International Journal of Textile Science 2019, 8(1): 16-25
DOI: 10.5923/j.textile.20190801.03

The Optimization of Knitted T-Shirt for Rapid Production Process

Asif Shahriar

Department of Textile Engineering, Daffodil International University, Dhaka, Bangladesh

Abstract This study is based on calculation of standard minute value (SMV) of T-shirt by determining the manpower and machine allocation for particular target. It seems that there are some differences between target production and actual production. In some cases target production was higher than that actual production while in some cases the other way round .i.e. actual production was higher than target production. It may also happed due to wrong data that lead to calculation of target production. It was also observed that SMV of a T-shirt increased in terms of decorative garments and there is a decrease of productivity. On the other hand SMV was relatively for the less decorative garments so that their productivity increased.

Keywords SMV, T-Shirt, Operation Breakdown, Work Study, Line Balancing

1. General Introduction

A **T-shirt** (or **T shirt**, **tee-shirt**, or **tee**) is a style of shirt. A T-shirt's defining characteristic is the T shape made with the body and sleeves. It is normally associated with short sleeves, a round neck line known as a "crew neck", and no collar.

Typically made of cotton fibers knitted in a jersey stitch, they have a distinctive soft texture compared to woven shirts. The majority of modern versions have a body made from a continuously woven tube, on a circular loom, so that the torso has no side seams. The manufacture of T-shirts has become highly automated, and may include fabric cutting by laser or water jet.

The T-shirt evolved from undergarments used in the 19th century, through cutting the one- piece "union suit" underwear into separate top and bottom garments, with the top long enough to tuck under the waistband of the bottoms. With and without buttons, they were adopted by miners and stevedores during the late 19th century as a convenient covering for hot environments.

Objects of the Project Work

- To calculate the SMV of T- shirt.
- To determine line balancing
- To determine operational sequence of the manufacturing process of T-shirt
- To develop the target of the manufacturing process
- To increase the productivity of the company
- To make proper distribution of SMV
- To make better utilization of man, machine and materials

2. Methodology

Production of a Knit T-shirt

In sewing section there are various types of product are produced such as T-shirt, polo shirt, tang top, Hollywood style, jersey top, jacket, hoody jacket, under wear, trouser, sportswear, swimming wear and so on. The production details of a knit T-shirt is given below'

Tools used in Cutting Section:

- ✓ Pattern paper
- ✓ Measuring Tape
- ✓ Scissor
- ✓ Pencil
- ✓ Eraser
- ✓ Curve Ruler

Method of making t-shirt:

First of all a pattern is required. This was adopted from an existing shirt. A size 4 t-shirts sample from vintage sew for Toddler was used. The patters of the sample were adopted from the pattern book available in Knit Asia ltd. The patterns were then traced onto freezer paper. It can be seen on close looking that the wrong size was traced first. What happened there is not rembered by me but it was one of the two tracings I have of this pattern. Front, back, sleeve and background- these are the 4 pieces my pattern has.

* Corresponding author:
asifshahriar25@gmail.com (Asif Shahriar)
Published online at http://journal.sapub.org/textile

A pretty big piece of fabric is owned by me, so to waste the least amount of fabric and also be able to manage the whole thing one pattern piece was cut out by me at a time. The front is started first – the center from the edge needs to be on placed on the fold of the fabric. By looking closely at the fabric it is made sure by me that tiny knit stitches are running straight (not at an angle) with fold line. Also, the stretch of this fabric is going up and down in the photo, or across the body of the t-shirt front and back pattern pieces. Your knits are wanted to be cut out with the stretch going the right way.

Then the same is done with back by me. First the small amount of scrap is cut off from the front and the fabric was refolded wide enough to do the back. Here my cute pattern weights can be seen. My patterns are not pinned by me- pattern weights and rotary cut around the edges of the patterns can be seen. Scissors can be used in absence of rotary cutter. My scissors need to be sharpened and a new rotary blade is needed- cutting this out wasn't as easy and fun as it should have been.

