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Determination of Optimum Speed of a Knitting Machine by Analyzing the Different Parameters

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Abstract

The objective of this research was to determine the optimum speed of a knitting machine. This study compared the different parameters of a knitting machine running at various speeds. For this, a knitting machine of 22-inch diameter and 24 gauge with 66 feeders knitting 24 Ne yarn was selected and was run at 40 rotations per minute (r.p.m.).; 42 rotations per minute (r.p.m.).; and 44 rotations per minute (r.p.m.) for total 24 hours for each speed. Data was collected for two days for 12 hours each. The different causes of stoppages were recorded with their frequencies and time for total of a 24 hours. Again, actual fabric production and the defective amount were recorded in kg. Moreover, different machine problems (like needle breakage, oil problem etc.) that occurred during the machine running was also recorded. Finally, the efficiency at different speeds was calculated with the help of calculated production and actual production of the knitting machine. Considering the stoppage data, machine efficiency, defective fabric production, and different machine problems, it was found that the optimum speed for the knitting machine is 40 rotations per minute among the three different speeds.

Keywords: Knitting machine, Yarn breakage, set–off, needle breakage, knitting machine efficiency, defective fabric, rotation per minute, optimum speed

Introduction

The yarn is the raw material in the knitting section, and the fabric is the output. Like all other textile industries, the knitting section also demands high production. If the speed of a knitting machine is high the production is also high, just like all other machines. But experience says that the high speed of a machine may yield more production, but it leads to defective production, damage to the machine, and extra load on the operator. To avoid this, every machine is suggested to run at optimum speed. The knitting machine may run at various speeds. To avoid defective production, damage of machine and extra load on operator, speed must be optimum by sacrificing the extra amount of production. This determined the optimum speed of a knitting machine by analyzing the different parameters that involve the amount of the defective output, machine damage, and extra load on the operator. In their work, Pawar Hemraj et al. (n.d.) showed, the speed factor and its effect on the production and efficiency of the weft knitting machine and defective fabric. They showed that the speed of the machine plays an important role in fabric defects. Thus, an optimum speed should be maintained for optimum production. In this project speed alteration was made, and the various process parameters were then recorded. In their study, the machine speed was increased by 1 and 2 r.p.m. daily and a negative impact on the various parameters like fabric defects, yarn breakages, and needle defects was found. (Pawar Hemraj et al, n.d.)

Speed and number of feeders influence the amount of production significantly. The calculation of production of a single jersey knitting machine is as follows:

$$\frac{\text{Stitch length X } \Pi \text{ X machine dia X gauge X No.of feeder X Machine R.P.M. X 60}}{\text{10 X 2.54 X 36 X 840 X yarn count X 2.2046}} \text{ kg / hour,}$$

(Spencer, n.d.)

According to the equation, if we increase the knitting machine r.p.m. the fabric production also increases.

The r.p.m. of a knitting machine depends on: (Iyer, Mammel, and Schach, n.d.)

i. Type of machine.
ii. Yarn count.
iii. Stitch length.
iv. Fabric structure.
v. Needle gauge
vi. Number of feeder. etc.

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The speed of the knitting machine is adjusted by the recommendation of the machine manufacturer and on a trial and error basis. Here the speed factor plays a great role in the knitting machine speed. For this knitting machine, the speed factor was 1050. The speed of the machine was calculated by the following calculation:

$$\frac{\text{Speed Factor of the Kntting machine}}{\text{Diameter of the knitting machine}} \text{ X } 0.90\%$$

$$= \frac{1050}{22} \text{ X } 0.90$$

$$= 42.95 \text{ r.p.m.}$$

From the calculation, the suggested speed of the knitting machine is 43 r.p.m. The study was made by collecting data by running the machine at 40 r.p.m.; 42 r.p.m. and 44 r.p.m. The purpose was to see whether the optimum speed for the knitting machine is less or more speed than the suggested speed.

Methods

During analysis of the performance of knitting machine speed, a single machine of 22” diameter and 24 gauge with 66 feeders was selected. The machine was knitting cotton ring combed yarn of 24 N_e. There was no lycra yarn attached during knitting. The machine was run by varying its speed to 40 r.p.m.; 42 r.p.m. and 44 r.p.m. Then data was collected in a data collection sheet. For a particular knitting machine speed (r.p.m.), data was collected for 12 hours for two days. The data included no. of yarn breakages and time to repair, no. of set-offs and time to repair, various reasons for stoppages and their time, production every 12 hours, amount of defective fabric produced, etc. Data were collected for two days (for 12 hours each day) for each speed. In this way, data was collected for 24 hours for each machine’s speed. For this study, a set of data was collected for three whole days from the knitting machine. Again, the efficiency of the knitting machine at the three different speeds was calculated from actual production and the calculated production of the knitting machine. Finally, the accumulated data were organized in tables and analyzed with the help of graphs. The obtained tables and graphs lead to conclude the optimum speed of the knitting machine.

