THE INFLUENCE OF MACHINE PARAMETERS ON THE PROPERTIES OF DOUBLE JERSEY KNITTED FABRICS

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Abstract The present work is an experimental account of the way in which several machine settings, particularly cylinder knock-over and dial-height, influence fabric dimensions, course length, bending behavior and load extension of fabrics produced on a circular knitting machine. The results show that there are certain optimum settings for such variables as knock-over depth and dial-height for producing fabrics with optimum liveliness, dimensions and bending behavior. This study confirms the suggestion that due to the asymmetry of fabric take-down on circular double jersey machines, it is not possible to produce a fabric with identical properties on the face and back sides. No conclusive evidence of robbing yarn from the cylinder loops to dial loops which cause asymmetry in the fabrics could be found but alternate suggestions were examined.

Kew Words Knitting, Knock-over, Dial-height, Cylinder, Dial, Bending Behavior, Extension, Dimensions, Course-length, Asymmetry Take-down Tension

چکیده در این پژوهش تأثیر چگونگی تنظیم ماشین گردباف به ویژه ناک‌اور سیلندر و فاصله بین صفحه و سیلندر بر روی ابعاد پارچه، طول نخ مصرفی در رج و رفتار خمشی و کششی پارچه بررسی شده است. نتایج نشان می دهد که تنظیم های بهینه ای برای متغیّرهای گوناگون مانند عمق ناک‌اور و ارتفاع صفحه نسبت به سیلندر وجود دارد که منجر به تولید پارچه هائی با خواص بهینه از نظر ابعادی، خمشی و کششی می شود. مطالعه حاضر این نظر را تأیید می کند که عدم تقارن کشش پارچه بر روی ماشین های گردباف، تولید پارچه ای با خواص یکسان در سمت رو و پشت پارچه را غیر ممکن می سازد. هیچگونه دلیل قاطعی نیز مبنی بر ربایش نخ از حلقه های سیلندر به حلقه های صفحه مشاهده نگردیده است که توجیهی بر عدم تقارن خواص پارچه باشد، و لذا نظریه های دیگر مورد آزمایش قرار گرفته اند.

INTRODUCTION

All knitted fabrics change in dimensions on leaving the knitting machine. Many factors influence this change in dimension. These include, but are not limited to, the type of machine, needle, sinker, yarn and fabric, yarn count, stitch length, the timing of the various motions, the types of gating, the knock-over depth, dial-height, type of relaxation and finishing. Clearly, some influence fabric dimension more than others. The relative importance of these parameters may be fully understood through systematic investigations.

It is believed that the formation of fabric at the point of loop formation is influenced by the setting of the dial and cylinder knock-over position, dial-height, yarn tension, and needle timing. Note, however, that the board width and take-down tension influence the fabric dimensions until the fabric has passed below the take-down rollers [1].

Knapton [2] showed that differences in fabric dimensions could be caused by altering machine settings such as take-down tension, stretcher-board, etc., while maintaining the length of the yarn in the structural-knit cell (l_u) constant.

Little [3] established that alterations in knitting machine settings, such as take-down tension, dial-height, and stretcher-board width can cause significant changes in the linear dimensions of all wool fabrics. These changes in dimensions resulting from varying extents of loop distortion have been found to be more pronounced in the off-machine and dry-relaxed states than in the fully-relaxed states. He [4] further showed how machine settings can affect the linear dimensions of double-knit fabrics made from textured-polyester yarn and showed that these can result in considerable variation in length and width dimensions.

Other researchers [5, 6] investigated the effect of machine settings on the apearance, dimensions and geometrical behavior in knitted fabrics. Hurt [5] reported that the minimum fault rate on the fabric occurs at a positive value of [(cylinder knock-over)-(dial knock-over)]. The effect of different gauges on a sinker top machine, have been examined for knitted fabrics constructed from rotor spun cotton yarn [7] and the data on the loop length of the resultant dry relaxed fabrics were used to generate relationships between yarn count, machine gauge, and tightness factors of the resulting fabrics. These data were used [8] to model the mechanism of the knitting process.

It is possible that a change in one machine setting may alter the effect of another. Therefore, it is necessary to consider each setting individually while keeping other parameters constant (as far as possible) to avoid multiple interactions.

