Mansoura Engineering Journal (MEJ) vol.16, No.1,June 1991. T.45.

CHARACTERISTIC OF LET-OFF MECHANISM FOR WIDE WEAVING MACHINES WITH DOUBLE WARP BEAM

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خواص جهاز الرخو لماكينات النسيج العريضة مزدوجة مطوة السداء

الخلاصة :
في هذا البحث تم دراسة خواص التحكم لجهاز الرخو لماكينة نسج سولزر ذات العرض الكبير والتي يستخدم فيها مطوتي سداء . وكذلك تم قياس الشد في خيوط السداء بعرض ماكينة النسيج باستخدام الطرق الحديثة في ٣٠ موضع بواقع ١٥ موضع لكل مطوة سداء وقد وجد أنه مستوى الشد الديناميكي الناتج عن ضم المشط لخيط اللحمة أثناء تكوين [illegible] النفس السفلية يمثل القيمة العظمى .

لوحظ أن [illegible] في الجهة اليمنى لماكينة النسيج (جهة استقبال المقذوف) والتي يتم ادارة المشط من جهتها أعلى من [illegible] ويتم الربط بين الزيادة في مستوى الشد في تلك الجهة وسرعة نفاد خيوط السداء من المطوة في تلك [illegible] الأخرى وذلك من خلال دراسة خواص جهاز الرخو المستخدم على ذلك النوع من ماكينات النسيج ذات مطوتين [illegible]

ABSTRACT

In this work the characteristic of the used control system for let-off mechanism on sulzer weaving machine with double warp beam was studied. The distribution of maximum dynamic warp tension (due to beating-up at bottom shed) was measured across the width of warp sheet in 30 position (15 position per warp beam). It was found that the level of warp tension at checking side of weaving machine (drive side for reed) is higher than the warp tension on the other side. From the study of the characteristic for let-off mechanism it was found that the effect of increase in warp tension at checking side of weaving machine has an influence on the rate of flow for warp sheet at this side.

1.0 INTRODUCTION

The let-off process on weaving machine affects many factors such as fabric quality, warp tension and percentage waste of warp sheet (in case of using double warp beam), and to improve these mentioned factors the rate of flow for warp sheet during weaving process must be constant as allowable as possible.
During weaving on machines with double warp beams the control on let-off mechanism is more difficult. By measuring the difference in the rate of flow between warp beams on 123 weaving machines, it was found that the rate of flow for warp sheet at checking side is higher than the warp sheet at picking side. This difference varies from 1 to 18 mm per meter length of warp sheet /1/. The variation in the flow rate of warp sheet leads to an increase in the difference between the lengthes of warp sheets at the end of unwinding from warp beam /2/.
To avoid the increase in the percentage waste at the end of unwinding from warp beams the following parameters must be considered /3/:

- the distance between flanges should be the same for both warp beams.
- during winding the warp beams the total number of winds per warp beam and winding tension must be constant for both warp beams.

By measuring the distribution of warp tension across double warp beams /1/, /2/ and /4/ the warp tension has no definite shape, many parameters affect the distribution of warp tension.
To obtain a woven fabric with a high quality and special fabric structure the electronic let-off mechanisms must be used /5/. The electronic let-off mechanism has the following advantages /6/:

- decrease the variation in warp tension at start of the weaving machine.
- improving the movement of back rest and rate of flow for warp sheet.

2. BLOCK DIAGRAM FOR LET-OFF MECHANISM

Fig (2) shows the block diagram for let-off mechanism shown in Fig (1) as input parameters are:

- flow of warp sheet due to take-up motion.
- loading the back rest with springs, and

as output parameter is:

- resultant warp tension.

2.1 Nomenclature

- $\bar{V}1$ = mean value for the rate of flow for warp sheet during let-off motion in (cm/min).
- $\bar{V}2$ = mean value for the rate of flow for warp sheet due to take-up motion in (cm/min).
- E = extension in warp thread (cm).
- $\bar{F}$ = mean value of yarn tension in (N).
- $\Delta F = k.\Delta E$ = variation in yarn tension in the elastic range (N).
- k = spring constant of warp yarn (N/cm).
- $\Delta F1$ = variation in yarn tension due to the variation in let-off.
- $\Delta F2$ = variation in yarn tension due to the variation in take-up.
- ω = frequency of signal (1/sec).
- G1(s) = transfer function for system element.
- G2(s) = transfer function for feedback element.
- Go(s) = transfare function for closed system.