Results

Knitting machine stoppage time due to yarn breakages:

The following table shows the stoppage time and frequencies due to yarn breakages at different running speeds:

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Table 1: Knitting machine stoppage time due to yarn breakages at different r.p.m.:

Machine speed	**40 r.p.m.**		**42 r.p.m.**		**44 r.p.m.**	
	No. of Yarn Breakage	Stoppage Time (Min)	No. of Yarn Breakage	Stoppage Time (Min)	No. of Yarn Breakage	Stoppage Time (Min)
Day 01 (12 hours)	28	30	31	31	34	32
Day 02 (12 hours)	27	30	24	24	47	47
Total (24 hours)	**55**	**60**	**55**	**55**	**81**	**79**

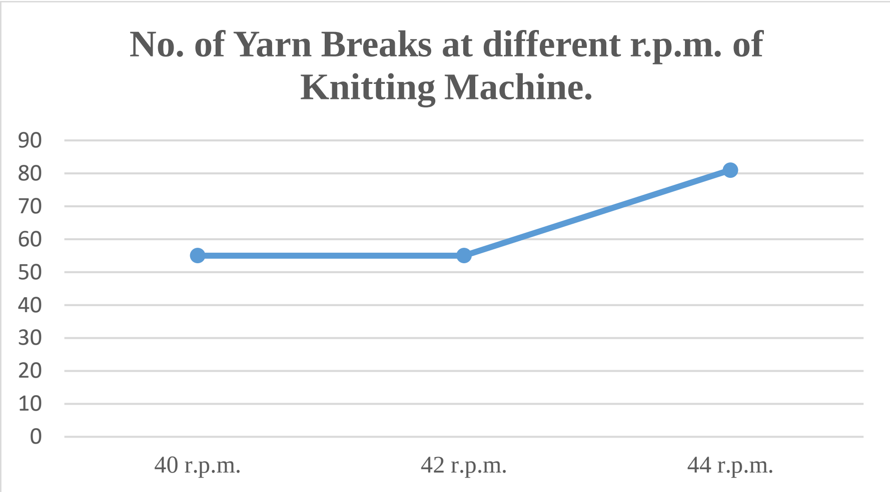

Figure 1: Number of yarn breaks at different r.p.m of knitting machine in 24 hours

In table 1 and figure 1, it is seen that the number of yarn breakage at 40 r.p.m. and 42 r.p.m. is equal, which is 55. The maximum number of yarn breakage is 81 when the machine runs at 44 r.p.m.

Knitting machine stoppage due to set-off:

The following table shows the stoppage time and frequencies due to set – off in different running speeds:

Table 2: Knitting machine stoppage time and frequencies due to set–off at different r.p.m.

Machine speed	**40 r.p.m.**		**42 r.p.m.**		**44 r.p.m.**	
	No. of set-off	Stoppage Time (Min)	No. of set-off	Stoppage Time (Min)	No. of set-off	Stoppage Time (Min)
Day 01 (12 hours)	5	17	5	17	4	15
Day 02 (12 hours)	7	26	9	31	5	24
Total (24 hours)	**12**	**43**	**14**	**48**	**9**	**39**

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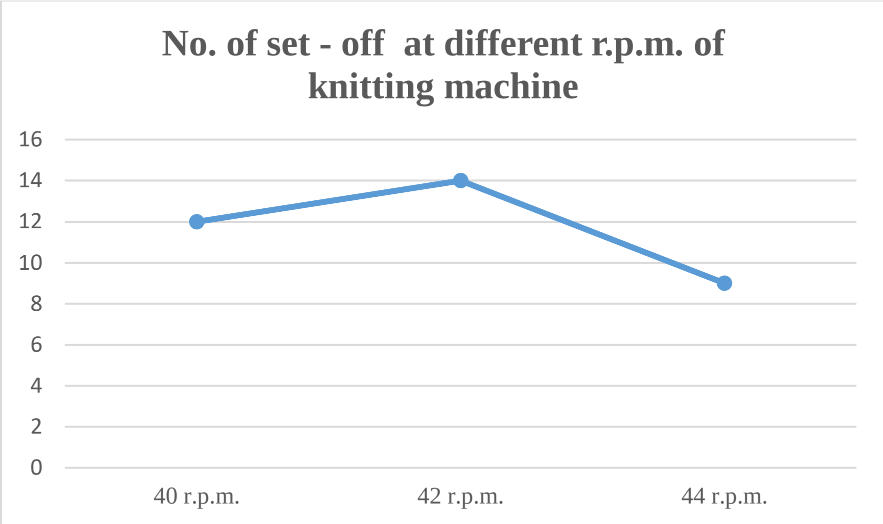