The sleeve is again refolded; so enough width to lay out the sleeve pattern is available. Can the long straight line be seen? It's the pattern grain line and should line up with the grain of the fabric. In other words, line up with straight up and down lines of knitted stitches in the fabric. If a t-shirt was found twisting around your body when you were wearing it- it was cut off again. It's not hard to make sure your fabric and patterns are on grain when you're cutting.

Neckline ribbing- this fabric is laid out with the stretch going left to right. The pattern piece is laid on the fold. A cotton/lycra rib knit is used for this piece, if main shirt fabric is ribbed or fairly stretchy, the same fabric can be used for the neckline. This shirt fabric is a jersey that's not really stretchy enough to go over my boy's head and not have stitches pop right away.

Sewing:

Sewing step 1: Place front and back pieces together with right sides facing. Match the pieces up at the shoulder and pin them if you want. Here they are serged together. Before I had a serge I would sew the seam, then zigzag the edges together because I don't like unfinished edges.

Sewing step 2: Pin the top center of the sleeve to the shoulder seam.

Pin the front and back edges of the sleeve seam. This is kind of difficult to show in a photo.

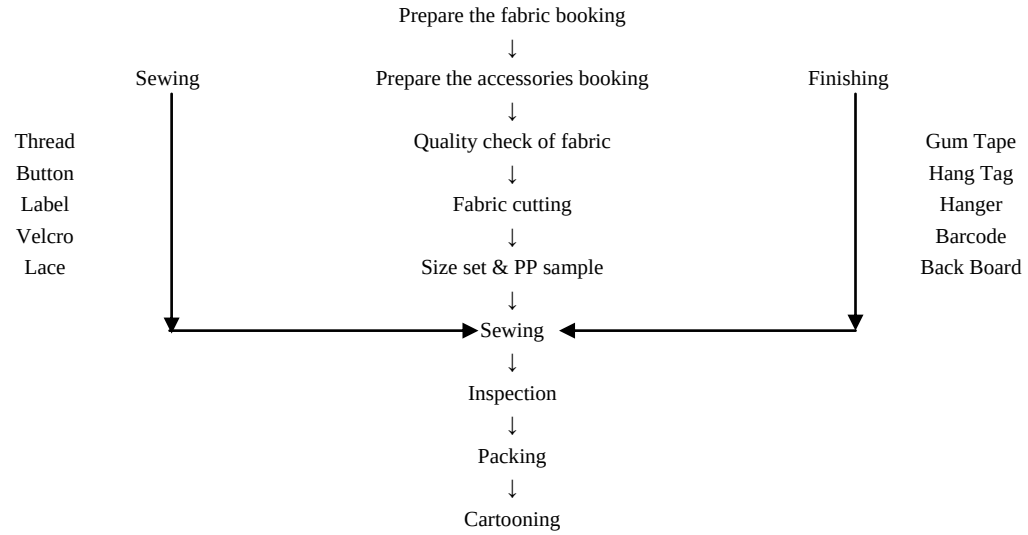
Sewing step 3: Fold the shirt so the front and back line up and the sleeve edges line up. Starting at the sleeve hem edge, and all at once, sew the sleeve edges together, then the front and back together at the sides. Do both sides.

Sewing step 4: Sewing the neckband on is explained here in T-shirt.