This study outlines an attempt to analyze the degree to which settings on a double jersey knitting machine influence the properties of the resultant fabrics. This study presents the results obtained for the following machine variables: (1) dial-height (D. H.), (2) cylinder knock-over (C. K.), and (3) dial knock-over (D. K.) in relation to one another.

METHODS AND MATERIALS

Our materials consist of two series of fabrics knitted in our laboratory. The first set of fabrics, referred to herein as series A, were knitted in six groups using 17.78 tex polyester filament yarn. The various machine settings used are reported in Table 1 and the rib structure used in producing this series of fabrics is shown in Figure 1a. Concerning this design, on odd feeds 6 needles knit, 10 miss, while one even feed 10 needles knit, 6 miss.

A second set called series B, was produced from 27.68 tex spun yarn (acrylic), consisting of five groups of fabrics. The various machine settings used for this set are given in Table 1 and the rib structure used is given in Figure 1b. The average course length of the odd and even feeders for each sample are also given in Table 1.

When a double jersey knitting machine is used to knit a designed fabric, normally a positive feed device is not used in feeding the yarn. Therefore, in this study, a positive feed system was not used. Thus, the course length that is not controlled by a positive feed device may be expected to change with a change in knock-over depth and dial-height.

The yarn consumed by odd and even feeders was measured by HATRA instrument to obtaine the course length of feeders. In this experiment three odd and three even feeders were chosen at random, and then

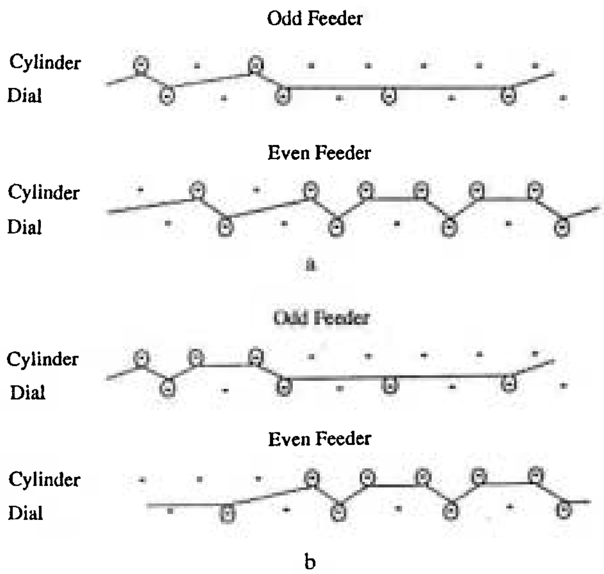

Figure 1. (a) The fabric structure for A series fabrics.
(b) The fabric structure for B series fabrics.

Table 1. The various machine settings for A and B fabrics. (L = course length, D. K. = dial knock-over, C. K. = cylinder knock-over, D. H. = dial-height).

sample	D. K.(mm)	C. K.(mm)	D. H.(mm)	(odd feed) L(Cm.)	(even feed) L(Cm.)
A1	2.25	2.00	1.65	462.2	670.5
A2	2.25	2.00	1.78	477.5	695.9
A3	2.25	2.00	1.90	497.8	741.6
A4	2.25	2.25	1.65	472.4	711.2
A5	2.25	2.50	1.65	474.4	721.3
A6	2.25	2.75	1.65	492.7	751.8
B1	2.25	2.75	1.65	546.6	802.6
B2	2.25	2.75	1.78	570.0	826.0
B3	2.25	2.75	1.90	587.2	859.5
B4	2.25	2.50	1.65	518.1	768.1
B5	2.25	2.25	1.65	511.0	737.6

the length of yarn consumed by each was measured over three complete revolutions of the machine.

Four main properties of the fabrics are investigated in this research. These are:

a) Fabric dimensions including: wales and courses per centimeter, and stitch density

b) Course length

c) Fabric bending behavior

d) Load extension behavior

Each was examined under different relaxation conditions. These conditions are listed below.

a) dry relaxation (D. R.)

b) wet relaxation (W. R.)

c) wet relaxation plus tumble drying (W. R. + T. D.)

d) wet relaxation plus tumble drying twice (W. R. + T. D.) x 2

In the first treatment, the samples are laid on a smooth flat surface in a condition room for at least 48 hours.

