed & color blindness test (KSA Technopak, 2008), (IL&FS, 2014)'s color blindness test, color perception test (Stitchworld, 2011).

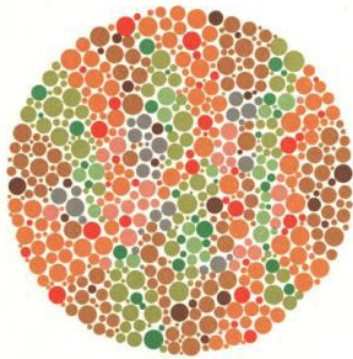


Fig.7- Color blindness test {(Source- (IL&FS, 2014)}

It has mentioned that after dexterity, the next most important requirement to work in the garment industry is visual accuracy of the operators. A paper having diagrams of entangled lines starting from 1 to 10 (similar to a snake and ladder format) at one end and the candidate has to move his finger (with pencil) on the corresponding line and mark the corresponding boxes at other end. There are two such forms A & B, the candidate would be asked to complete one practice sheet before starting on the other. The target time for completing both A & B test is 120 seconds and candidates are graded according to the number of correct boxes marked out of total 20, Grade 1 being the lowest score and grade 5 being the highest score. It has also mentioned that color is important for any worker entering the industry to have a strong perception of the same; hence a test is conducted to analyse the color sensitivity of the operator. Certain colors like red, green, blue and yellow cannot be distinguished by certain people due to inherited conditions. The test is carried out similar to color blindness test with the help of 5 color cards and a stopwatch. Some number, shape or letter is written in the card using multi-color dots (camouflaged), and the candidate has to tell the correct number or shape and also try to find the starting and end point of the dotted line in the card. The target time is of 15 seconds for all five cards. The candidate is graded from 1 to 5 based on the time taken, Grade 1 being the lowest score and grade 5 being the highest score and to be considered for selection the candidate needs to score 4-5 minimum. All have mentioned about checking color blindness of sewing operator (Stitchworld, 2011).

Visual accuracy and speed test developed by Technopak (KSA Technopak, 2008) has mentioned the purpose of this test is to know how fast one can use his/her eyes. On the left-hand side of the figure, ten squares numbered are mentioned from 1 to 10. From each of these squares, a line starts, crosses the

rectangle, and stops in one of the ten squares on the right-hand side of the figure. A candidate must follow each line in turn, and write the starting numbers into the right-hand square where the line stops a candidate must not follow the line with his/her pencil or fingers. Use only your eyes. It is possible that two lines stop in the same square. Test for color blindness (color vision deficiency) is a condition in which certain colors cannot be distinguished, and is most commonly due to inherited condition. Red/ Green color blindness is by far the most common form (about 99%), and this causes problems in distinguishing reds and greens. Another color deficiency Blue/Yellow also exists but is rare, and there is no commonly available test for it. It is advisable to take some advice from a doctor on how to carry out the test for color blindness. In short, the test for color blindness includes some figures or diagrams in various colors, which a color-blind person will not read or perceive the color. Color-blind people are not eligible for admission to the course. After the completion of filling up the forms, a set of dexterity tests has to be carried out. The enrolment has to be complete in all respects. There should be a firm insistence on a valid BPL number. Before carrying out the dexterity test the candidate should be informed that the test is to judge the basic level of coordination and it is not any examination of sorts. The candidate should be put at ease and should not panic or feel stressed. The way of doing the test should be explained properly; if needed a demonstration should be carried out on how the test is to be performed; it should be made sure that the candidates have correctly understood the way of doing the tests. However, do not give it as a practice before conducting the actual test because it may change some observations; please remember that the candidates have to be put under the same set of constraints. There are 4 tests for ascertaining the basic dexterity, which is aimed at checking the hand-eye coordination.

As mentioned by (IL&FS, 2014) color blindness or color vision deficiency is a condition in which certain colors cannot be distinguished, and is most commonly due to inherited condition. Red/ Green color blindness is by far the most common form (about 99%) and this causes problems in distinguishing reds and greens. Another color deficiency Blue/Yellow also exists but is rare, and there is no commonly available test for it. The test for color blindness has to be carried out as per the instructions are given in the Ishihara book, to test color blindness. It is advisable to take some advice from a doctor on how to carry out the test for color blindness. In short, the test for color blindness includes some figures or diagrams in various colors, which a color-blind person will not read or perceive the color. Color-blind people are not eligible for admission to the course.