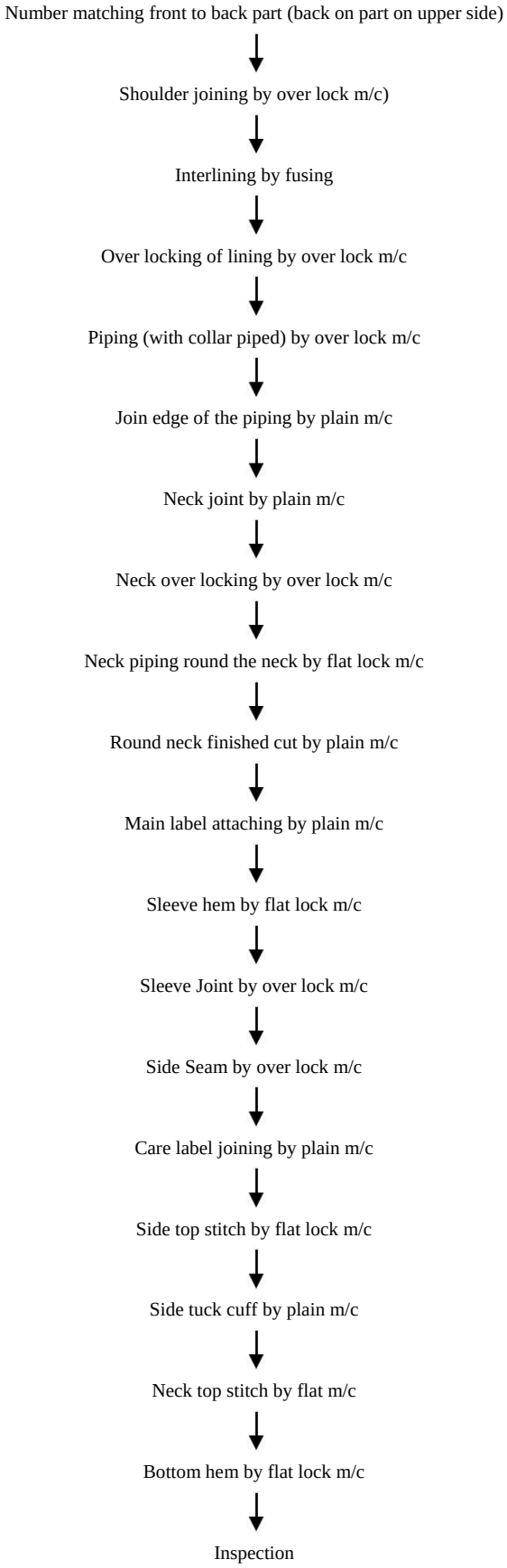
Sewing step 5: Fold the sleeve edges and bottom edge up once and stitch in place. I have a "why you don't need a free arm to sew hems of small sleeves".

To make a T-shirt Single jersey knitted fabric for body, Rib for neck, Sewing thread, Pattern paper, Measuring Tape, Scissor, Pencil, Eraser, Curve Ruler etc are required. The various component of a T-shirt are neck, front part, back part, sleeve and hem.

Flow Chart of Making T-shirt



MACHINE SEQUENCE OF T-SHIRT MANUFACTURE PROCESS:



Study on T-Shirt:

Figure of T-Shirt (Item-1)

Sketch of T-shirt (A)

Sketch of T-shirt (B)

Target Efficiency

Every garments factory has a policy to have the idea about target efficiency in advance. In fact this gives an opportunity to get the idea about time required to get certain production in advance. In table-1 the target efficiency for various SMV is given.

Table 1. SMV Wise Target Efficiency

SMV	Product Type	Target efficiency
Less than 7	Basic	75%
8-14	Semi-Critical	60%
More than 14	Critical	50%

Table 2. Operation Bulletin

BUYER : LIDL

ITEM : BOY -T SHIRT

S T Y L E LHK-86542

OP	MACHINE	OPERATION DESCRIPTION	SMV	Manpower	TGT/operator	TOTAL TGT
1	4OL	SHOULDER JOIN ONE SIDE	0.18	1.0	326	326
2	HP	SHOULDER PALACKET & RIB	0.69	3.0	87	261
3	SNLS	RIB BOTH SIDE STITCHING	0.23	1.0	261	261
4	SNLS	NECK TUCK WITH PLK	0.64	2.0	93	186
5	HP	THREAD CUT & CHECK	0.34	1.0	178	178
6	4OL	NECK JOIN	0.25	1.0	245	245
7	FL	BACK PIPING & CUT	0.28	1.0	217	217
8	SNLS	PIPING CLOSING TUCK & EXCESS	0.20	1.0	301	301
9	SNLS	PLACKET CLOSE	0.37	2.0	163	326
10	FL	FRONT NECK T/S	0.20	1.0	301	301
11	HP	THREAD CUT & LABEL MARKING	0.18	1.0	326	326
12	SNLS	BACK TAPE T/S with label	0.28	1.0	217	217
13	SNLS	SHOULDER PLK INNER TACK	0.23	1.0	261	261
14	FL	SLEEVE HEM	0.28	1.0	217	217
15	HP	THREAD CUT & FOLD	0.18	1.0	326	326
16	HP	SLD SCISSORING	0.23	1.0	261	261
17	HP	SLEEVE & BODY MACHING	0.25	1.0	245	245
18	4OL	SLEEVE JOIN	0.52	2.0	115	230
19	HP	THREAD CUT & FOLD	0.23	1.0	261	261