In the second treatment, the samples are laid flat in a shrinkage bath for 24 hours. The bath consists of water and 1% wetting agent (Typol G) at 40°C. Then the samples were replaced in the bath which had been filled with clean water after which excess water was removed. The samples were then left to dry naturally for at least 48 hours under standard conditions.

The third treatment namely tumble drying is to investigate the effect of full relaxation on the fabrics dimensional, physical and mechanical properties. Initially the samples were treated as for the wet relaxation process but after removing excess water from the cloth the sample is tumble dried at 60°C for 1.5 hours in a hot air tumble dryer. Then the sample is laid flat on a smooth surface under standard atmospheric conditions for at least 48 hours. Now the sample is ready for testing.

For twice wet relaxation plus tumble drying, the foregoing treatmet was repeated.

Series A fabrics were studied under D. R., W. R., (W. R. + T. D.) and (W. R. + T. D.)x2 treatments, and series B were examined under D. R., W. R., and (W. R. + T. D.)x2 conditions.

In order to investigate the effect of the machine settings on the bending behavior and load extension characteristics of our samples, both series A and B were examined under different relaxation states. Bending behavior was characterized using the Shirley cyclic bending tester, and load extension was investigated on an Instron tensile testing machine.

The results of the bending test can be expressed as hysteresis loops, from which various parameters may be derived [9, 10]. A summary is given below:

a) Low-curvature Elastic Flexural Rigidity "Go". The parameter "Go" is that part of the stiffness that arises from bending and twisting of fibers and yarns and represents the purely elastic component of the fabric stiffness in the two sides of the hysteresis loop in the low-curvature region. It is calculated from the slope of these straight regions.

b) Coercive Couple "Co". This factor represents that part of the stiffness that arises from the frictional forces between fibers and yarns. In the absence of any curling tendency, it would be the couple required to straighten the fabric after it had been bent to a curvature of $5Cm^{-1}$. This parameter is calculated from the vertical width of the intercept of the hysteresis loop on the couple axis. The formula of "Go" and "Co" can be found from the hysteresis loop.

c) "Go + Co". A study of subjective handle has shown that the sum "Go + Co" gives a good indication of the stiffness as felt by fingers [11]. The proportion in which they are combined varies with the type of fabric but, without other information, the sum Go + Co can be taken as an estimate of subjective stiffness.

d) Residual Curvature "Co/Go". The same study [11] showed that the ratio Co/Go was inversely correlated with the subjective liveliness of the fabric. This ratio represents the curvature left in the fabric after being bent and gently released. If Co/Go is high, the handle is dead and fabric drapes in an uneven manner, whereas if Co/Go is low, the handle is lively and the fabric drapes smoothly.

e) Natural Curvature, "Kn". The form of the hysteresis curve for knitted fabric may be asymmetric and not centered on the origin. This fact suggests that the fabric is curly. By taking the mid point of the intercept of the loop on the curvature axis, an additional factor that characterizes the curliness may be obtained. This factor represents the curvature to which the fabric would curl without inter-filament and inter-yarn frictional restraints and of gravitational forces [12].

Hysteresis tests were performed in both wale and course directions for fabrics listed in Table 1. For a given strain, the ratio of the wale direction over that in the course direction is defined as the extensibility asymmetry factor "E" of the fabric:

$$E = \left(\frac{L_W}{L_C}\right)$$

where:

L_W = load at a certain of wale direction extension.

L_C = load at a certain of course direction extension.

RESULTS AND DISCUSSION

The present study attempts to analyze changes caused by varying machine settings in fabric dimensions, course-length, bending behavior and load extension characteristics in fabrics consisting of different yarns, different counts and geometry under various relaxation treatments.

The results may be of interest to industry from the point of view of quality control. Although this work was undertaken solely on Kirkland D. J. K. 36 Patternlock 18 gauge circular knitting machine, we feel that our observations should be valid for all double jersey knitting machines.