### **2.3 Spatial relationship:**

Solinger (Solinger, 1988) has raised the importance of spatial relationship as it should distinguish the variations in geometric forms – like curvatures in lines at a distance of 15 to 20°. Test for spatial relationship inculcates to able to variations in length and space relationships. The distance is varied by the size of the operator and the details of the operation and work place. Some individuals cannot detect curvatures in lines unless the curvature is strongly pronounced. All line seems straight to them unless the line forms one of the following shapes: an angle approximately 160\* or less, an arc whose depth is at least one fifteenth the length of the line. Such individual makes poor operators. They cannot detect the quality defect in their sewing when they fail to use the attachments correctly. They may have 20/20 vision. They can easily identify letters, if they were shown two prints of the same letter of the alphabet that differ in line proportion and curvature, they would not be able to distinguish between the two proportions or curvatures.

Spatial ability is required in production, technical and design jobs where plans and drawings are used in engineering, architecture, surveying and design. These tests bear a superficial resemblance to abstract reasoning tests, as both types of question contain series of pictorial figures rather than words or numbers. However, spatial ability does not involve analysis and reasoning; it is purely a test of mental manipulation. Spatial ability questions often involve the visual assembly and the disassembly of objects that have been rotated, which are viewed from different angles or objects that have different

markings on their surfaces. Generally speaking, if the questions involve the manipulation of 2-dimensional objects, then they are probably fairly straightforward, but one will be challenged to answer them all in the given time. If the questions involve the manipulation of 3-dimensional objects, then many people find them extremely difficult. This is one skill which can be significantly improved with practice. These sample question papers each contain 45 questions and have a suggested time limit of 20 minutes each. The questions are presented in Letter/ A4 format for easy printing and self-marking (Stitchworld, 2011).

### **2.4 Shape test**

The purpose of the shape test is to analyze the intelligence and ability to establish spatial relationships, as in apparel industry, the cloth pieces have to be matched and placed on the machine rapidly and accurately. This test consists of test A and test B. In test A, the candidate has to place the shapes into the suitable spaces with one hand as soon as possible. B test contains half shapes of test A. Two hands can be used in test B. Performance of the candidate is determined by the time passed the test. Aptitude test measures the mathematical and practical intelligence of the candidate. These skills show the ability to evaluate the events systematically and noticing relationships among them. It is found that very few companies are carrying out aptitude tests and it is not considered a qualifier but only an indicator of the potentiality of the candidate. There is also debate on whether it should be the starting of the selection process or the final test after ability and attitude tests (Kurumer, Karabay, & Sever, 2011).



Fig.8- Shape test A {(Source- (Kurumer, Karabay, & Sever, 2011))}



Fig.9- Shape test B {(Source- (Kurumer, Karabay, & Sever, 2011))}

### **2.5 Time sense & Sight Reading**

Solinger (Solinger, 1988) has explained about the time sense one must be able to have a working awareness of three concepts- tempo, rhythm and sight



reading. Sight reading is a work cycle activity of anticipating, visualizing and planning the next phase of activity cycle in sufficient time to permit the doer to execute the next phase and its relationship in preceding phase with proper phase requirement. It is mantle process. A skillful operator can pickup and preposition the next piece for sewing, while the present piece is being sewed, without disturbing the desired rhythm or tempo of the sewing cycle. The pattern concept of sight reading- sight reading is based on pattern concept. The good sight reader can see, grasp and mentally retain large patterns regardless of whether the patterns are formed by music notations or fabric contours and sewing guides. He has also explained about the muscular memory as the ability to execute a motion pattern without conscious control. The operator must be able to work harmoniously with her/ his colleagues and supervisors as well as with the machine, materials and physical conditions of space, sound, light, and temperature that sounded the occupation.

## **2.6 Communication ability test**

This test comprises of reasoning tests, designed to measure the candidate's problem-solving abilities and communication skills (Stitchworld, 2011). Verbal critical reasoning questions assess the candidate's ability to use words in a logical way. These questions may take the form of comprehension exercises, which are straightforward or more complex statements where the best tactic is to make notes about what you can deduce from each part of the text. These tests usually consist of 10 to 15 questions which need to be completed in 20 to 30 minutes and are designed to test your reasoning ability rather than your facility with the language. The questions measure the understanding of vocabulary, class membership and the relationships between words. Some questions measure the ability to perceive and understand concepts and ideas expressed verbally. While these questions are designed to measure reasoning ability rather than educational achievement, it is recognized that verbal reasoning test scores are influenced by educational and cultural background

## **2.7 Numerical ability test**

Numerical ability tests assess the mathematical abilities, as also the ability to use numbers in a logical and rational way (Stitchworld, 2011). The test can be divided into tests of simple numeracy, where the candidate is told which arithmetic operations to apply, and numerical reasoning tests where candidates are presented with some data and questions but the methods required to answer the questions are not specified. The score in the simple speed tests will be very much influenced by the candidate's ability to

add, subtract, multiply and divide quickly and accurately.