20	4OL	SIDE SEAM	0.49	2.0	122	245
21	HP	THREAD CUT & FOLD	0.25	1.0	245	245
22	FL	BODY HEM	0.29	1.0	206	206
23	HP	THREAD CUT & FOLD	0.21	1.0	280	280
24	SNLS	SLV INSIDE & OUTSIDE TACK	0.35	1.0	170	170
25	SNLS	LABEL STITCHING	0.34	1.0	178	178
26	BH	BUTTON HOLE	0.26	1.0	230	230
27	HP	BUTTON MARK	0.20	1.0	301	301
28	BA	BUTTON ATTACH	0.23	1.0	261	261
29	HP	BUTTON INSERT	0.28	1.0	217	217
30	HP	FINAL THREAD CUT	0.35	1.0	171	171
TOTAL	M/C-22	HP-14	SMV 9 .00	36	Actual Production/Hr	170

Calculation of Target/hrs

Formula:

60% Efficiency Target= Manpower X Working Minute X Expected Efficiency Percentage/SMV

60% Target = 60 X 36 X 0.60/ 9.00 =144
Where, 1hrs=60 min
Total Manpower = 36
Expected efficiency =60% SMV=9.00
Per hrs target = 144

Table 3. Summary of man, machine, SMV, target per /hrs & expected efficiency

M/C:	SNLS	SNCS	OL4	OL5	KAN	FOA	BA	BH	BT	FL
SMV:	2.64	0.00	1.44	0.00	0.00	0.00	.23	.26	0.00	1.05
QTY:	10	0	6	0	0	0	1	1	0	4

	OPERATOR	HELPER	TOTAL
Summary	22	14	36
	TTL S.M.V		9.00
	TARGET/HR	60%	144
	ACTUAL PRODUCTION /HR	71%	170

Where, SNLS=Single needle lock stitch.
SNCS=Single needle chain stitch.
4OL= Four thread over lock FL=Flat lock
OP=Operator HP=Helper
AML=Allocate man level TGT=Target
HR=Hour BH=Button hole BA=Button attach BT=Bartack KAN=Kansai

Study on T-Shirt

This T-shirt make S/J fabric & operation bulletin make man, machine, SMV, target per/hrs & expected efficiency. Where this t-shirt order from buyer – artsana, style no -26018.

Figure of T-Shirt (Item-2)

Sketch of T-shirt (A)

Sketch of T-shirt (B)

Target Efficiency

Every garments factory has a policy to have the idea about target efficiency in advance. In fact this gives an opportunity to get the idea about time required to get certain production in advance. In table-1 the target efficiency for various SMV is given.

Table 1. SMV Wise Target Efficiency

SMV	Product Type	Target efficiency
Less than 7	Basic	75%
8-14	Semi-Critical	60%
More than 14	Critical	50%