The dimensions of all samples in each two series, were measured under different relaxation treatments, and averaged and tabulated in Tables 2 & 3. Hysterisis results are averaged and reported in Tables 4 & 5, and the extensibility asymmetry factor E, for all samples are reported in Table 6 (the load extension properties for A fabrics were measured at 5% and 10% extension,

Table 2. The fabric dimensions for A and B fabrics with (C.K.-D.K.) variable. (1/C=course spacing, 1/W=wale spacing, 1/S=stitch area).

Sample	1/C (Cm.)	1/W (Cm.)	1/S (CM^2.)	relaxation
A1	0.1127	0.0878	0.00989	D. R.
A4	0.1190	0.0879	0.01046	
A5	0.1272	0.0853	0.01085	
A6	0.1329	0.0865	0.01149	
A1	0.1101	0.0868	0.00955	W. R.
A4	0.1164	0.0859	0.00999	
A5	0.1264	0.0840	0.01061	
A6	0.1307	0.0863	0.01127	
A1	0.1082	0.0856	0.00926	W. R.+T. D.
A4	0.1152	0.0854	0.00983	
A5	0.1210	0.0848	0.01026	
A6	0.1278	0.0864	0.01104	
A1	0.1034	0.0838	0.00866	W. R.+T. D. x2
A4	0.1132	0.0829	0.00938	
A5	0.1199	0.0820	0.00983	
A6	0.1259	0.0836	0.01052	
B1	0.0780	0.0909	0.00709	D. R.
B4	0.0705	0.0932	0.00657	
B5	0.0665	0.0943	0.00627	
B1	0.0774	0.0930	0.00719	W. R.
B4	0.0702	0.0923	0.00647	
B5	0.0646	0.0933	0.00602	
B1	0.0734	0.0938	0.00688	W. R.+T. D. x2
B4	0.0695	0.0896	0.00622	
B5	0.0642	0.0902	0.00579	

but for B fabrics only at 10%). Below, we examine each settings separately.

a) The Effect of Knock-over Setting on the Dimensions and Course Length

The results may be summarized as:

I) An increase in cylinder knock-over appears to increase the course spacing but the change in wale spacing is negligible. Hence, the length of loop varies but not its width. Consequently, the fabric should curl in the length direction toward the back because of a longer cylinder loop. This did not occur and it was suspected that the dial loops must be increasing in length by robbing yarn from either the cylinder loop or the body of fabric during knitting or relaxation as suggested by Gray [1] for simple fabrics. From the results for different knock-over settings on fabric series B, it appears that a similar effect occurs similarly to the trend observed for double jersey fabrics of series A. Consequently the effect of changing the cylinder knock-over on fabric dimensions is not dependent substantially on the type of yarn used or the design of the fabric that only appears to influence the importance of the effect.

Table 3. The fabric dimensions for A and B fabrics with dial-height variable. (1/C=course spacing, 1/W=wale spacing, 1/S=stitch density).

Sample	1/C (Cm.)	1/W (Cm.)	1/S (Cm^2.)	relaxation
A1	0.1127	0.0878	0.00989	D. R.
A2	0.1170	0.0901	0.01054	
A3	0.1303	0.0893	0.01163	
A1	0.1101	0.0868	0.00955	W. R.
A2	0.1133	0.0865	0.00980	
A3	0.1228	0.0871	0.01069	
A1	0.1082	0.0856	0.00926	W. R.+T. D.
A2	0.1119	0.0879	0.00983	
A3	0.1209	0.0873	0.01055	
A1	0.1034	0.0838	0.00866	W. R.+T. D. x2
A2	0.1082	0.0837	0.00905	
A3	0.1180	0.0828	0.00977	
B1	0.0780	0.0909	0.00709	D. R.
B2	0.0787	0.0952	0.00749	
B3	0.0793	0.0958	0.00760	
B1	0.0774	0.0930	0.00719	W. R.
B2	0.0780	0.0954	0.00744	
B3	0.0787	0.0956	0.00753	
B1	0.0734	0.0938	0.00688	W. R.+T. D. x2
B2	0.0743	0.0946	0.00703	
B3	0.0760	0.0943	0.00716	

Table 4. The bending behavior for A and B fabrics with C.K.-D.K. variable. (C=course direction, W=wale direction).

