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The Automatic Determination of the Twist in Single Wool Worsted Yarns

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ABSTRACT

The effect of wetting wool worsted yarns prior to testing on the twist values obtained by the double untwist-twist and untwist-retwist tests on an automatic twist tester has been investigated. These values were also compared with the nominal twist values and those obtained manually. The results obtained on the wet yarns were found to correspond very closely to those obtained on the dry yarns using the standard test methods.

The agreement between the automatic twist test results and the nominal values was excellent with a correlation coefficient of about 0,998 (17 readings). The correlation between the manual twist test results and the nominal and automatic test values, respectively, was lower, about 0,977, due mainly to a larger error contained in the manual values.

KEY WORDS

Automatic twist test – wool worsted yarns – nominal twist – manual twist – correlation – wet twist tests.

INTRODUCTION

With the increasing trend towards automation in all spheres of the textile industry it can be expected that more and more use will be made of automatic twist testers to determine the twist in yarns. Contrary to the long established manual method which determines the number of turns per unit length of yarn directly (the direct counting method) the automatic testers generally employ an indirect method of measuring the yarn twist. One method, which is also employed on some hand-operated twist testers, is based upon the fact that the length of a yarn segment, under tension, increases as twist is removed (i.e. as the fibres are allowed to take up a more direct path) until the point of zero twist is reached. When all the twist in the yarn segment has been removed and rotation of the one end of the clamped yarn is continued in the same direction as before the yarn segment begins to decrease in length due to the twist now being inserted in the opposite direction to that which was originally present in the yarn. A stop normally prevents the yarn, which is under a pre-set tension, from extending more than about one *per cent.* Rotation continues until the yarn returns to its original length as assessed visually or by a microswitch in the case of an automatic twist tester. The total number of turns recorded is then taken to represent twice the number of turns originally present in the yarn segment tested. This method has been termed the untwist-twist test or the untwist-retwist test. To compensate for, amongst other things, the inertia of the moving clamp, some automatic twist testers store the above information, discard the yarn segment, clamp a new piece of yarn and then carry out a second test which completes the cycle. This has been termed the "double untwist-twist test"[1–3].

Another method which is used on automatic testers is the slip test where the yarn, which is under a pre-determined tension, is untwisted until the fibres in the yarn slip apart (i.e. the yarn breaks). Once again it is customary to compensate for the fact that the yarn will break before all the twist has been removed due to the tension imposed.

An interesting non-destructive test which measures the folding twist in two-fold yarns employs a light stylus which rests on the yarn while it is drawn past at a constant speed and transmits the yarn profile to a recorder[4]. To determine two-fold twist manually is, however, normally straightforward and quick, and therefore the necessity for an automatic test method is not so great.

From the above discussion it is apparent that the methods employed on automatic testers differ fundamentally from the direct counting method and it, therefore, becomes necessary to compare the results so obtained with those obtained by the direct counting method. The latter is normally taken as a measure of the absolute level of twist in a yarn. In fact such a comparison was attempted some years ago[5] but it was found that there was such a large operator error in the manual (i.e. direct counting) method that no valid comparison was possible. Nevertheless, it was concluded that the double untwist-twist test employed over a specimen length of 50 cm, gave very consistent and reproducible results with a coefficient of variation (C.V.) of twist of about seven *per cent.* If anything this method gave a slightly lower C.V. than the slip test and a mean twist value which was slightly higher than that obtained manually. The latter was especially noticeable in the case of yarns with high twist levels. This was partly ascribed to the fact that an operator normally encounters difficulty in determining the twist in very thin (i.e. high twist) places in the yarn. They, therefore, tend to either discard these thin places after an initial unsuccessful attempt to determine their twist or to avoid clamping very thin places in the yarn. Results are consequently biased towards lower values.

In an investigation into the twist measurement on short lengths of yarn Du Bois and Ten Cate[6] also observed large differences between the results obtained by the same and also different operators on the same yarn.