Numerical Reasoning questions assess their ability to use numbers in a logical and rational way. The questions require a basic level of education to successfully complete and are therefore measuring numerical ability rather than educational achievement. The questions measure their understanding of things such as number series, numerical transformations, the relationships between numbers and the ability to perform a numerical calculation.

## **2.8 Other factors:**

Solinger (Solinger, 1988) has mentioned the physiological aspects as criteria for selection of sewing machine operators; however, no known tests are found to be in practice checking this issue. He has further mentioned about the importance of muscular action for body and limb muscular movement & muscle tone for sewing machine operators. Solinger also emphasized the important of the correct posture of sewing machine operators. Three types postures that operators must minimize occurrence are [1] postures which twist the muscle, [2] postures which press or push the muscles against some skeletal member or outside object and rigid posture in which both the reciprocal muscles, the antagonists and protagonists are contracting at the same time with great strength, creating a state of equilibrium in the skeletal member they can move. These factors although important, are not susceptible to standardization regarding degrees of health and physical fitness, hence currently are not part of any selection tests. (Solinger, 1988) mentioned about the requirement of physical fitness for the sewing machine operators. Physical fitness refers to the ability of the individual to do that job at a given pace for particular period without injury to the body.

(Solinger, 1988) has also explained the importance of psychological aspects of sewing machine operations as it is related to physiological aspects. Relaxation is controlled physiologically to a great extent by posturing, muscular relaxation. Elements of relaxation are muscle tone, tenseness and tension. He has further mentioned about the effect of emotion on muscle tone as the degree of tent reading senses and rigidity varies. The mind can make some of the muscles to tense (stiffness) or to release at will.

**2.8.1 Tracing the star-** There is a kind of memory that is largely unconscious, but very important (Saini & Jana, 2012). We learn and remember essential skills, such as walking, using chopsticks or riding a bicycle. The mirror tracing activity is visual and motor test that involves learning a new motor skill. The task requires moving a pencil to trace the diagram

of a star while looking at your hand only as a reflection in a mirror. The act of drawing is a learned skill that requires visual and proprioceptive feedback to control muscle movement. Proprioception is a special sense that tells one's brain, the position of various parts of his/her body and is used here for assessment. The characteristics checked during this test are proception ability, ability to learn a new motor skill, cognition, sensory and muscular activity. The candidate has to trace the star pattern looking at mirror tracing clockwise and counterclockwise and decide which feels most comfortable. In this test candidate can use either hand or use the most comfortable combination i.e. left-handed clockwise and so on. The candidate will get the time to practice the sheet without the mirror. 1 small trial will be given for demonstration purpose after that a total of 4 trials for evaluation purpose. During the evaluation, the error will be captured if candidate touches a line. This is a time bond test weightage will be allocated on the scale of 1 to 4, where 4 in the case if a candidate has taken least time.

## **2.8.2 Cut the number-**

**2.8.2.1 The group embedded figure tests** (Oltman, Ruskin & Wiltkin, 1971) measures ability to encode a spatial pattern and recognize it in a complex figure. In this test, participants are given a sheet showing several simple 2-D geometric figures. On each trial, they are shown a complex 2-D figure, and their task is to locate the simple figure within the complex figure and to trace it in pencil. There are three sections with 9 items each for which participants are allocated 5 min a piece.

**2.8.2.2 The arrow span test** (Shah & Miyake, 1996) measures the ability to maintain spatial information in working memory. This test was presented on a computer compatible with 486 computers running MEL software. On the each trial a set of arrows was presented on the computer screen, one at a time, in one of the eight possible directions.

Apart from this, it was also discussed to find out the maximum working area using anthropometric data, designing for the average, designing for adjustability, percentiles and designing dimensions (Saini & Jana, 2012). During use of anthropometric data person's body dimensions and proportion like body size varies with age, gender, nationality, ethnic origin, occupation, etc. has been taken into consideration. For example, truck drivers tend to be larger males. The allowance has to be made if special clothing or person protection equipment needs to be wear.