	Go (dyn Cm²/Cm)		Co (dyn Cm/Cm)		Co/Go (Cm^{-1})		KN (Cm^{-1})		
sample	C	W	C	W	C	W	C	W	relaxation
A1	130	85.0	400	175.0	3.07	2.05	-0.50	-1.25	D. R.
A4	155	70.0	440	137.5	2.84	1.96	-0.10	-0.70	
A5	160	70.0	370	125.0	2.31	1.71	-0.15	-0.35	
A6	175	70.0	410	127.5	2.34	1.82	-0.10	0.00	
A1	160	82.5	450	150.0	2.81	1.81	-0.10	-0.60	W. R.
A4	165	80.0	434	142.5	2.62	1.78	0.00	-0.75	
A5	175	80.0	400	137.5	2.28	1.72	0.00	-0.40	
A6	185	80.0	430	140.0	2.32	1.75	-0.15	-0.25	
A1	165	95.0	450	160.0	2.75	1.68	-0.10	-0.60	W. R.+T. D.
A4	180	85.0	425	142.5	2.36	1.67	0.00	-0.70	
A5	185	80.0	415	115.0	2.24	1.43	0.00	-0.70	
A6	195	82.5	440	127.5	2.25	1.54	0.00	-0.50	
A1	180	95.0	475	165.0	2.63	1.73	-0.20	-0.90	W. R.+T. D. x2
A4	210	90.0	470	150.0	2.23	1.66	0.00	-0.70	
A5	215	90.0	455	145.0	2.12	1.60	0.00	-0.70	
A6	220	85.0	460	130.0	2.14	1.53	0.00	-0.60	
B1	170	75.0	475	140.0	2.79	1.86	-0.35	-0.40	D. R.
B4	270	117.5	735	200.0	2.72	1.70	-0.35	-0.35	
B5	250	130.0	725	230.0	2.90	1.77	-0.90	-0.30	
B1	187.5	70.0	457.5	120.0	2.44	1.71	-0.40	-0.10	W. R.
B4	232.5	100.0	517.5	140.0	2.22	1.40	-0.35	-0.35	
B5	237.5	115.0	587.5	200.0	2.47	0.74	-0.40	-0.10	
B1	255.0	102.5	450.0	107.5	1.76	1.04	-0.20	-0.20	W. R.+T. D. x2
B4	325.0	145.0	525.0	130.0	1.61	0.89	-0.15	-0.15	
B5	262.5	135.0	500.0	130.0	1.90	0.96	-0.45	-0.20	

II) Due to the increase in cylinder knock-over, a corresponding increase in stitch area and course length has occurred. This increase is greater for the series B fabrics.

III) When the difference between the knock-over depth of the cylinder and dial needles is around 0.00mm to 0.25mm, all fabrics (used in this study) appear to become more nearly balanced between the face and back. The off-center position around (C. K.-D. K.) = 0.25mm might be attributed to the asymmetry of fabric take-down tension that tends to impose more tension on the dial needles.

b) The Effect of Dial-Height Setting on the Dimensions and Course Length

The results for this machine setting can be summarized as follows:

I) A change in dial height affects the fabric

Table 5. The bending behavior for A and B fabrics with dial-height variable. (C=course direction, W=wale direction)

	Go (dyn Cm^2/Cm)		Co (dyn Cm/Cm)		Co/Go (Cm^{-1})		KN (Cm^{-1})		
sample	C	W	C	W	C	W	C	W	relaxation
A1	130	85.0	400	175.0	3.07	2.05	-0.50	-1.25	
A2	160	77.5	380	180.0	2.37	2.31	0.00	-0.95	D. R.
A3	135	70.0	390	142.5	2.88	2.03	-0.05	-0.70	
A1	160	82.5	450	150.0	2.81	1.81	-0.10	-0.60	
A2	200	90.0	470	180.0	2.35	2.00	-0.05	0.00	W. R.
A3	170	85.0	430	150.0	2.53	1.76	-0.05	-0.50	
A1	165	95.0	450	160.0	2.72	1.68	-0.10	-0.60	
A2	195	92.5	420	172.5	2.15	1.86	-0.05	-0.85	W. R.+T. D.
A3	145	77.5	390	135.0	2.69	1.74	-0.20	-0.70	
A1	180	95.0	475	165.0	2.63	1.73	-0.20	-0.90	
A2	190	92.5	380	155.0	2.00	1.67	0.00	-0.95	W. R.+T. D.
A3	170	90.0	390	135.0	2.29	1.50	-0.15	-0.60	x2
B1	170.0	75.0	475.0	140.0	2.79	1.86	-0.35	-0.40	
B2	255.0	97.5	615.0	162.5	2.41	1.66	-0.40	-0.20	D. R.
B3	247.5	105.0	667.5	190.0	2.69	1.80	-0.45	-0.60	
B1	187.5	70.0	457.5	120.0	2.44	1.71	-0.40	-0.10	
B2	225.0	100.0	450.0	107.5	2.00	1.07	-0.50	-0.20	W. R.
B3	195.0	77.5	465.0	130.0	2.38	1.67	-0.45	-0.30	
B1	255.0	102.5	450.0	107.5	1.76	1.04	-0.20	-0.20	W. R.+T. D.
B2	262.5	95.0	457.5	90.0	1.74	0.94	-0.45	-0.15	x2
B3	255.0	105.0	465.0	115.0	1.82	1.09	-0.10	-0.45	