2.2 DIFFERENTIAL EQUATION FOR THE SYSTEM

$$F = \bar{F} + \Delta F \quad , \quad V1 = \bar{V}1 + \Delta V1 \quad , \quad V2 = \bar{V}2 + \Delta V2$$

$$V2 - V1 = 1/k \; . \; dF/dt$$

for steady state $V2 - V1 = 0$

$$\Delta V2 - \Delta V1 = 1/k \; . \; d(\Delta F)/dt$$

at constant flow of take-up ($\Delta V2 = 0$) the value of warp tension decreases with increasing the rate of flow for let-off , then

$$\Delta V1 = -\,1/k \; . \; d(\Delta F1)/dt \qquad . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (1)$$

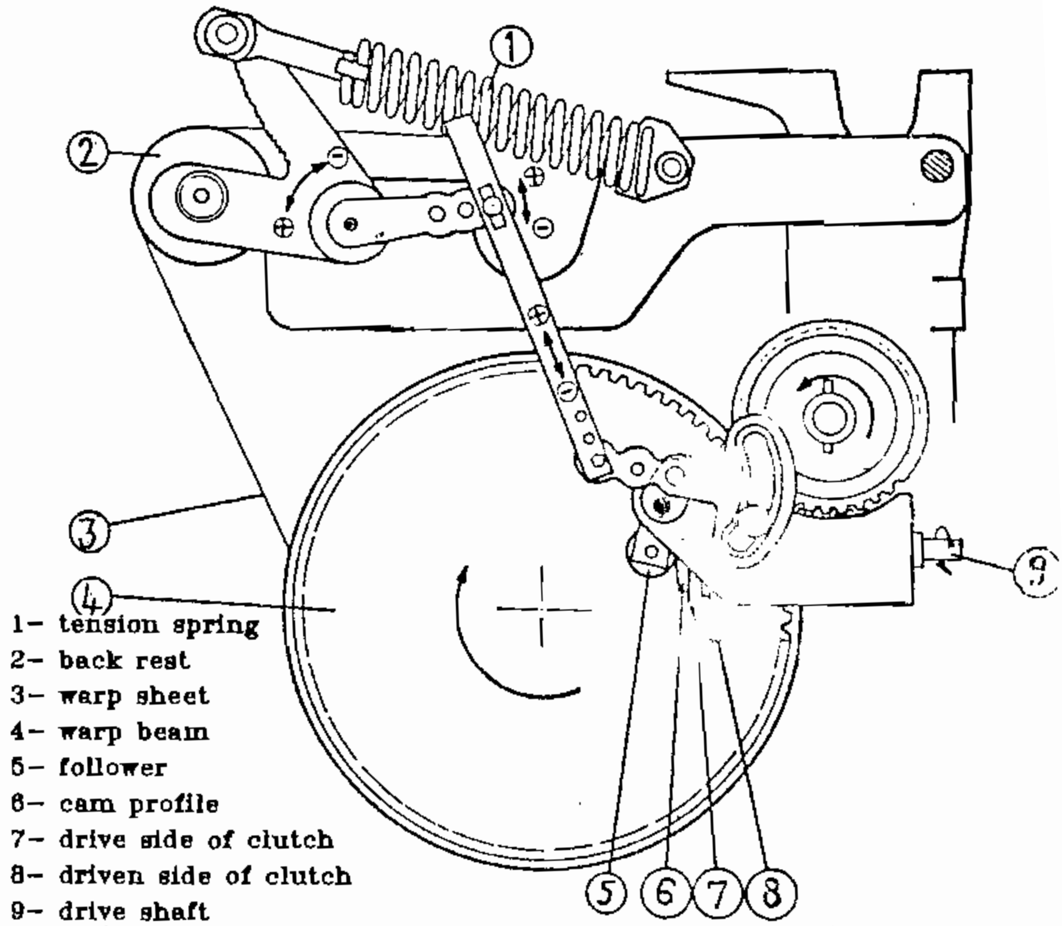


Fig (1): Let-off mechanism for sulzer weaving machine

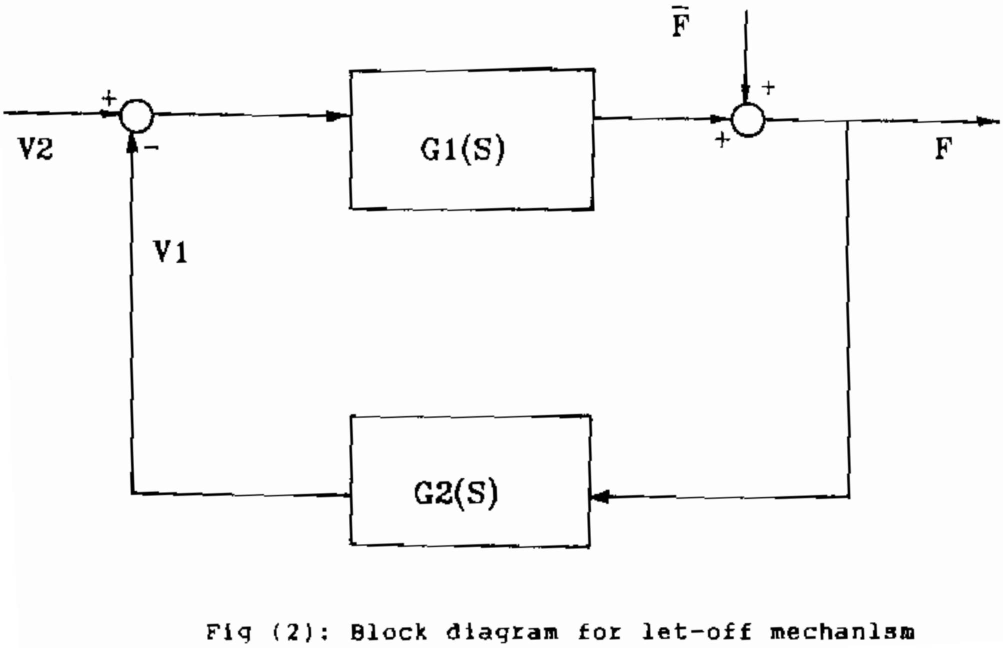


Fig (2): Block diagram for let-off mechanism at constant flow of let-off ($\Delta V1 = 0$) the value of warp tension increases with increasing the rate of flow for take-up , then

$$\Delta V2 = 1/k \cdot d(\Delta F2)/dt \qquad . \; . \; . \; . \; . \; . \; . \; . \qquad (2)$$

$$\Delta F = \Delta F1 + \Delta F2 \qquad \text{and} \qquad d(\Delta F)/dt = d(\Delta F1)/dt + d(\Delta F2)/dt$$

from (1) and (2)

$$k \cdot \Delta V2 - k \cdot \Delta V1 = d(\Delta F)/dt \qquad . \; . \; . \; . \; . \qquad (3)$$

for control system is ,

$$K1 \cdot \Delta F = \Delta V1 \qquad . \; . \; . \; . \; . \; . \; . \qquad (4)$$

from (3) and (4) is ,

$$K \cdot \Delta V2 = \Delta F + T \cdot d(\Delta F)/dt \qquad . \; . \; . \; . \; . \; . \; . \qquad (5)$$

where $K = 1/K1$ (N.sec/m) and $T = 1/(k.K1)$ (sec)

