ANALYSIS OF THE FACTORS AFFECTING THE OUTPUT OF THE WEAVING MACHINES

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ABSTRACT

The development of weaving machine construction shows production gains in shuttless weaving machines. The speed of shuttless weaving machine had reached 1000 r.p.m. while the maximum shuttle loom is not more than 220 r.p.m for equal weaving widths. This higher speed on shuttless weaving machine is a resultant of the reduction of moving masses and developing of a new weft insertion systems. This paper deals with the analysis of the main factors which are taken in the construction of the new weft insertion systems to raise the weaving machine speed and, Consequently, the output of the machine. It is found that the output of the weaving machine is an interrelation with the kinetic energy of the weft insertion element, the mass of the weft insertion element, the weft insertion angle, and time consumed to insert the weft yarn. An equation is developed to adjust the running speed of the weaving machine in dependence on the weft insertion time. Also the efficiency of the weaving machine as a function of yarn quality and machine speed is discussed. It is found that, high speed weaving machines is only suitable for light fabrics and good quality warp and weft. Heavy fabrics are suitable to be woven on low speed shuttless weaving machines as well as shuttle weaving machines.

NOTATIONS

WIR, WIR' = weft insertion rate m/min.
n = weaving machine speed r.p.m
Δn = increase or decrease in weaving machine speed r.p.m.
W = width in reed m
E = kinetic energy of the insertion element N.m
v = speed of the insertion element (average speed) m/s
t = time of weft insertion ms
T = time of one revolution min
α = angle of insertion 0
m = mass of weft insertion element gr
η, η' = weaving machine efficiency %
T = time loss due to machine stoppages min
Tex = time necessary to exchange warp beam Converted to one hour of the working shift min
P_w = warp breaks/10^5 picks for 10^5 warp threads
P_f = weft breahs/10^5 picks at a speed n_1
$t_{rep.w}$ = average time necessary to repair one warp break
$t_{rep.f}$ = average time necessary to repair one weft break.

INTRODUCTION

At the end of 50 years and the start of 60 years was the trend in loom design to increase the loom speed. Through this period many developments were carried out to increase the loom speed with the aim of increasing the output of the machine i.e fabric production.

It was only advantageous to increase the loom speed to a certain optimum when the loom capital cost increases slowly with the speed (1). Also, if the kinetic energy of the shuttle during checking could be returned by any means to the system, this could cause a saving in energy. The mounting of frictionless bearings on the shaft had made such change not economic (1).

The developments of weaving machine construction found an increase in the weaving machine output through new weft insertion systems. In the course of economic progress, a continued increase in output is gained through utilization of electronic means and reduction of weaving masses. The running speed had reached now to more than 1000 r.p.m.

For equal yarn and fabric parameters, the higher speed will theoretically lead to more stops per unit of time, this being due to the greater length of yarn woven in the time interval considered.

The use of new weft insertion principles has, in itself, already contributed a great deal due to a reduction in stop rates, especially due to the minimization of the shed height and disappearance of shuttle friction on warp threads. Reducing the stops rates by using a better quality yarn can bring a slight improvement, also warp preparation should be with higher carfull, weft preparation should also be appropriate for high drawing speeds encountered, and personel training should be intensified to avoid mistakes in yarn handling and machine operation.

SCOPE OF WORK

The new modern shuttless weaving machines run at high speeds. This high speed is not quite good for all yarn types. Many factors may be considered for increasing the machine output with minimum stoppage rate.

In this work, the factors which effect the speed of the running weaving machine will be analysed in order to increase the weft insertion rate. These factors are the mass of the weft insertion element, the speed of the weft yarn, weft insertion time, width of the weaving machine and the weft insertion angle. Three fabrics different in weight, construction and type are chosen to study the effect of weaving machines speed on the machine efficiency.