Table 2. Operation Bulletin

BUYER ARTSANA
ITEM : GIRLS L/S LVT-SHIRT
S T Y L E 26018.00
G S M 160

OP NO.	MACHINE	OPERATION DESCRIPTION	SMV	M/P	TGT/OP	TOTAL TGT
1	OL4	SLV JOIN WITH BACK & FRONT PART	0.95	3.0	63	189
2	HP	BACK & FRONT PART MATCHING	0.29	1.0	206	206
3	SNLS	LABEL STITCHING	0.15	1.0	391	391
4	HP	PLKT LINING & FUSING	0.21	1.0	280	280
5	OL4	PLKT OVERLOCKING & MARKING	0.18	1.0	326	326
6	OL4	NECK & SLV OVERLOCKING	0.48	2.0	126	252
7	HP	BODY MARKING FOR PLKT JOIN	0.26	1.0	230	230
8	OL4	FRILL OVERLOCKING	0.34	1.0	178	178
9	HP	FRILL SIZE WISE CUT	0.21	1.0	280	280
10	SNLS	FRILL TUCK	0.29	1.0	206	206
11	SNLS	FRILL JOIN ON NECK	0.97	3.0	62	186
12	FL	FRILL T/S	0.37	1.0	163	163
13	HP	THREAD CUT	0.21	1.0	280	280
14	HP	PLKT MATCHING WITH BODY	0.21	1.0	280	280
15	SNLS	PLKT JOIN & 1/16 T/S	0.43	2.0	140	280
16	HP	BODY SCISSORING	0.25	1.0	245	245
17	SNLS	LABEL JOIN	0.18	1.0	326	326
18	SNLS	PLKT CLOSE	0.29	1.0	206	206
19	SNLS	LABEL JOIN	0.29	1.0	206	206
20	SNLS	PLKT BINDING TUCK	0.34	1.0	178	178
21	SNLS	FRILL JOIN ON SLV	1.23	3.0	49	147

22	HP	THREAD CUT	0.26	1.0	230	230
23	FL	FRILL T/S	0.34	1.0	178	178
24	HP	THREAD CUT	0.20	1.0	301	301
25	SNLS	SLV INSIDE TUCK	0.57	2.0	106	212
26	OL4	SIDE JOIN	0.52	2.0	115	230
27	HP	THREAD CUT	0.21	1.0	280	280
28	FL	BODY HEM	0.31	1.0	196	196
29	HP	THREAD CUT	0.20	1.0	301	301
30	HP	BUTTON MARK & INSERT	0.43	2.0	140	280
31	SB	BUTTON ATTACH & INSERT	0.49	2.0	122	245
32	FL	BOW PIPING & SIZE WISE CUT	0.28	1.0	217	217
33	SNLS	PIPING OUTSIDE TUCK & CUT	0.35	1.0	170	170
34	HP	BOW MAKE	0.69	2.0	87	174
35	HP	BODY MARKING FOR BOW ATTACH	0.21	1.0	280	280
36	SNLS	BOW JOIN	0.28	1.0	217	217
37	HP	FINAL THREAD CUT	0.84	2.0	71	142
TOTAL	M/C-33 HP-18		SMV 14.32	M/P-51	Actual Production per Hr	120

Calculation of target/hrs:

Formula:

55% Efficiency Target= Manpower X Working Minute X Expected Efficiency Percentage/SMV

55% Target= 60 X 51 X 0.55/ 14.32
=118
Where, 1hrs=60 min
Total Manpower = 51
Expected efficiency =55% SMV=14.32
Per hrs target = 144

Table 3. Summary of man, machine, SMV, target per /hrs & expected efficiency

MC:	SNLS	SNCS	OL4	OL5	KAN	FOA	BA	BH	SB	FL
SMV:	5.37	0.00	2.47	0.00	0.00	0.00	0.00	0.00	0.49	1.29
QTY:	18	0	9	0	0	0	0	0	2	4

Summary	OPERATOR	HELPER	TOTAL
	33	18	51
	TTL S.M.V		14.32
	TARGET/HR	55%	118
	ACTUAL PRODUCTION/HR	56%	120

Where, SNLS=Single needle lock stitch. SNCS=Single needle chain stitch. 4OL= Four thread overlock
FL=Flat lock OP=Operator
HP=Helper
AML=Allocated man level TGT=Target
HR=Hour BH=Button hole BA=Button attach BT=Bartack KAN=Kansai

Study on T-shirt

This T-shirt make S/J fabric & operation bulletin make man, machine, SMV, target per/hrs & expected efficiency. Where this t-shirt order from buyer – artsana, style – 26013.