Using one side Laplace-transform with the form,

$$\mathcal{L}(X(t)) = X(S) = \int_0^\infty X(t) \cdot e^{-St} \, dt$$

under the following conditions:
- the differential equation is linear with a constant coefficient
- the system has a steady state for $t \leqslant 0$, then

$$G1(S) = \frac{k}{S} \quad , \qquad G2(S) = K1$$

The transfare function for the closed system is:

$$Go(S) = \frac{G1(S)}{1 + G1(S) \cdot G2(S)} = \frac{K}{1 + ST}$$

and by using frequency response is:

$$Go(i\omega) = \frac{K}{1 + i\omega T}$$

The locus diagram for the closed system could be represented in the complex plane as shown in Fig (3-a).

2.3 Stability of the control systm (Nyquist Diagram):

The transfer function for the open-loop of the control system is:

$$G1(i\omega) \cdot G2(i\omega) = \frac{1}{i\omega T}$$

Fig (3-b) shows a plotting for the function $G1(i\omega).G2(i\omega)$ in the complex plan at different values for ω. By completing the plott in counterclockwise and not enclose the point -1 , i0 then the system is stable.

2.4 Dynamic control factor Vd(i ω) and amplitude factor |Vd(i ω)|

$$Vd(i\omega) = \frac{1}{1 - G1(i\omega)\,.\,G2(i\omega)} = \frac{i\omega T}{i\omega T - 1}$$

and

$$\left|Vd(i\omega)\right| = \frac{\omega T}{\sqrt{1 + (\omega T)^2}} \qquad (T = 0.58 \ \ \mathrm{sec})$$

Fig (4-a) and (4-b) show the behavior of dynamic control factor and amplitude factor at different values for ω. It is preferable to regulate the system at small value for ω.