Recently the I.W.T.O. adopted a method[7] by means of which the twist in wool worsted single yarns may be determined using the untwist-twist test (also termed the untwist-retwist test). The method specifies, however, that the yarn has to be immersed for two hours in water containing 0,1% of a non-ionic wetting agent prior to testing and that it has to be tested in the wet state. It is stated that only under these conditions does the untwist-twist test give a valid result due to the removal of the effect of any set present in the yarns. It was therefore decided to investigate the effect of wetting the yarn, according to the I.W.T.O. specification, on the results obtained on an automatic twist tester employing the double untwist-twist test and to compare the values so obtained with those obtained with the direct counting method, the untwist-retwist and the usual double untwist-twist test carried out on the yarn in the dry state. A comparison of the results so obtained with the nominal twist and the results obtained manually was also attempted. For this purpose a number of single marl yarns covering a range of counts and twist were spun. Twist tests were also carried out on a range of commercial yarns.

EXPERIMENTAL

Yarns used

A range of single marl yarns, varying in twist factor and count was spun on a Rieter H2 ring spinning machine by delivering an undyed and a red roving simultaneously to each pair of back rollers on the frame (see Table I for details of the yarns). This type of yarn was selected to facilitate the manual twist measurements. To investigate the effect of setting the yarns on the twist results each set was divided into two lots: one half being autoclave-steamed at 110°C for 10 minutes while the other half was left unsteamed. A range of commercial yarns differing widely in twist and counts and comprising both undyed yarns and yarns dyed to different shades was included in the investigation in order to compare the results obtained by different test methods for yarns of the type which would normally be tested in practice (see Table II). All these yarns had been set.

Manual Twist Test

Yarn twist was determined manually according to the I.S.O. direct counting method[8] on a Zweigle manual twist tester (type 310). A pre-tension of 0,5 ± 0,1 centinewton (cN)/tex was applied to the yarn in accordance with I.S.O. specifications. In the case of the single marl yarns a gauge length of 5 cm was employed and 40 tests were carried out on each yarn (20 each on the steamed and unsteamed yarns). A gauge length of 2,5 cm was employed in the case of the commercial yarns with 50 tests being carried out on each yarn (see Table II). A longer gauge length, which gives greater accuracy for the same number of tests, could be employed in the case of the single marl yarns since it was much easier to determine the twist on these yarns manually.

Automatic Twist Tests

The automatic twist tests were carried out on a Zweigle Automatic Twist Tester (D 130) employing the double untwist-twist test[1] and the untwist-twist test. On this particular tester the yarn end is rotated at a speed of approximately 1500 revolutions per minute (r.p.m.). It is interesting to note that the I.W.T.O.

TABLE I

TWIST VALUES OBTAINED ON SINGLE MARL YARNS

Yarn Count	Nominal twist	Twist values obtained manually*		AUTOMATIC TWIST TEST RESULTS							
				NORMAL METHOD (DRY)				WET METHOD			
				Steamed Yarns		Unsteamed Yarns		Steamed Yarns		Unsteamed Yarns	
Tex	(t.p.m.)	Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)
60	280	291	14,8	289	3,9	282	6,9	279	3,6	275	4,7
	300	318	14,2	303	5,3	298	5,1	303	4,1	299	4,5
	340	344	14,3	348	9,3	341	4,4	340	3,9	339	4,5
	380	395	13,0	396	4,2	386	5,2	388	3,9	394	4,4
40	340	358	17,8	337	6,5	332	5,3	343	7,3	328	7,0
	380	409	17,8	391	6,2	379	4,9	385	6,0	390	6,0
	400	404	15,5	402	5,4	390	4,9	391	6,0	389	6,1
	460	464	21,5	457	7,3	465	8,5	463	5,3	455	5,1
	520	471	21,1	508	5,6	515	4,9	514	5,2	516	5,0
30	440	436	28,1	437	6,1	428	5,7	430	4,5	434	7,2
	480	457	25,1	469	5,8	496	4,2	470	6,6	472	6,5
	540	560	24,8	535	5,8	532	5,9	541	6,2	523	5,1
	600	572	22,6	574	6,1	589	4,7	595	6,1	597	5,1
20	540	550	27,4	539	6,9	507	8,4	533	6,5	543	7,6
	580	618	29,1	575	7,5	548	7,5	565	8,8	566	8,5
	660	713	25,3	630	6,0	627	7,0	647	6,7	643	6,3
	740	690	31,7	716	6,5	697	7,0	732	5,3	731	5,3