Fabric specifications are follows.

$$\textit{Light fabric weight}\ \frac{40 \times 34}{135 \times 135Nm}\ 120 \times 2\ cm$$

$$\textit{Meduim fabric weight}\ \frac{30 \times 30}{50 \times 50\ Nm} 248 \times 1\ cm$$

$$\textit{Heavy fabric Weight}\ \frac{24 \times 16}{14 \times 14\ Nm}\ 162 \times 2\ cm$$

DISCUSSION

Output of weaving machine is commonly measured as amount of weft inserted per unit of time. In other wards, output is given by multiplying weaving machine speed by the width of the weaving machine, i.e, width in the reed

$$WIR = w.n \qquad (1)$$

Equation 1 repnesents the theoretical output of the weaving machine, the actual output can be written as follows

$$W/R = W.\ n.\ \eta \qquad (2)$$

The energy required to drive the weft insertion element to across the machine width is

$$E = \tfrac{1}{2}\ m\ v^2 \qquad (3)$$

assuming angular velocity of the main crankshaft then t α and

$$v = \frac{w.6.n}{\alpha}$$

substituting in equation 3

$$E = 18m\frac{w^2.n^2}{\alpha^2}$$

and

$$w.n = \alpha\sqrt{\frac{E}{18m}} \qquad (4)$$

This means that, the weft insention rate or the weaving machine output is a function in the energy of the insertion element, the mass of the element and the angle of insertion

Kinetic Energy of the Weft Insention Element

Table 1. shows the kinetic energy required to drive the weft insertion element for different weft insertion systems.

In the shuttle weaving machine, the energy required to move the shuttle has the larger value against the other weft insertion systems. This is referred to the higher mass of the shuttle, although its average velocity is the smaller. In this mechanism, the energy is used to accelerate the all heavy parts and also to overcome the friction within the mechanism, i.e. in the shuttle boxes and between the warp sheets at its way into the shed and out of it. The other part is dissipated through impact with swell, picker and with the puffer.

On the shuttless weaving machines all these parts are not found and the small amount of energy required is to carry the yarn through the shed and to resist the air resistance through its transport across the shed.

Therefore, for equal motor capacity of 1.8 - 2.0 KW, on shuttless weaving machine a cause to raise the loom speed is the small amount of energy required and transmitted to the weft insertion element, an increase in the weaving machine output is to be expected.

It is also important to point out that, in spite of the small value of the mass of the insertion element, and the velocity on shuttless weaving machine is higher than the shuttle velocity and as the kinetic energy is propontional to the square value of the velocity, then the kinetic energy transmitted to the weft insertion mechanism is smaller than that required on shuttle weaving machines.

Mass of Weft Insertion Element

An important factor affecting the speed of the weaving machine and consequently its output is the mass of the weft insertion element and also the ratio of the weight of the weft yarn to this mass. As the mass of insertion element increasess, the speed of the weft yarn decreases, and consequently the weft insertion rate decreases, Fig. 1 As shown in table 1. the ratio of yarn to the weft insertion mass on shuttle weaving machine is very low while on shuttless weaving machines increases as the mass of insertion element decreases. This means that the higher magnitude of acceleration may be given to the inserted yarn. This statement can be fullfil through the newton's law

$$F = m.\,a \tag{5}$$

For the same equal picking force, a higher acceleration is transmitted to the weft yarn and consequently the weft inserted time may be decreased.

Weft Insertion angle

The weft insertion angle is a limited variable. This variable ranged from 140° to 210° and its value depends on the type of insertion element and also the yarn structure. The developed equation (4) shows that as α is increased the weft insertion rate increases, but its value, as discussed is limited and has no great effect on the

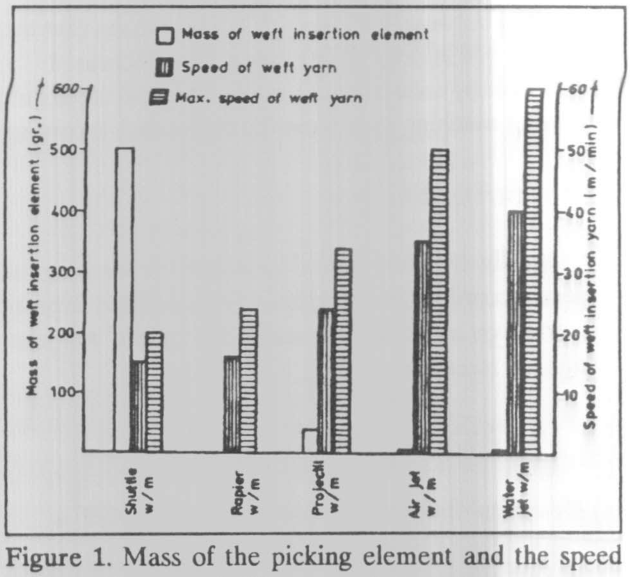

Figure 1. Mass of the picking element and the speed of the weft yarn of different weft insertion systems.