dimensions in a similar manner to a change in knock-over; that is, an increase in dial height is proportional to the increase in course spacing but the wale spacing will remain nearly constant. Generally speaking, it can be said that the machine settings affect the fabric dimensions only in the course direction accompanied by a corresponding change in stitch area. This is not unexpected since a change in the knock-over and dial height will cause forces to be imposed in the length direction of the loops.

II) As the dial height is increased, a corresponding increase in course length occurs. Consequently, the fabric will become less compact. This increase in greater for the series B fabrics. Therefore, for a given course length, machine settings are more critical when producing fabrics from spun yarns.

III) It was observed that at the same setting of cylinder and dial knock-over and dial height, the number of courses per unit length in the B series fabric is greater. Therefore, the stitch density of fabrics in series A will be less than that of fabrics in series B. This phenomenon can probably be attributed to the elastic properties of the filament yarn used.

Table 6. The extesibility asymmetry factor $E=L_W/L_C$ for A and B fabrics with C.K.-D.K. and dial-height variables.

sample	D.R.	W.R.	W.R.+T.D.	(W.R.+T.D.)x2	extension	variable
A1	1.81	1.90	1.82	1.78		
A4	2.17	2.20	1.98	2.10	5%	C. K.+D. K.
A5	2.18	2.26	2.34	2.32		
A6	2.37	2.51	2.55	2.72		
A1	1.80	2.09	1.91	1.92		
A4	2.35	2.50	2.25	2.32	10%	C. K.-D. K.
A5	2.43	2.61	2.52	258		
A6	2.69	2.90	2.82	2.91		
A1	1.81	1.90	1.82	1.78		
A2	1.85	1.95	1.88	1.81	5%	dial-height
A3	2.02	2.01	1.93	1.97		
A1	1.80	2.09	1.91	1.92		
A2	1.90	2.05	1.97	2.02	10%	dial-height
A3	2.13	2.13	2.05	2.07		
B1	3.66	3.48	---	3.60		
B4	2.93	3.42	---	3.14	10%	C. K.-D. K.
B5	2.89	2.93	---	2.56		
B1	3.66	3.48	---	3.60		
B2	3.47	3.34	---	3.54	10%	dial-height
B3	3.44	3.33	---	3.50		

c) The Effect of Cylinder Knock-over on the Bending Behavior and the Load Extension

The results are summarized as follows:

I) Due to the increase in cylinder knock-over, the low-curvature elastic flexural rigidity, "Go" is increased whereas, the coercive couple, "Co" and the value of "Co/Go" decrease owing to less jamming of loops. The experimental results show that "Co" and "Co/Go" values tend to form a peak around a C. K. - D. K. value of +0.25 mm for both course and wale directions. This tendency supports the suggestion that around this point (C. K. - D. K. = +0.25 mm), the sum of the frictional forces at the sliding inter-filament contact points is equal for both face loops and back loops of the double jersey fabric. Thus, at this point, fabrics that are most balanced can be produced.

These results are similar for both series A and B fabrics, however the fabrics in series B are stiffer. Nevertheless the series B fabrics are more lively than the series A fabrics. This is probably due to the nature of the yarn used.