2.5 Behavior of warp tension due to harmonic variation in the flow of warp sheet:

Example: $\Delta V2 = 0.011$ cm/sec , $\omega_o = 1/T = 1.73$ rad/sec
$T_o = 2.\pi/\omega_o = 3.63$ sec , $K = 2.22$ N.sec/m

The input harmonic signal is:

$$\overrightarrow{\Delta V2} = \Delta\hat{V}2\,.\,e^{i\omega_o t} \qquad \text{and}$$

$$\left|Go(i\omega_o)\right| = \left|\frac{K}{1 + i\omega_o T}\right| = 1.55 \qquad \mathrm{N.sec/cm}$$

and the phase angle is, $\Phi_{\omega_o} = \arctan(-\omega_o.T) = \arctan(-1) = -\pi/4$

Then the behavior of yarn tension is:

$$\overrightarrow{\Delta F(t)} = \overrightarrow{\Delta V2}\,.\,\frac{K}{1 + i\omega_o T} = \Delta\hat{V}2\,.\left|\frac{K}{1 + i\omega_o T}\right|.\,e^{i(\omega_o T + \Phi_{\omega_o})}$$

$$\overrightarrow{\Delta F(t)} = 0.017\,.\,e^{i(\omega_o.t - \pi/4)} = 0.017\,.\,\cos(\omega_o.t - \pi/4)$$

Fig (5) shows the behavior of the variation in yarn tension due to the harmonic variation in the flow of warp sheet as a function from the time.

2.6 Using the unit test signals to test the control syatem

As input signal the unit test signals Impulse- , Step- and Ramp-functions could be used to control the system:

by using the unit Impulse function the output function is:

$$g(t) = \mathcal{L}^{-1}\left(1\,.\,\frac{K}{1 + ST}\right) = \frac{K}{T}\,.\,e^{-t/T} \qquad (\mathrm{N/cm})$$

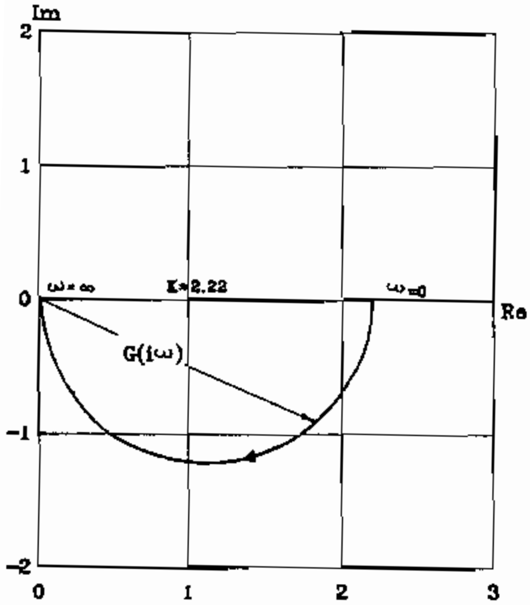
by using the unit Step-function the output function is:

$$j(t) = \mathcal{L}^{-1}\left(\frac{1}{S}\,.\,\frac{K}{1 + ST}\right) = K\,.\,(1 - e^{-t/T}) \qquad (\mathrm{N.sec/cm})$$

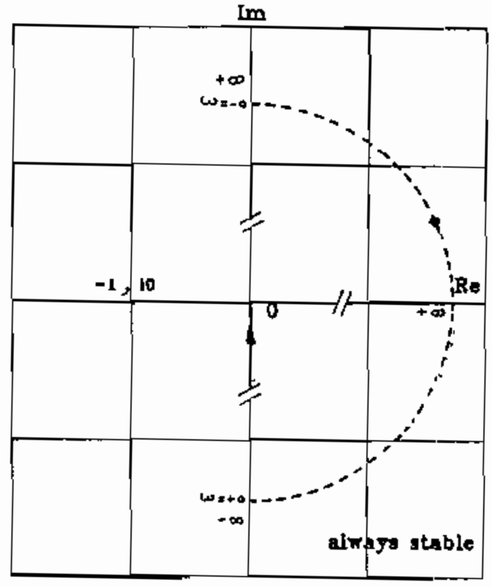
by using the unit Ramp function the output function is:

$$h(t) = \mathcal{L}^{-1}\left(\frac{1}{S^2}\,.\,\frac{K}{1 + ST}\right) = K\,.\,(t - T + T.e^{-t/T}) \qquad (\mathrm{N.sec^2/cm})$$

Fig (6) shows the behavior of the three output signals as functions from time.