WIR, mathematically, in the above equation.

Weft Insertion Time

The weft insertion time is the time consumed for one pick to across the shed from one side to the other side. We can explain and state that on shuttle looms as the ratio of weft yarn to the weft insertion element weight decreases the weft insertion time is not affected. But on shuttless weaving machines the weft insention time is very sensitive and is affected through many factors. In the literature [7] it is found that the weft insertion time, due to the force transmitted from water or air stream to the yarn, depends on the water or air effective yarn surface. It is found that, its value can be increased or decreased as yarn count, fibre count, yarn twist, number of filament, the crimp of false twist textured yarn and loap frequency of air jet textured yarns, fibre properties, spinning system, singeing operation and by oil coating, are varied. On sulzer weaving machine, in spite of varying yarn count and the increase of peak tension the value of the weft insertion time is not affected.

Assume a straight line movement of the weft insention element .

$$v = (w/t)$$

$$\text{or } t = (w/v) \tag{6}$$

For equal weaving widths, and higher velocity of weft yarn on modern shuttless weaving machines, the weft insertion time according to equation (6) may be decreased. This time is proportional to the weft insertion angle α, which is limited between 140° and 210°. This means that the time of one revolution (1/n) may be decreased and consequently an increase in machine speed is possible. The weaving machine speed can be calculated according to

$$n = (\alpha/6t)\ 10^3 \qquad (7)$$

Practically, it is very useful to adjust the weaving machine speed according to equation (7) to suit the type of yarn inserted on only air and water Jet looms. For the same angle of insertion:

$$(n \pm \Delta n) = \frac{\alpha}{6} \times 10^3 \times \frac{1}{(t \pm \Delta t)} \qquad (8)$$

This means that an increase or loss in output is

$$W.I.R' = w(n \pm \Delta n) \quad \text{or}$$

$$W.I.R' = w(n \pm \Delta n)\eta \qquad (9)$$

Equation 9 is true, when the loom efficiency is not affected due to the increase or decrease in weaving machine speed.

Figure 2. Illustrates the running speed of the weaving machine at different weft insertion time and for different weft insertion angle. This relation is useful to determine the recommended running speed if the weft insertion time is known and the insertion angle is selected. It is also possible, from figure 3, to determine the weaving machine output. On jet weaving machines, i.e, air jet and water jet, the weft insertion time depends to a great extent on the yarn parameters. If a change in weft yarn count or yarn twist produces a decrease in weft insertion time Δt, then an increase in weaving machine speed Δn can be gained, from Figure 2 or equation (8), and the weft insertion rate W.I.R' can also quickly calculated from Figure 3 or equation (9) if the weaving machine efficiency is kept contstant. In practice, it is very difficult to keep the weaving machine efficiency constant. It is quite possible to keep it within a very norrow range by using good quality yarn in both warp and weft through good warp and weft preparation to resist highly drawing speeds.

Factors affecting Weaving Machine Efficiency

Weaving machine efficiency is a function of many parameters, mainly yarn quality, fabric construction, machine speed . Due to an increase or decrease in