II) The required load to extend the fabric along both the course and the wale directions is inversely proportional to the increase of cylinder knock-over. This is because the number of courses per unit length of fabric decreases when the cylinder knock-over is increased.

III) An increase in cylinder knock-over requires a higher load in the wale direction than the course direction for a given strain. This ratio increases with an increase in strain.

IV) A similar trend was observed for the load extension properties of both series A and B fabrics when the cylinder knock-over was changed. However, the extensibility asymmetry factor "E" is greater for series B fabrics. This is to be expected since these fabrics had a higher stitch density.

d) The Effect of Dial Height Setting on the Bending Behavior and the Load Extension

I) Some noticeable effects of dial height on the liveliness of fabrics are apparent from the resultant curves of fabric liveliness when Co/Go is plotted against dial height for bending in both course and wale directions. These effects are:

i) the effect on bending in the course direction is opposite to the wale direction.

ii) around a dial height value of 1.78mm, the fabric reaches its maximum liveliness in the wale direction.

II) As for the natural curvature of the fabrics around a dial height value of 1.78mm, minimum asymmetry in the course direction occurs, while maximum asymmetry is observed in the wale direction. It should be noted that this asymmetry is less along the course direction than along the wale direction.

III) The load required to stretch the fabrics is dependent uopn the number of loops along the course direction. Thus, with an increase in dial height, the required load decreases along both principal directions of the fabric. But, the extensibility asymmetry factor "E" increases when the dial height is increased. Therefore, to extend the fabric along the wales, a higher ratio of load is required.

IV) With a change in dial height, similar results were observed on the load extension properties and the bending behavior of both series of A and B fabrics.

e) The Effect of Relaxation Treatments on the Fabric Properties

When cylinder knock-over and dial heights were varied at different settings, the results suggested that:

I) As relaxation occurs, the number of loops per unit length in both directions i.e. along the course and wale directions increased. Therefore, the stitch area decreases. Perhaps this can be attributed to a partial release of some forces imposed on the loops during knitting.

II) Relaxation makes the fabrics more lively. This is probably due to a reduction of the geometrical restraints imposed when the yarns were converted into their bent shape during knitting.

III) After wet relaxation, a greater load is required to stretch the fabric in both directions. This is probably due to an increase in the number of loops per unit area of fabric. However, this tendency is reversed when tumble drying is employed.

IV) Much of the information gained from the experiment on further relaxation on the second series of fabrics has served to provide greater evidence for the effect of relaxation on a fabric's properties such as dimensions, liveliness and load extension property described for series A fabrics. However, unexpectedly, because of further relaxation, a lower load was required to stretch the series B fabrics along both the wale and course directions. This is probably due to the structural properties of the spun yarn changing when the fabrics are subjected to mechanical agitation and heat tumble drying.

FURTHER INVESTIGATION AND CONCLUSIONS

This study confirms the suggestion that due to the asymmetry of fabric takedown on circular double jersey machines, it is not possible to produce a fabric with identical properties when examined on the face (cylinder) and back (dial) sides. Furthermore, a closer approximation to this equality can be achieved by reducing the dial knock-over (D. K.) and increasing the cylinder knock-over (C. K.) so that C. K. - D. K.

= 0.25 mm. However, the mechanism by which unequal cylinder and dial knock-over settings partially compensate for the asymmetric takedown is not fully understood. It has been suggested by Gray [1] that this is probably due to the robbing of yarn by the dial needles from the cylinder loops. No conclusive evidence to support this suggestion could be found and it is considered that this is more probably due to the distortion of the loops during and immediately following their formation.

Of course, it was suggested that [1] because of the asymmetric take down, the dial loops rob the yarn from the cylinder loops. Therefore, to obtain loops of final similar size on both the face and the back, the cylinder knock-over must be greater than the dial knock-over. To confirm this suggestion, the knitting action was recorded on a video tape. However even when the film was viewed at a reduced speed or viewed one frame at a time, no evidence of this robbing action could be detected. Nor could any evidence be found of yarn moving from the zone between the two beds into the dial loops. Furthermore it is unlikely that such a robbing action would occur after the knitting action.