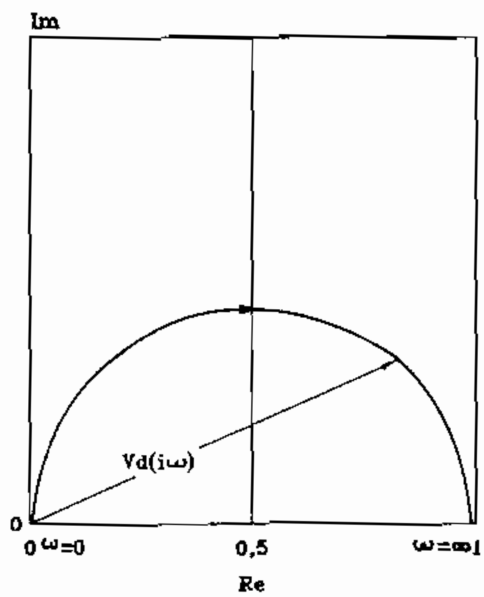


(a)

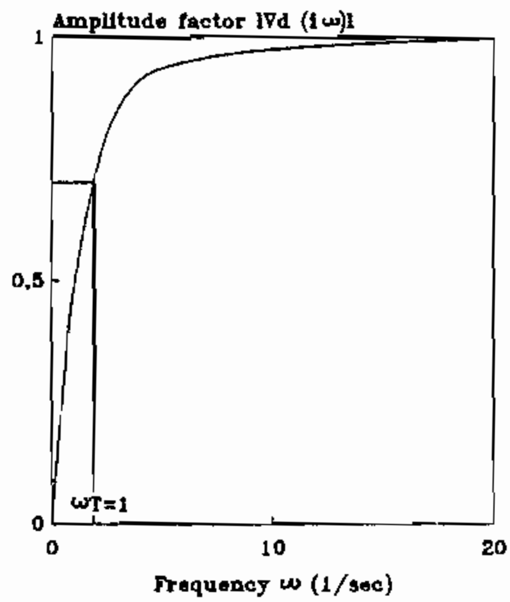


(b)

Fig (3)



(a)



(b)

Fig (4)

Effect of harmonic variation in the flow of warp sheet on warp tension

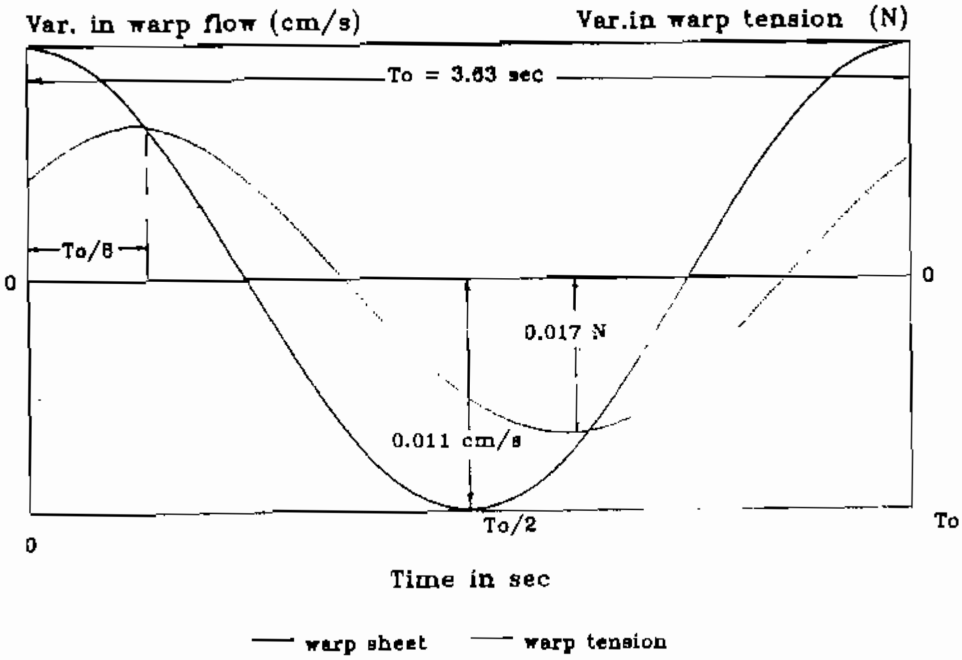


Fig (5)