Figure 2: Knitting machine stoppage time due to set–off at different r.p.m in 24 hours

In table 2 and figure 2, it is seen that the number of set-off at 40 r.p.m. is 12; at 44 r.p.m. it is a minimum of 9. The maximum number for set-off is 14 when the machine runs at 42 r.p.m.

Knitting machine stoppages in minutes due to other reasons:

Table 3: Knitting machine stoppage in minutes due to other reasons at different r.p.m. in 24 hours:

Machine speed	40 r.p.m.	42 r.p.m.	44 r.p.m.
Yarn joining	19	39	19
Needle broken	0	5	8
Oil problem	0	30	0
Machine cleaning	0	5	0
Total	19	79	**27**

In table 3, it is seen that due to yarn joining, the stoppage time was 19 minutes at 40 r.p.m., 39 minutes at 42 r.p.m. and 27 minutes at 44 r.p.m. Again, Needles broke when the speed was increased from 40 r.p.m. i.e., 42 r.p.m. and 44 r.p.m. Due to an oil problem the knitting machine was stopped for 30 minutes at 42 r.p.m. Finally, the knitting machine was stopped for 5 minutes for cleaning at 42 r.p.m.

Actual Fabric production in kgs at different r.p.m. in 24 hours:

Table 4: Actual Fabric production in kgs at different r.p.m. in 24 hours:

Machine speed	40 r.p.m.	42 r.p.m.	44 r.p.m.
Day 01 (12 hours)	185.9	189.5	206.6
Day 02 (12 hours)	191.2	190.8	204.2
Total Actual Fabric Production in kg (24 hours)	**377.1**	**380.3**	**410.8**

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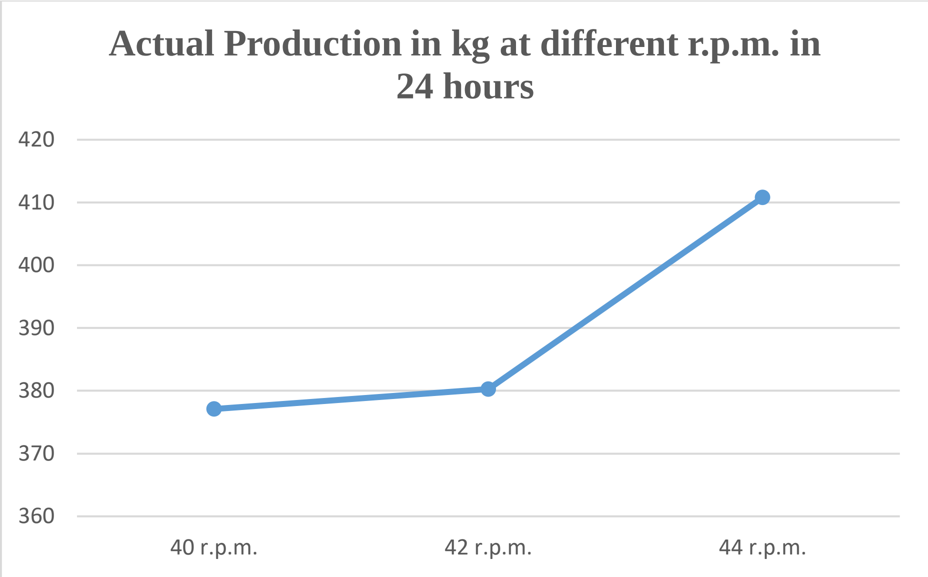

Figure 3: Fabric Production in kgs at different r.p.m.

Table 4 and figure 3 show that fabric production was 377.1 kgs at 40 r.p.m., 380.3 kgs at 42 r.p.m. and 410.8 kgs at 44 r.p.m. in 24 hours.

Calculated production in kgs at different r.p.m. in 24 hours:

From the equation,

$$\frac{\text{Stitch length X } \Pi \text{ X machine dia X gauge X No.of feeder X Machine R.P.M. X 60}}{\text{10 X 2.54 X 36 X 840 X yarn count X 2.2046}} \text{ kg / hour[1]}$$

The calculated production was found at different r.p.m. at 24 hours. The calculated production is shown in table 5.