This is difficult to achieve on a sample of fabric in a tension free state. So it would be only reasonable to expect it to be more difficult when the face loops are under tension as is the case when the fabric is on the machine. However, when an unequal amount of tension is applied to the face and back of the fabric, the loops on the respective sides are probably distored to differing extents, and if the dial loops are subjected to a greater tension, they may be expected to be more elongated than the cylinder loops. The loops on both beds would, however, have a similar width since this is largely decided by the mechanical gauge of the knitting machine. This is supported by the evidence of only a nominal change in the width of the fabric occuring when the knock-overs are altered. Thus, if one considers the two sides of the fabric individually, the back would consist of elongated loops that would lay more nearly flat than the cylinder loops in the face side of the fabric since these are under less tension. This hypothetical situation cannot arise since the two sides of the fabric would have substantially differing lengths. However, when the fabric is released from the tensions applied during manufacturing the effect of relaxation will differ on the two sides and consequently the properties of the resultant fabric may also differ on the two sides when equal knock-overs are employed.

When the cylinder loops increase in size so that their length is similar to the elongated length of the dial loops, the fabric is more nearly dimensionally balanced during manufacturing. When the fabric is released from tension, it will probably remain so. Otherwise it would involve the occurence of some robbing or similar mechanism. This is unlikely because of the frictional restraints imposed on the yarn at the yarn/yarn interfaces. This suggestion cannot yet be proven.

This hypothesis which is based on loop distortion and not yarn movement in the fabric, a condition more readily achievable, may justify further study. Therefore, an attempt is made to devise and apply a new technique to a circular double bed knitting machine that would enable it to operate without an asymmetric takedown [13].

REFERENCES

1. P. S. Gray, Ph. D. thesis, Bradford University (1977).
2. J. J. F. Knapton, "Factors Affecting the Stable Dimensions of Double Jersey Structures", *J. Textile Inst.*, 65, (1974) 293-299.
3. T. J. Little, "Factors Influencing the Exact Replication of Double-knit Fabrics, Part I: All Wool Fabrics"., *Textile Res. J.*, 48, (1978) 361-365.
4. T. J. Little, G. A. V. Leaf and J. J. F. Knapton, "Factors Influencing the Exact Replication of Double-knit

Fabrics, Part II: Textured Polyester Fabrics"., *Textile Res. J.*, 48, (1987) 400-407.

5. F. N. Hurt, "Effect of Machine Settings on the Appearance, Dimensions and Fault Rate in Knitted Fabrics"., Melliand Textilber. Intern. (English Ed.), 9, (July 1980) 951-958.

6. C. W. Joo, S. W. Park and J. I. Raw, "Statistical Analysis of the Effect of Machine Settings on the Dimensions of Double Knit Fabrics"., *Journal of The Korean Society of Textile Engineers and Chemists*, 22, No. 1, (1985) 28-35.

7. P. K. Banerjee and T. S. Alaiban, "Mechanism of Loop Formation at Extreme Cam Settings on a Sinker Top Machine, Part 1: Relationship between Count, Gauge, and Tightness Factor"., *Textile Res. J.*, 57, No. 9, (1987) 513-518.

8. P. K. Banerjee and T. S. Alaiban, "Mechanism of Loop Formation at Extreme Cam Settings on a Sinker Top Machine, Part 2: Analysis of Limiting Conditions"., *Textile Res. J.*, 57, No. 10, (1987) 568-574.

9. R. G. Livesey and J. D. Owen, "Cloth Stiffness and Hyteresis in Bending"., *J. Textile Inst.*, 55, (1964) T516-T530.

10. J. D. Owen, "The Bending Behavior of Plain-weave Fabrics Woven From Spun Yarns"., *J. Textile Inst.*, 59, (1968) 313-343.

11. V. H. Dawes and J. D. Owen, "The Assessment of Fabric Handle, Part I: Stiffness and Liveliness", *J. Textile Inst.*, 62, No. 5, (1971) 233-244.

12. I. Davies and J. D. Owen, "The Bending Behavior of Warp Knitted Fabrics"., *J. Textile Inst.*, 62, No. 4, (1971). 181-197.

13. A. A. A. Jeddi, "The Development of a Circular Knitting Machine to Operate without a Take-down Tension System"., In preparation.