For the designing for the average, it is important to realize that there is no average individual. A person can be average for one or two body dimensions i.e. arm

length, height, etc. designing for the average is often seen as a bad design as it only accommodates 50% of a population, however, there are few cases where it appropriates. For the designing for adjustability, wherever it is possible, it is best to design for adjustability into any workplace. An example is the interior of a car where the driver's sheet has height adjustment and forward and backward adjustment to comfortably fit as many users as possible. While percentiles are shown in anthropometry tables and tell the measurement given in the tables relates to the average person or someone who is above or below average in a certain dimension. Next one is designing dimensions. In some situations, a specific dimension of workspace layout becomes the limiting factor that may restrict the use of the workspace for some people. This limiting factor can either be designing for the minimum or maximum value for a population, depending upon what is required. The design for the minimum population when the minimum value (lowest) of the feature has to accommodate all user. For example, control should be within reach of the smaller operator. The design for the maximum population is the case, when the maximum value (highest) of a feature has to accommodate all users. For example, the height of a doorway should allow all users to pass through without stopping and banging their heads. It is now practice to design the layouts for all users. Next one is finding the size of the letter a normal human being see, while sitting. The size of the letter is derived from the near vision test card released in public domain, by choosing the appropriate distance of testing.

Visual workplace-we alter our direction of gaze by moving our eyeballs within their sockets and by moving our head. It is good to have some movement of the head during work in order not to tire the neck muscles.

Vision acuity- a major difference between topography and vision science is the reliance of topographers on the physical size of type on the page and the reliance of vision scientists on angular size of print (often measured in minutes of arc or degree of visual angle). The angular measure depends on both the physical size of the print and the subject's viewing distance. Angular size is preferred by vision scientists because it determines retinal image size. Topographers measure physical type size to determine how many text characters fit in a line, column, page or screen of fixed dimensions and also to estimate apparent character size at a typical viewing distance. The characteristics checked for speed test, visual accuracy, reaction time, muscular activity, hand-arm movement. Evaluation for this test is done based on a table between time and weightage. Maximum 20 points can

be assigned for the completion of test less than 2.3 minutes.

### **3. FINDINGS**

Selection tests mentioned by individual consultant/authors, training and/or consulting organizations and training institutes are elaborated one, and the various forms of dexterity and hand-eye co-ordination test are still popular among established apparel manufacturers. Most of the selection tests emphasize on the physical requirement. While the tests for physical requirement mention the cut off limit, none of these have any mention about the weightage of each test to be taken during the final selection (KSA Technopak, 2008), IL&FS (IL&FS, 2014). The literature does not mention the sequence at which the tests to be carried out on a subject, if any. Neither it is clear from the literature whether all the tests are required to be carried out on each subject nor any minimum number prescribed, if any. Except for Saini & Jana no test was found that address the important skill of separating plies while picking up a limp piece of fabric from a stack of plies (Saini & Jana, 2012). There is also lack of information about the relation between the type of selection test being carried out and the ability of developing sewing skill, if any.

### **REFERENCES**

1. Dinero, D. (2005). *Training Within Industry: The Foundation of Lean*. Newyork: Productivity Press.
2. Glock, R. E., & Kunz, G. I. (2004). *Apparel Manufacturing Sewn Product Analysis* (4th ed.). (4th ed.). Prentice Hall.
3. IL&FS. (2014). *Trainer's Manual*. New Delhi: IL&FS.
4. KSA Technopak. (2008). *Advance Analytical Method of Training Manual*. Gurugram (NCR): Technopak Advisors Pvt. Ltd.
5. Kurumer, G., Karabay, G., & Sever, S. (2011). A research on workers selection and training in apparel industry. *Journal of Textile and Apparel*, 171-175.
6. Oltman P. K., Ruskin E., Witkin R. A. (1971). *Group Embedded Figures Test*. Palo Alto, CA: Consulting Psychologist Press.
7. Saini, L., & Jana, P. (2012). To design a recruitment test for the sewing operator. NIFT, Department of Fashion Technology. Delhi: National Institute of Fashion Technology.
8. Shah, P., Miyake, A., 1996. The separability of working memory resources for spatial thinking and language processing: An individual differences approach. *Journal of Experimental Psychology*.
9. Solinger, J. (1988). *Apparel manufacturing handbook- Analysis, Principles, and Practices* (2nd ed.). Bobbin Blenheim Media Corp.
10. Stitchworld. (2011, October). *The 3As of Operator Selection Evaluate Aptitude, Ability and Attitude*. Stitchworld.
11. Stohlman, D. G. (1986). *Sewing - Performance and Methods- Analysis*. Columbia, South Carolina: Bobbin International, Inc.