Table 5: Calculated production in kg at different r.p.m. in 24 hours:

Machine Speed	**40 r.p.m.**	**42 r.p.m.**	**44 r.p.m.**
Calculated Production in kg	473.25	496.91	520.57

Knitting machine efficiency at different r.p.m. in 24 hours:

The knitting machine efficiency was calculated at a different speed from their respective calculated production and actual production in kgs in 24 hours. The data was tabulated in the following table:

Table 6: Knitting machine efficiency at different r.p.m. in 24 hours:

Machine speed	**40 r.p.m.**	**42 r.p.m.**	**44 r.p.m.**
Calculated production in kg in 24 hours	473.25	496.91	520.57
Actual Production in in kg in 24 hours	377.1	380.3	410.8
Efficiency (measured in percent)	**79.68**	**76.53**	**78.91**

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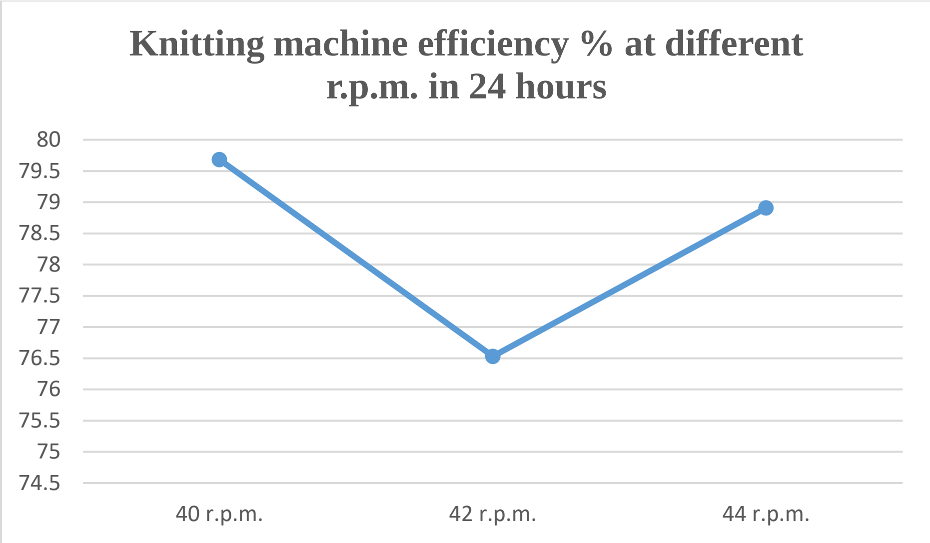

Figure 4: Knitting machine efficiency at different r.p.m. in 24 hours

Table 6 and figure 4 show that machine efficiency was maximum at 40 r.p.m. (79.68 %). When the speed increased to 42 r.p.m. the efficiency was reduced to 76.53 %. Finally, at 44 r.p.m. it was 78.91 %

Defective Fabric produced in kgs at different r.p.m. in 24 hours:

Table 7: Defective fabric produced in kgs in 24 hours

Machine speed	40 r.p.m.	42 r.p.m.	44 r.p.m.
Total Defect amount in kg	1.9	2.7	4.5