*Five cm gauge length employed

TABLE II

TWIST VALUES OBTAINED ON COMMERCIAL YARNS

Sample No.	Count (tex)	Manual Twist*		AUTOMATIC TWIST TEST RESULTS			
				Normal Method (Dry)		Wet Method	
		Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)	Mean (t.p.m.)	C.V. (%)
1	37	456	20,9	411	4,8	405	5,6
2	30	534	22,0	511	6,1	504	5,3
3	28	560	21,9	523	7,4	514	6,7
4	31	430	21,7	423	5,2	429	6,8
5	17	636	27,9	586	8,6	581	6,5
6	22	549	19,4	559	7,3	534	7,8
7	30	498	27,2	472	6,8	457	7,4
8	25	566	18,0	491	8,6	493	6,1
9	28	573	30,9	498	8,6	491	6,7
10	26	573	23,1	555	6,9	545	9,0
11	28	705	20,3	658	5,2	643	7,2
12	25	522	22,8	497	7,1	478	5,7
13	53	372	20,8	362	6,5	360	6,2
14	28	716	21,1	642	4,5	631	7,1
15	16	708	28,0	705	7,3	698	7,0
16	53	372	20,8	337	7,5	332	5,3
17	30	—	—	631	6,4	628	6,1
18	32	—	—	546	7,1	543	6,2
19	37	—	—	495	7,3	488	7,1
20	36	—	—	390	6,3	400	4,9
21	30	—	—	564	6,5	543	6,8
22	17	—	—	603	8,2	590	7,6

*A gauge length of 2,5 cm was employed

untwist-retwist test method[7] recommends a speed of rotation of the clamp of 1000 ± 200 r.p.m. Tests were carried out with the yarn in a dry state and also with the yarn wetted out according to the I.W.T.O. method as described below. The double untwist-twist test on the yarns in the dry state corresponds to the normal routine test method employed on this automatic twist tester and this has been termed the *dry test.*

Wetting Treatment[7]

The yarns were wound onto dyesprings and then immersed in water containing 0,1% by volume of Tergitol Speedwet (Union Carbide), a non-ionic wetting agent, at room temperature (20°C) for two hours. After this the yarns were removed and the water allowed to drain for approximately one minute. The yarns were then tested wet. The pre-tension of the yarn, when clamped, was chosen according to the I.W.T.O. specifications[7] as follows:

YARN TWIST FACTOR (t.p.m. x $(tex)^{\frac{1}{2}}$)	PRE-TENSION* (cN/tex)
Less than 2530	0,10 ± 0,02
2530 to 4743	0,25 ± 0,05
Greater than 4743	0,50 ± 0,10

*1 centinewton (cN) = 1,02 gf

In some of the tests on the wet yarn the first reading of the double untwist-twist test, which represents the untwist-retwist test value, was noted for purposes of comparison.

The dry tests were carried out on yarns drawn over-end from the spinning tubes as would be the case in practice. In all cases a value of 10 t.p.m. was subtracted from the value obtained when the tests were carried out on yarn taken from the dyesprings. This was done to correct for twist inserted into the yarn as it was drawn over-end from these packages. The I.W.T.O. method stipulates that the yarn must be unwound from the wet package by rotating the package in which case no additional twist is inserted and the results are directly comparable with those obtained on yarn drawn over-end from the spinning tubes. The former method, however, was more suitable in the present case. The twist test carried out on the wet yarns has been termed the *wet test.*

RESULTS AND DISCUSSION

No consistent differences were found between the twist test results obtained manually on the steamed and unsteamed single marl yarns and their results were therefore grouped together. The relevant results which were obtained by means of the various test methods are given in Tables I and II while in Table III the results of