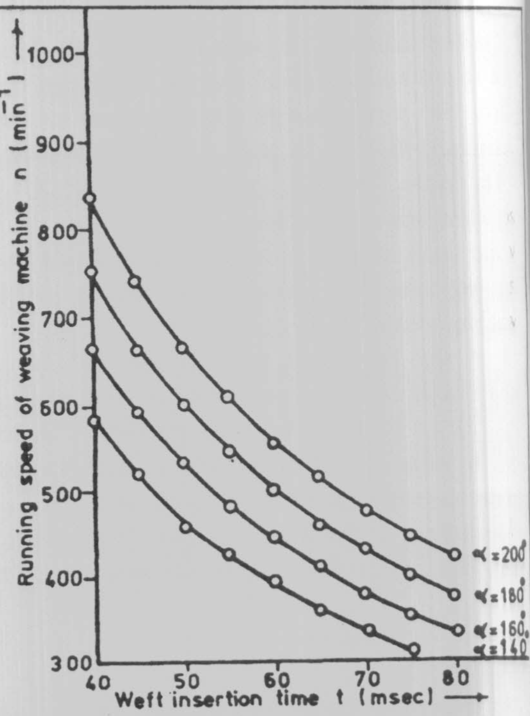

Figure 2. Relation between weft insertion time and running speed of W/M.

machine speed by Δn equation (9) becomes.

$$W.I.R' = (n \pm \Delta n)\ \frac{\eta'}{\eta} \qquad (10)$$

η and η' are the machine efficiency at n and ($n \pm \Delta n$). The value of η can be calculated as

η or η' = 1 - % of time loss due to machine stops. Machine stoppages are due to warp and weft breaks, warp or art change and mechanical repairs . Warp breaks P_w are affected through the total number of ends in the warp, construction of the fabric and the quality of the yarn. The time loss due to the warp breaks can be written as:

$$P_w \cdot W \cdot 10^{-5} t_{rep.w}$$

Also weft breaks is a function of the machine speed and yarn quality. Then time loss due to weft breaks is:

$$P_f \times \frac{n + \Delta n}{n} \times t_{rep.f}$$

Warp beam change or art change te is a function of the length of the warp wound on the warp beam, warp beam diameter and the warp running time.

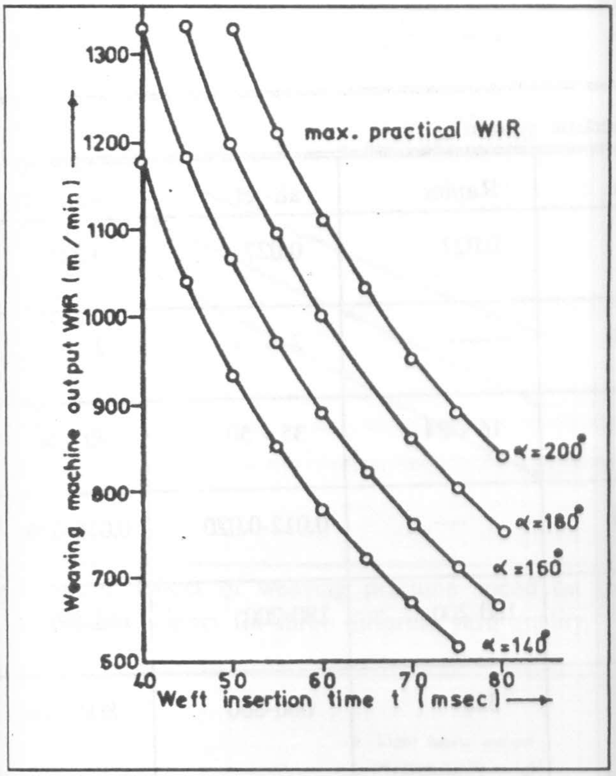

Figure 3. Relation between weft insertion time and weaving machine output.

Mechanical stoppages may be kept to a minimuim through good maintenance. Then the total time loss can be put.

$$T_{loss} = T_{ex} + P_w \times w \times 10^{-5} t_{rep.w} + P_f \times \frac{n + \Delta n}{n} \quad (11)$$

The value of t_{repw} and t_{repf} depend on the skill of the weaver and the degree of difficulty of the article.

The value showed in Figures 4,5 and 6 are quated from practice and [8].