Output functions for control system under the effect of test signals

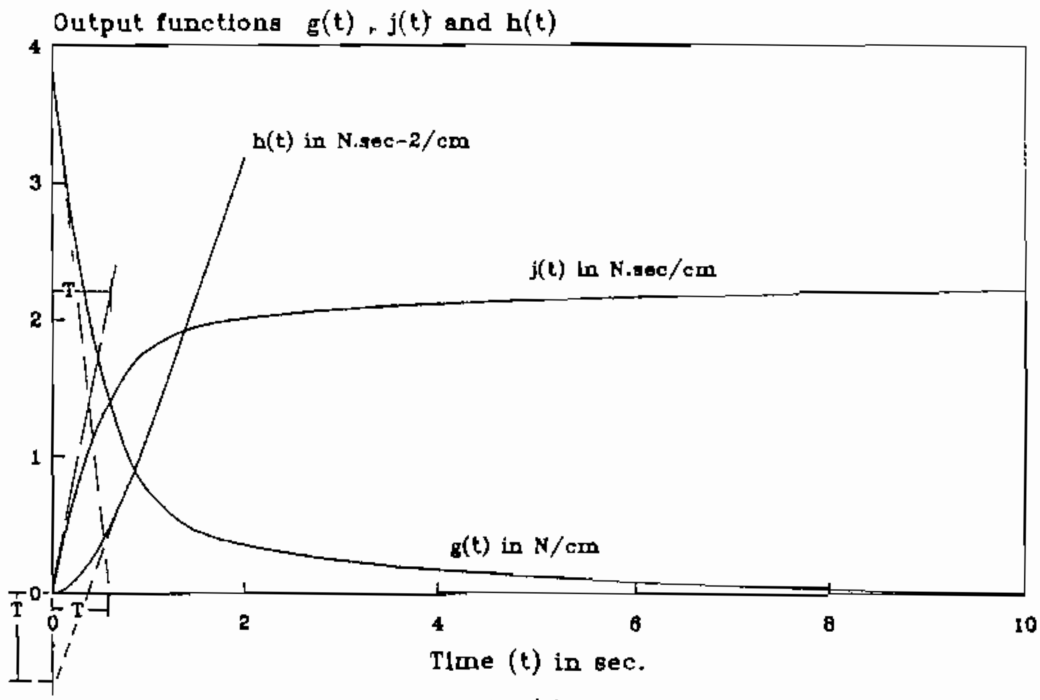


Fig (6)

3 EXPERIMENTAL

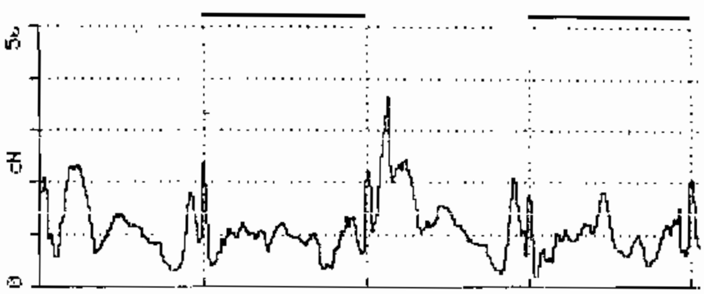
3.1 Specification of weaving machine and material used

Type of weaving machine	Projectile P 7100 (Sulzer - Ruti)
Weaving machine speed	350 picks/min
Maximum reed space	400 cm
warp width in reed	2 X 175 cm (double warp beam)
Ends/cm	47 , cotton Ne 50/1
Picks/cm.................................	28 , cotton Ne 50/1
Number of heald shafts	4 + 2 for selvedge
Fabric structure	plain weave

3.2 Measurements of warp tension and instruments used

Thirty single warp threads distributed across the width of double warp sheets were marked provided that they pass through the first heald shaft and the last dropper bar. After running the weaving machine untill stable weaving condition, the special electronic measuring instrument (DEFAT) for warp tension was used. By using this instrument up to 128 signals could be stored for warp tension, each signal contain the variation in warp tension during one weaving cycle. The measuring instrument has a micro processor to evaluate the values of warp tension for the stored signals. Fig (7) shows example for the evaluated parameters from 86 weaving cycles and its diagram, these parameters are:

- mean value of tension for top and bottom shed
- mean value of tension for top shed
- C V % of tension in top shed
- mean value of tension for bottom shed
- C V % of tension for bottom shed
- maximum tension during beating-up (top shed)
- C V % of tension for max. beating-up (top shed)
- maximum tension during beating-up (bottom shed)
- C V % of tension for max. beating-up (bottom shed)
- mean value of minimum tension
- C V % of minimum tension
- mean value of maximum tension
- C V % of maximum tension
- difference between maximum and minimum tension