Figure of T-Shirt (Item-3)

Sketch of T-shirt (A)

Sketch of T-shirt (B)

Target Efficiency

Every garments factory has a policy to have the idea about target efficiency in advance. In fact this gives an opportunity to get the idea about time required to get certain production in advance. In table-1 the target efficiency for various SMV is given.

Table 1. SMV Wise Target Efficiency

SMV	Product Type	Target efficiency
Less than 7	Basic	75%
8-14	Semi-Critical	60%
More than 14	Critical	50%

Table 2. Operation Bulletin

BUYER ARTISANA ITEM : T-SHIRT

STYLE 26013

OP NO.	MACHINE	OPERATION DESCRIPTION	SMV	MAN POWER	TGT/operation	TOTAL TGT
1	OL4	SHOULDER JOIN & THREAD CUT	0.23	1.0	261	261
2	HP	BODY MARKING FOR FRILL JOIN	0.38	1.0	157	157
3	SNLS	FRILL MAKE	0.34	1.0	178	178
4	SNLS	LEFT SIDE FRILL JOIN	1.06	3.0	57	170
5	SNLS	RIGHT SIDE FRILL JOIN	1.06	3.0	57	170
6	HP	PLACKET LILING & FUSING	0.23	1.0	261	261
7	OL4	PLACKET OVERLOCKING	0.20	1.0	301	301
7	HP	PLACKET MARKING	0.21	1.0	280	280
8	HP	BODY MARKING FOR PLACKET JOIN	0.25	1.0	245	245
9	SNLS	PLACKET JOIN	0.35	1.0	170	170
10	HP	BODY SCISSORING	0.25	1.0	245	245
11	SNLS	PLACKET LOWER SIDE CLOSE	0.28	1.0	217	217
12	SNLS	PLACKET BINDING	0.31	1.0	196	196
13	HP	LILING ATTACH ON NECK	0.18	1.0	326	326
14	HP	NECK FOLDING	0.21	1.0	280	280
15	OL4	NECK OVERLOCKING	0.20	1.0	301	301
16	HP	PLACKET MARKING	0.21	1.0	280	280
17	HP	NECK MARKING	0.20	1.0	301	301
18	SNLS	NECK TUCK	0.31	1.0	196	196
19	FL	NECK JOIN	0.29	1.0	206	206
20	SNLS	PLACKET CLOSE	0.31	1.0	196	196
21	SNLS	LABEL STITCHING	0.18	1.0	326	326
22	SNLS	LABEL JOIN	0.21	1.0	280	280

23	HP	SLV & BODY MATCHING		0.26	1.0	230	230
24	OL4	SLV JOIN		0.49	2.0	122	245
25	HP	THREAD CUT		0.20	1.0	301	301
26	OL4	SIDE JOIN		0.61	2.0	98	196
27	HP	THREAD CUT		0.21	1.0	280	280
28	FL	SLV HEM		0.43	2.0	140	280
29	HP	THREAD CUT		0.25	1.0	245	245
30	FL	BODY HEM		0.28	1.0	217	217
31	HP	THREAD CUT		0.20	1.0	301	301
32	BH	BUTTON HOLE		0.28	1.0	217	217
33	HP	BUTTON MARKING		0.23	1.0	261	261
34	BA	BUTTON ATTACH		0.29	1.0	206	206
35	HP	BUTTON INSERT		0.31	1.0	196	196
36	HP	FINAL THREAD CUT		0.58	2.0	103	206
TOTAL	M/C-27	HP-18	SMV	-12.07	45	Actual Production / Hr	130

Calculation of Target/hrs-

Formula:

60% Efficiency Target= Manpower X Working Minute X Expected Efficiency Percentage/SMV

60% Target= 60 X 45 X 0.60/ 12.07
=134 Where,
1hrs=60 min
Total Manpower = 45 Expected efficiency =60%
SMV=12.07
Per hrs target = 134

Table 3. Summary of man, machine, SMV, target per/hrs & expected efficiency

MC:	SNLS	SNCS	OL4	OL5	KAN	FOA	BA	BH	SB	FL
SMV:	4.40	0.00	1.73	0.00	0.00	0.00	0.29	0.28	0.00	1.00
QTY:	14	0	7	0	0	0	1	1	0	4