Figures 4,5 and 6 illustrate the effect of weaving machine speed on weaving machine efficiency for three different fabric weights and yarn quality. It is clear from Figure 4 that machine efficiency at higher running speeds is slightly affect when good yarn are used, while the machine efficiency is dropped as the machine speed increases for both average and medium quality yarn. The difference in machine efficiency when the fabric is woven on shuttle loom at 200 p.p.m. and shuttless at 1000 p.p.m is 3,4% , 5,6 % and 7,4 % for good, average and bad quality yarn. For medium fabric weight the reduction in machine efficiency is 7,6% 9,2 % and 11% for good, average and

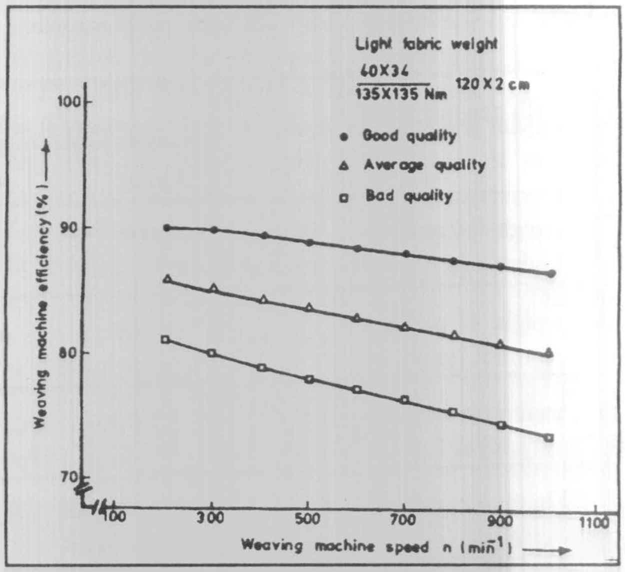

Figure 4. Effect of weaving machine speed on the machine efficiency for three different yarn quality.

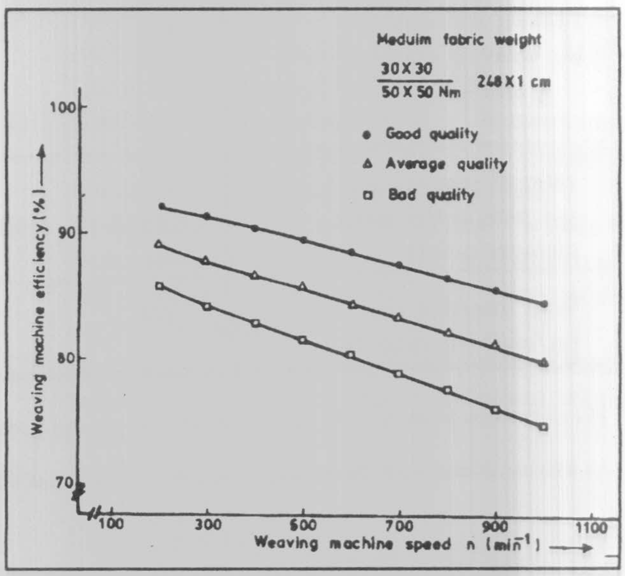

Figure 5. Effect of weaving machine speed on the machine efficiency for three different yarn quality.

bad quality yarn.

From Figure 6. It is clear that the weaving machine efficiency is highly affected by running speed. From a runing speed of 200 to 1000 p.p.m the weaving machine efficiency is dropped by 12,6% for good quality, 14,2% for average quality and 16% for bad quality yarn. Therefore, it is quite clear that not only the good quality yarn for warp and weft is suitable for high speed weaving machines but also fabric weight is very important to gain quality and quantity; this means light fabric are only suitable for

Table 1. Comparison of the different weft insertion systems.

with respect to ↓	Weft insertion system				
	shuttle	Projectile	Rapier	air-jet	water-jet
weight of one* pick [gm]	0.027	0.027	0.027	0.027	0.027
weight of picking element [gr.]	~ 500	40 & 60	-------	2 - 4	2 - 4
weft yarn velocity [m/s]	15 - 20	24 - 34	16 - 24	35 - 50	40 - 60
kinetic energy [N.m]	0.56 - 1.0	0.08-0.13	----	0.012-0.020	0.016-0.04
Weft insertion angle [α^o]	170-210	180-200	180-200	180-200	140-180
running speed of the weaving machine [min^{-1}]	220	350	320	600-800	800-1000
ratio of yarn weight per pick to the picking element weight	1:20000	1:1500	---	1: 75 1:150	1:75 1:150
Weft insertion rate [m/min] (theortical)	440	700	640	1200-1600	1600-2000

* For comparison is taken a weft yarn of 135 dtx and weaving machine of 200 cm width.