MITTL.KFZ:	9.9	cN
MW-OBEN.KFZ:	7.7	cN
CV-OBEN.KFZ:	8.35	%
MW-UNTEN.KFZ:	12.01	cN
CV-UNTEN.KFZ:	7.68	%
MW-MAX.LAO:	16.10	cN
CV-MAX.LAO:	15.43	%
MW-MAX.LAU:	25.51	cN
CV-MAX.LAU:	14.59	%
MW-MIN.BINRAP:	1.24	cN
CV-MIN.BINRAP:	36.81	%
MW-MAX.BINRAP:	25.69	cN
CV-MAX.BINRAP:	14.09	%
DELTA:	24.45	cN

Fig (7) List of evaluated parameters for warp tension and the plotting diagram

Distribution of maximum dynamic warp tension across sulzer weaving machine with double warp beam

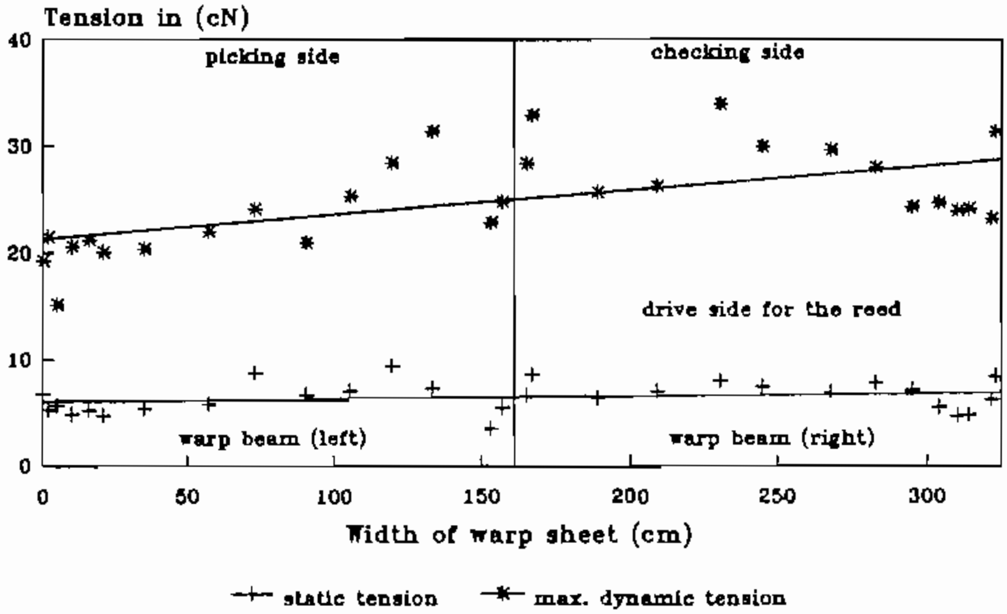
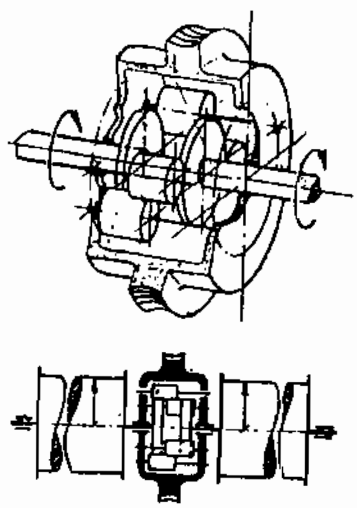


Fig (8)



Fiq (9): Symmetrical differential gear for double warp beam

3.3 Representation of results

The maximum dynamic warp tension due to beating-up at bottom shed was plotted in 30 different positions across the double width of warp sheet, see Fig (8).

4.0 DISCUSSION AND CONCLUSION

- From the study for the characteristic of let-off mechanism the relation between the input and the output signal could be described through differential equation first order with a constant time T. The value of the transfer function for the control system decreases with increasing the frequency.

- The stability of control system was tested with using the Nyquist Criterion at different values of frequency. The systen is always stable.

- The dynamic control factor and amplitude factor for the system increases with increasing the frequency. To avoid the increase in the the dynamic factors the regulation process is preferabale at low values of frequency.

- The effect of the harmonic variation in flow of warp sheet on the variation of warp tension shows that the signal of warp tension was lagging with phase angle $\Phi = -\pi/4$.

- Fig (6) shows the behaviour of output functions due to using the unit test signals. To improve the behaviour of output functions the time constant T must be small.