TABLE III

RESULTS OF STATISTICAL ANALYSIS

Twist Values Compared*		Number of Yarns	Regression Equation	Correlation Coefficient (r)	t-value**
Y	X				
FROM TABLE I					
Nominal	Manual	17	Y = 1,01X − 9,8	0,977	17,6
Steamed (dry)	Nominal	17	Y = 0,917X − 34,8	0,998	64,4
Unsteamed (dry)	Nominal	17	Y = 0,910X − 32,4	0,996	40,7
Steamed (wet)	Nominal	17	Y = 0,967X − 11,7	0,999	90,1
Unsteamed (wet)	Nominal	17	Y = 0,973X − 7,5	0,998	63,4
Steamed (dry)	Manual	17	Y = 0,930X + 24,7	0,977	17,9
Unsteamed (dry)	Manual	17	Y = 0,913X + 27,1	0,964	14,1
Steamed (wet)	Manual	17	Y = 0,978X + 2,6	0,975	17,0
Unsteamed (wet)	Manual	17	Y = 0,982X − 0,7	0,972	16,0
Steamed (dry)	Steamed (Wet)	17	Y = 0,946X + 24,3	0,998	59,9
Unsteamed (dry)	Unsteamed (Wet)	17	Y = 0,932X + 26,8	0,994	36,3
FROM TABLE II					
Dry Test	Manual	16	Y = 0,923X + 8,6	0,971	15,1
Dry Test	Wet test	22	Y = 1,03X − 8,0	0,997	55,7
Wet Test	Manual	16	Y = 0,900X + 12,2	0,973	15,8

* Unless otherwise stated the results are those obtained on the automatic twist tester employing the double-untwist-twist test

** These values are all significant at the 0,1% level at least.

correlation and regression analyses carried out on the various sets of results taken in pairs are presented.

Paired comparisons of the results obtained on the steamed and unsteamed yarns showed no significant differences between these results for both the normal (dry) test method and the wet test. The results obtained on the steamed yarns in the dry state, however, were on the average about one *per cent* higher than those obtained on the unsteamed yarns.

From the results of the statistical analysis (see Table III) the following conclusions may be drawn. The correlation between the results obtained with the automatic test method and the nominal twist was very high (correlation coefficient r ≑ 0,998) and higher than that (r ≑ 0,977) obtained between the manual twist test

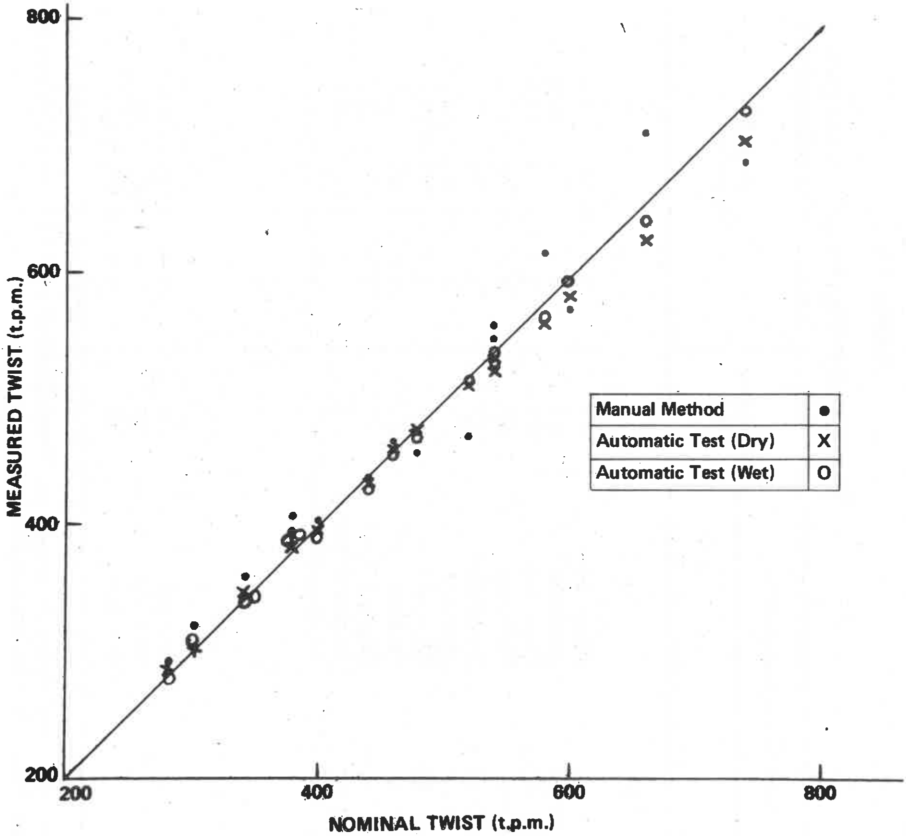

FIGURE 1

Twist values obtained by the different methods vs nominal twist for the single marl yarns

results and the nominal values. This lends support to the previous finding[5] that the automatic twist test results are generally more consistent than those obtained manually. The correlation between the wet and dry automatic test results was also very high, the correlation coefficient being about 0,997, and the absolute values generally agreed well too. The correlation between the automatic test results and those obtained manually was about 0,97. It may be noted, however, that the wet tests do generally give higher t-values than the corresponding dry tests. Nevertheless, these differences are not considered to be of sufficient practical significance to justify wetting the yarns prior to testing.