All data are quated from the cataloges and private connections with the machine makers.

high speed weaving machines, while medium fabrics may be have very high quality yarn to be woven on the modern high speed weaving machines. It is not econmic to weave heavy fabric weight with high quality yarn on high speed weaving machines as shown in Figure 7. It is also clear from the figure that light fabric at low speeds shows low efficiency than medium fabric weight. This is because this type of light fabric which is chosen has a higher degree of difficulty of the article than that of medium fabric, but higher than 600 p.p.m shows better results than those of lower degree of difficulty in article.

CONCLUSION

From the above analysis we can concluded that:

The output of the weaving machine is affected through different factors. These factors are, the kinetic energy of the weft insention element, the mass of the weft insertion element and the weft insertion angle.

On shuttle weaving machine the speed of the machine and consequently the output is rstricted due to high mass of the shuttle. This type of the machine with its limited speed is very useful and economic to weave heavy fabric weight, whatever is the yarn quality.

On shuttle weaving machines high running speed and high machine output is possible due to reduction of the mass of the weft insention element. By changing yarn

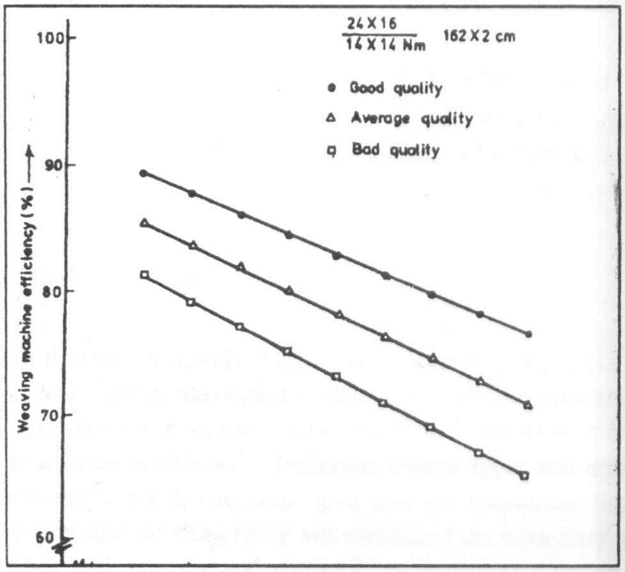

Figure 6. Effect of weaving machine speed on the machine efficiency for three different yarn quality.

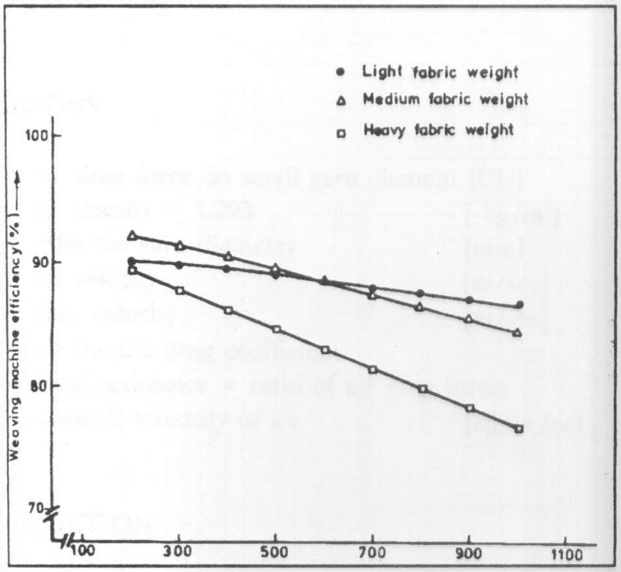

Figure 7. Effect of weaving machine speed on the machine efficiency for three different fabric weights.

parameters on air-and water jet loom, an equation to determine the running speed is developed. This equation is a relation between the weaving machine speed and the weft insertion time. A gain in the weaving machine output can also be calculated in dependence of the raise in running speed. This type of weaving machine is suitable for medium fabrics weight of high quality yarn and for light fabric of good and average yarn quality .

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