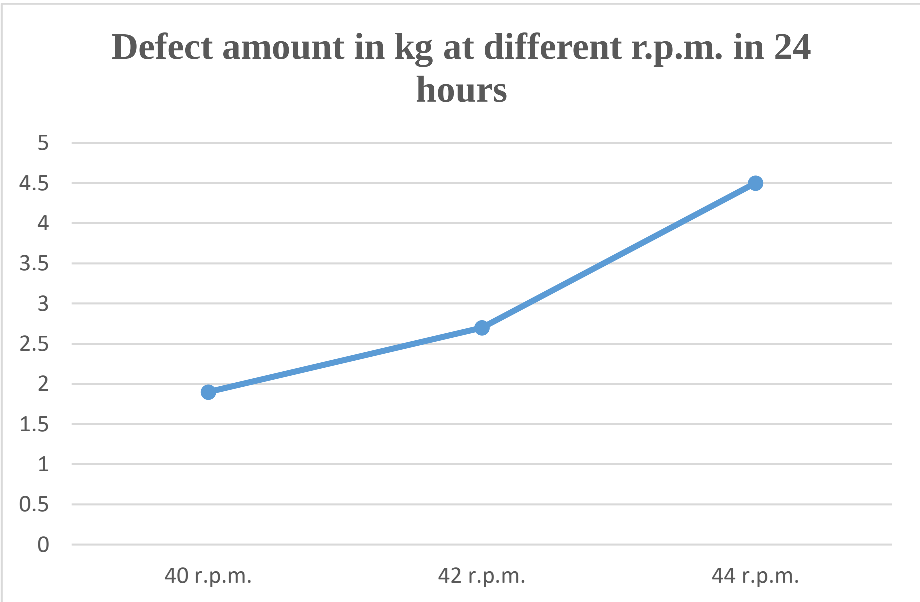

Figure 5: Defective fabric produced at different r.p.m. in 24 hours

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Table 7 and figure 5 show that the defective fabric amount was 1.9 kgs at 40 r.p.m., 2.7 kgs at 42 r.p.m. and 4.5 kgs at 44 r.p.m. in 24 hours.

Discussion

If we increase the speed of the knitting machine from 40 r.p.m. to 42 r.p.m. and higher, the following problems were realized:

When the knitting machine was running at speed 42 R.P.M.

1. The number of yarn breakage was 55, which consumed 55 minutes to repair. The frequency of yarn breakage was the same as 40 r.p.m.
2. The number of set-offs was 14. It was maximum frequency among the different r.p.m. It consumed 48 minutes to repair.
3. The efficiency was reduced to 76.53% from 79.68%. This was the minimum efficiency realized among the three different speeds.
4. Defect amount increased to 2.7 kgs from 1.9 kgs.
5. Knitting needle was broken during knitting and an oil problem occurred.

When the knitting machine was running at speed 44 R.P.M.

1. The number of yarn breakage was 81, which is the maximum among the data. It consumed 79 minutes to repair. The knitting machine operator was more engaged in improving the yarn breaks.
2. The number of set-offs was 9, which is the minimum among the data. It consumed 39 minutes to repair the nine set-offs.
3. The efficiency was 78.91% which was less than 79.68%.at 40 r.p.m.
4. Defect amount increased to 4.5 kgs, which is the maximum among the data.
5. Knitting machine needle was broken more frequently than at speed 42 R.P.M.

Decisions on the optimum speed of the Knitting Machine:

From the above discussions we can conclude that 40 r.p.m. is the optimum speed because:

1. There are 55 yarn breaks at 40 r.p.m and 42 r.p.m. At 44 r.p.m. it was 81. This means less workload on the knitting machine operator at 40 and 42 r.p.m. But it was increased to 81 at 44 r.p.m. This engaged the knitting machine operator to repair it.
2. It was observed that the maximum number of set-offs occurred at 42 r.p.m., which was 14. At 40 r.p.m. it was 12. Finally, at 44 r.p.m. it was 9, which is the minimum in the data table.
3. Machine efficiency was maximum at 40 r.p.m. (79.68 %). When the speed increased to 42 r.p.m. the efficiency was reduced to 76.53 %. Finally, at 44 r.p.m. it was 78.91 %.

4. The defective fabric produced after the knitting is regarded as hard waste. This defective fabric cannot be corrected and will cause a total loss of yarn that was used to produce the fabric. At 40 r.p.m., the least amount of defective fabric was produced. This means less wastage of yarn and utilities of the knitting section. But when the r.p.m. was increased to 42 and 44 r.p.m., the defective fabric amount increased to 2.7 kgs and 4.5 kgs, respectively.
5. The needle started to break, and an oil problem occurred when the knitting machine speed was increased to 42 r.p.m. Again at 44 r.p.m., the needle also broke.

Conclusion

The optimum speed helps to realize less wastage of yarn with optimum production and efficiency, less workload per operator, and fewer machine problems. The study found that number of yarn breaks was maximum at 44 r.p.m. and was equal at 40 and 42 r.p.m. Set–off was minimum at 44 r.p.m. and maximum at 42 r.p.m. At 40 r.p.m., it was at the medium among the three data. The knitting machine efficiency was maximum at 40 r.p.m. At 42 r.p.m. it was a minimum. At 44 r.p.m. a reduced efficiency was realized than 40 r.p.m. The maximum amount of defective fabric was produced at 44 r.p.m. and it was a minimum at 40 r.p.m. At 42 r.p.m., it showed a medium amount in the table. Finally, it was found that the knitting needles started to break, and oil problems occurred beyond the 40 r.p.m.

Considering the number of yarn breaks, set-off, efficiency, amount of defective fabric produced, needle breakages, and oil problems the optimum speed for the knitting machine is 40 r.p.m. among the three different speeds.

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