The statistical analyses discussed above show that the various sets of results are highly correlated but the actual agreement between the absolute values obtained using the various test methods is better illustrated graphically (see Figs. 1, 2 and 3). Fig. 1, in which the results obtained by means of the various methods have been

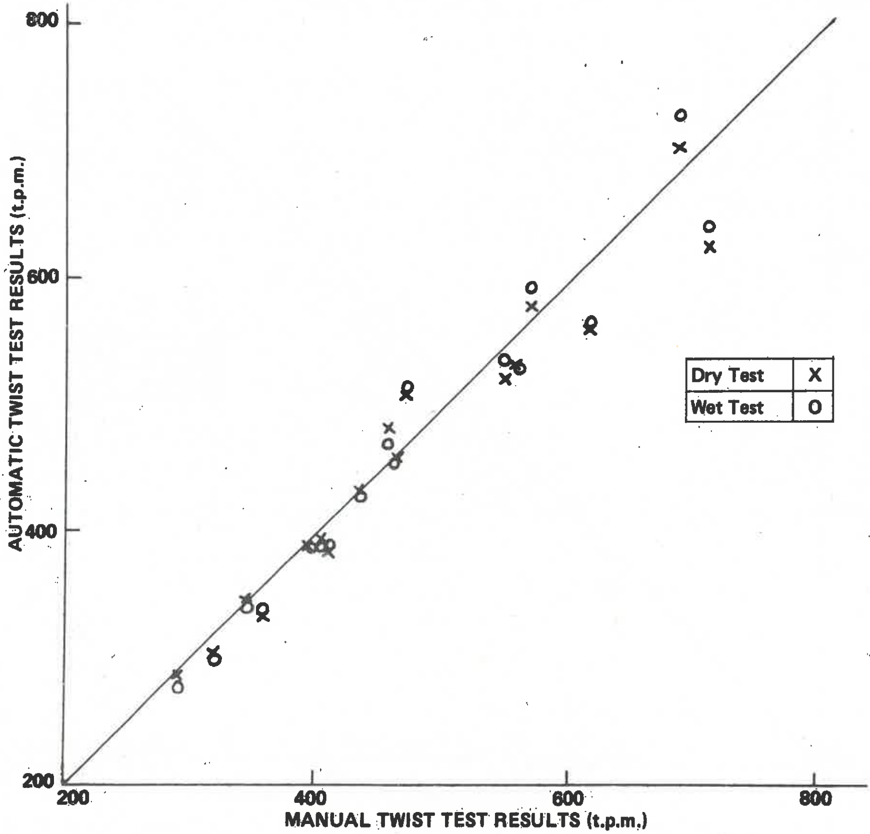

FIGURE 2

Automatic twist test values vs manual twist test values for the single marl yarns plotted against the nominal values for the single marl yarns, illustrates the conclusions drawn from the statistical analysis. Furthermore, it is apparent that the double untwist-twist test results obtained on the yarns in the wet and dry states, respectively, lie very close together and generally agree well with the nominal values. At high twist values there may be a tendency for the values obtained automatically to be lower than the nominal values. It is apparent, too, that the wet and dry test results do not differ in a consistent manner.

In Fig. 2 the automatic twist test results have been plotted against the manual results. Once again the figure illustrates the results of the statistical analysis with the automatic test results not appearing to differ in a consistent manner from the