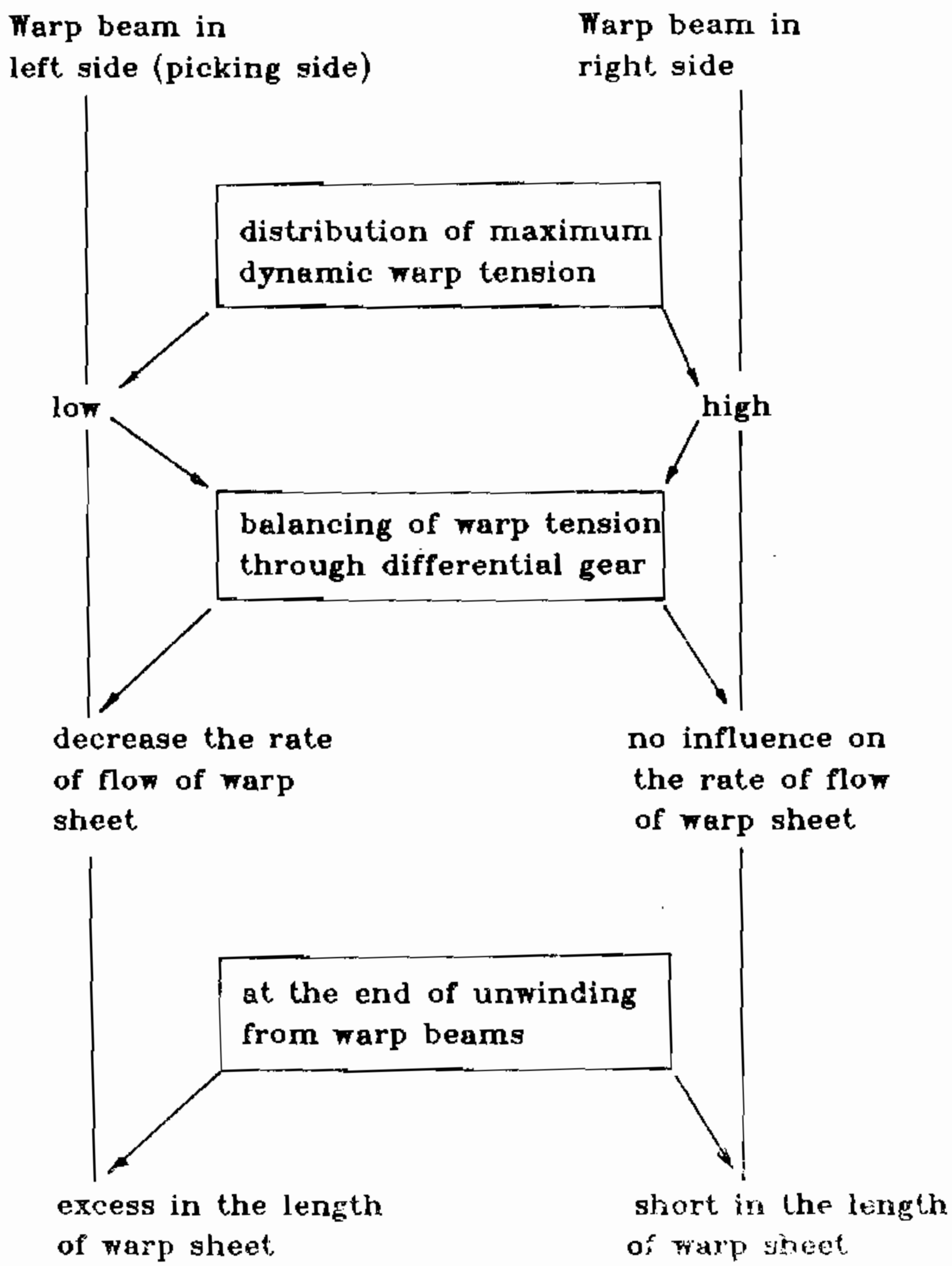
- The measured value of maximum dynamic warp tension is higher at the checking side than the picking side. The static warp tension has no influence on dynamic tension.

- The balancing for warp tension between double beams through the differential gear is by decreasing the rate of flow for warp sheet with the low level of tension. Fig (10) shows the effect of different parameters on the variation in the length of warp sheet at the end of unwinding from warp beams. The flow of these parameters could be described as follows:

a) due to the irregular movement of the reed the beating-up force at checking side (drive side for the reed) is high and tends to increase in the level of warp tension on this side.
b) the side with low warp tension has excess length of warp sheet at the end of unwinding.

- To avoid the variation in maximum tension level between warp sheets the drive for the reed must be from the middle of the main shaft. The tendency to twist the main shaft for wide weaving machines is high and by driving the reed from the side of weaving machine affects the regularity of beating-up force.

- Due to the unsymmetrical shedding (the back rest is in a higher level than the level of cloth fell) the maximum dynamic tension is due to beating-up during the bottom shedding.



Fig(10): Flow of warp sheet for double warp beam

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