Summary	OPERATOR	HELPER	TOTAL
	27	18	45
	TTL S.M.V		12.07
	TARGET/HR	60%	134
	ACTUAL PRODUCTION/HR	58%	130

Where, SNLS=Single needle lock stitch. SNCS=Single needle chain stitch. 4OL= Four thread overlock
FL=Flat lock OP=Operator
HP=Helper TGT=Target
HR=Hour BH=Button hole
BA=Button attach BT=Bartack
KAN=Kansai FOA=Feed of the Arm

Table 4. Summary of production details of the three garments

SL NO	Items	Fabric	GSM	Operators	Helpers	SMV	Target Efficiency	Target per hrs	Actual Production per hrs	Actual Production Efficiency
1	T-shirt	S/J	160	22	14	9.00	60%	144	170	71%
2	T-shirt	S/J	160	33	18	14.32	55%	118	120	56%
3	T-shirt	S/J	180	27	18	12.07	60%	134	130	58%

3. Results & Discussion

Explanation for Different Target Efficiency

Basic Type Items

It can be seen in tables 1, 2, 3 that the number of processes are less than that of semi-critical and critical type product. The tables also show that the time required for machine setup and technical support are less than semi-critical and critical type product. It is also seen in that tables the time for products are also less than semi-critical and critical type product.

Semi-Critical Type Items:

It can be seen in tables 1, 2, 3 that the number of processes are more than basic type product. The tables also show that the time required for machine setup and technical support are more than basic type product. It is also seen in that tables the time for products are also less than basic type product.

Critical Type Items:

It can be seen in tables 1, 2, 3 that the number of processes are more than basic & semi-basic type product. The tables also show that the time required for machine setup and technical support are more than basic & semi-basic type product. It is also seen in that tables the time for products are also more than basic & semi-basic type product.

Effect of SMV on Production

It can be seen in **table 4** that as the SMV decreases production increases and vice versa.

Effect of SMV on Operator

It can be seen in **table 4** that as the SMV increases operator also increases.

4. Conclusions

It seems that there are some differences between target production and actual production. In some cases target production was higher than that actual production while in some cases the other way round .i.e. actual production was higher than target production. It may also happed due to wrong data that lead to calculation of target production. It was also observed that SMV of a T- shirt increased in terms of decorative garments and there is a decrease of productivity. On the other hand SMV decreased on the less decorative garments. As a result productivity of garments is increased. Above discussion it is clear that current SMV calculation is the key factor for garments productivity.

REFERENCES

[1] RahmanMizanur, (Thursday, 06 December 2012). RMG sector: Secret of success and causes of unrest, senior vice- p resident (IBBL).

[2] Berg Achim, November 2011, Principal, McKinsey's Frankfurt, Co-coordinator, McKinsey's Apparels, Apparel, Fashion & Luxury Practice.

[3] Mücella G. Güner, Can Ü nal, Department of Textile Engineering, Faculty of Engineering, University of Ege, Izmir, Turkey, Line Balancing in the Apparel industry Using Simulation Techniques, FIBRES & TEXTILES in Eastern Europe April / June 2008, Vol. 16, No. 2 (67), p-75.

[4] Glock, R. E. & Kunz, G. I. (1995). Apparel Manufacturing-Sewn Product Analysis, Prentice Hall, New Jersey, p:4.

[5] Chuter, A. J. (1988). Introduction to Clothing Production Management, Blackwell Science, Oxford, pp. 60-63.

[6] Cooklin, G. (1991). Introduction to Clothing Manufacturing, Blackwell Science, Oxford, p. 104.

[7] Tyler, D. J. (1991). Materials Management In Clothing Production, BSP Professional Books Press, London.

[8] Eberle, H., Hermeling, H., Hornberger, M., Kilgus, R., Menzer, D., Ring, W., (2004). Clothing Technology, Beuth-Verlag GmbH, Berlin.

[9] Glock, R. E. & Kunz, G. I. (1995). Apparel Manufacturing-Sewn Product Analysis, Prentice Hall, New Jersey, p: 4.