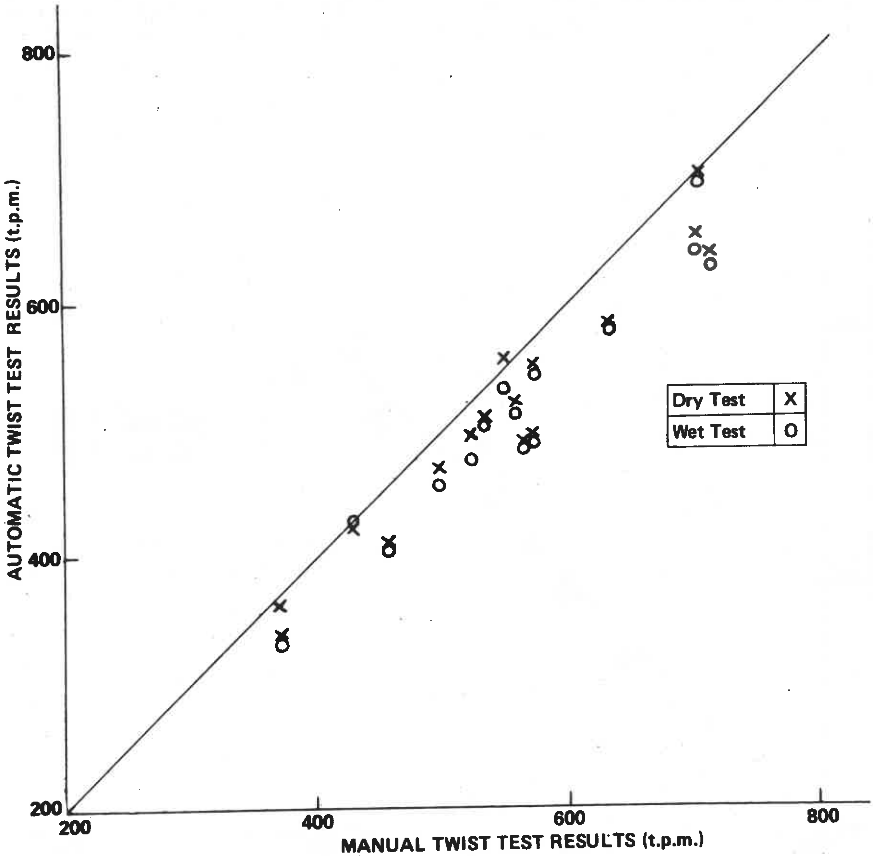

FIGURE 3

Automatic twist test values vs manual test results for the commercial yarns manual test results. The mean of the results obtained on the unsteamed and steamed yarns was used in the case of Figs. 1 and 2.

In Figure 3 the automatic twist test results have been plotted against those obtained manually for the commercial yarns. Here too, it is apparent that the dry and wet test values obtained automatically agree very well (within 1%). On the average the values obtained on the dry yarns were about 1% higher than those obtained on the yarns in the wet state. The difference is considered to be too small to be of any practical significance, however. If the automatic test results are compared with the manual ones it is apparent that the latter are generally higher

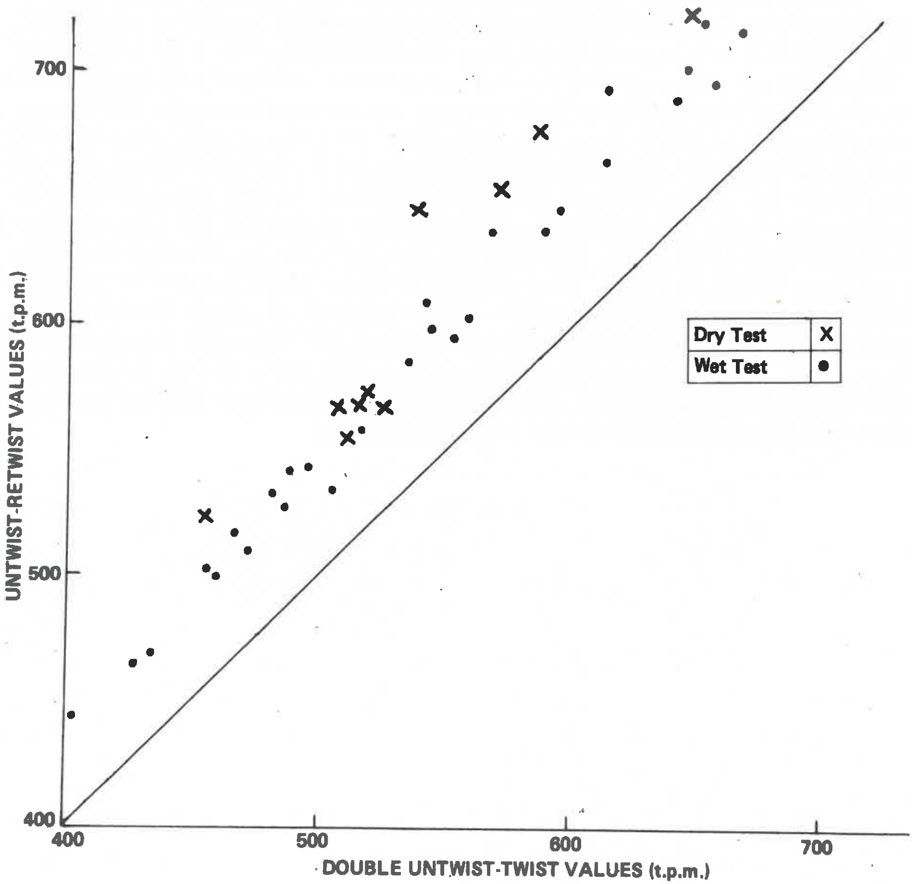

FIGURE 4

Untwist-retwist values *vs* double untwist-twist test values for the automatic twist tester (on the averages about 7%) than the former. In view of the results obtained on the single marl yarns and those obtained during the previous investigation it is concluded that it is the results obtained manually which are too high. This conclusion is partly based on the fact that the single marl yarns could have affected (increased the accuracy of) the manual tests but not the automatic tests. This once again supports the conclusion arrived at previously that the manual test method is very prone to operator error while the automatic test gives consistent and reproducible results. Wetting the yarns, therefore, does not appear to affect the results substantially.

In Fig. 4 the results obtained by means of the untwist-retwist (untwist-twist) method (i.e. the first value stored on the counter) using the tension recommended by the I.W.T.O. have been plotted against the double untwist-twist test values. It is obvious that the untwist-retwist values are consistently about 15% higher than the double untwist-twist values for both the dry and wet test methods. The former values were also generally about 15% higher than the nominal twist values for the marl yarns. Since the latter values were substantiated by the other test results it is concluded that, under the test conditions employed on this particular type of machine and using the pre-tension recommended by the I.W.T.O., the untwist-retwist method gives values which are consistently too high, irrespective of the yarns being wetted out or not. This is thought to be due to the inertia of the moving clamps and the high speed of rotation (1500 r.p.m.) of the clamp. Decreasing the speed of rotation of the clamp and the pre-tension in the yarn would most probably decrease the values and bring them closer to the true values. In fact the machine manufacturers recommend that, in the case of the untwist-twist test, the yarn pre-tension be adjusted until the correct values are obtained.

SUMMARY AND CONCLUSIONS

The effect of wetting out wool worsted yarns, according to the I.W.T.O. recommended method, on the double untwist-twist test and untwist-retwist test values obtained on an automatic twist tester has been investigated. Tests were carried out on a range of single marl yarns specifically produced for this purpose as well as on a range of commercial wool worsted yarns.

It was found that the values obtained on the yarns in the wet state corresponded very closely (within about 1 *per cent*) to the results obtained on the dry yarns using the standard test methods. Wetting out the yarns therefore appeared to offer no advantage on an automatic twist tester of the type employed in this investigation. The results obtained on the steamed and unsteamed yarns did not differ statistically significantly although the dry tests conducted on the steamed yarns gave values which were on the average about 1 *per cent* higher than the values obtained on the unsteamed yarns. This was probably due to the set imparted to the fibres.

The results obtained when employing an automatic twist tester were compared with the values obtained on a hand operated twist tester and with the nominal twist values. In general the agreement between the automatic twist tester results and the nominal values was excellent with a correlation coefficient of about 0,998 (17 readings). The correlation between the manual twist test results and the nominal values and the automatic test results, respectively, although very high (0,977) was not as good due mainly to a larger error involved in the manual values. It was also found that on the commercial yarns the manual test results were generally higher than those obtained with the automatic twist tester. It was concluded that the manual results were at fault.

Finally, it was found that the untwist-retwist test, when employed on this particular type of automatic twist tester and using the tensions recommended in the I.W.T.O. test method, gave results which were consistently too high.

It is therefore concluded that the values obtained on this particular type of automatic twist tester, when employing the test methods recommended for it, are sufficiently accurate and consistent, wetting the yarns offering no practical advantages under the test conditions employed on this type of machine.

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