# International Institute For Cotton

## Technical Research Division

## Manchester

**Research Record No. 161**


# A Preliminary Study To Investigate Whether There Is A Critical Moisture Content Below Which Maximum Tumble Drying Shrinkage Will Not Occur


**Robert D. Leah & Angela Mbeya**


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**Classification:** Fabrics/Knit1ed/Processing

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# Contents



*NB: Miss Mbeya's original text is not included in the digital version.  It has been discarded.*

## Introduction

The effect of using a tumble dryer on the potential shrinkage of knitted fabrics is well known and forms the basis of the IIC relaxation procedure for determining the *Reference State* of knitted structures.

To produce fabrics which have relatively low shrinkage figures to the tumble test the finisher must adjust the dimensions of the fabric to something approaching the *Reference State*. With the majority of knitgoods finishing equipment, particularly the drying equipment, this is not an easy task to achieve, particularly with fabrics having a low tightness factor.

The obvious solution to this problem is to incorporate a tumble drying operation into the scheme of finishing but, except for a few specialised qualities such as plush, this is out of the question for two main reasons.

1. It is a batch rather than a continuous operation.
2. It is highly labour intensive.

A number of machinery builders have appreciated this problem and have designed machines which introduce considerable mechanical agitation into the fabric during the drying operation to simulate the agitation which occurs in a tumble dryer.

Machines of this type include:

| | | |
|---|---|---|
| Babcock | - | Aerovar |
| Arbach | - | DSB |
| Passat | - | Air shrinker type 640 |
| Thies | - | Continuous tumbler T300 |
| Trofix | - | Continuous tumbler |
| Kiefer | - | Model not known |

To obtain realistic production speeds these machines are relatively large and hence quite expensive since fabric is initially delivered to them in the hydro-extracted or mangled state.

Some of us at IIC have held the conviction for some time that it may be possible to dry fabrics on conventional drying equipment down to a particular moisture level and then continue the drying operation on one of these specialised dryers to obtain maximum mechanical shrinkage. If this is the case it would mean that:

1. Existing conventional high-efficiency dryers can still be used to remove the bulk of the water.
2. A smaller mechanically assisted drying unit could be used to induce the shrinkage.
3. Productivity should be maintained without a considerable investment.

A considerable investigative study is obviously required to fully confirm our suspicions and this would be time-consuming and expensive.

As a first step, however, a laboratory investigation has been carried out by a Tanzanian student from UMIST, Miss Angela Mbeya, who spent six weeks working at TRD during the summer vacation.

In the time available only a limited amount of work could be attempted and therefore her brief was as follows.

*"Attempt to determine, for a limited range of knitted structures, whether there is a critical moisture content below which fabric will not develop its full potential shrinkage in a tumble dryer"*.

Miss Mbeya's report is attached but an outline of the work she carried out may serve to clarify the procedures reported.

A. Examination of the Hoover domestic tumble dryer: in particular, the temperatures obtained and the degree of fluctuation.

B. Determination of the full potential shrinkage of the fabrics to be included in the investigation.

C. Determination of the mechanical shrinkage (without wetting) of the fabrics included in the investigation.

D. Determination of the line dry shrinkage of the fabrics.

E. Measurements of shrinkage and residual moisture contents of fabrics against time in the tumble dryer.

F. Measurements of tumble dryer shrinkage after fabrics had been allowed to air dry down to various residual moisture levels.

## Observations

The determination of the characteristics of the tumble dryer was relatively straightforward and Miss Mbeya's graphs are given as *Figures 1 and 2*.

These show quite clearly how crude the thermostatic control is on a domestic tumble dryer. With a domestic machine there is no facility to control air flow or rotational speed of the drum. The determination of the potential tumble- and line drying was also straightforward as was the determination of mechanical (dry tumbling) shrinkage (*Figures 3-5*). The results of these determinations are given in *Table 1*.

**Table 1 Length Shrinkage %**

| Fabric | Water Only | Line Dry | Tumble Dry | Dry Tumble |
|---|---|---|---|---|
| Mercerised Crosstuck | 1.5 | 6.9 | 15.5 | 1.4 |
| Bleached Interlock | 10.1 | 17.1 | 16.5 | 6.0 |
| 1x1 Rib | 13.8 | 13.3 | 14.3 | 4.0 |
| Mercerised Single Jersey | 2.6 | 3.6 | 10.4 | ~ |

The relationship between shrinkage, residual moisture content and time in the tumbler was not easy to carry out due to tangling, stretching of the fabrics during untangling and measuring. Therefore some doubts must be thrown on the results.

The three replications are shown graphically in *Figures 6, 7 & 8*, but it is not possible to draw any conclusions from these graphs.

The final part of the investigation, which was not replicated due to limitations of time, has perhaps yielded the most useful information.

In this investigation fabrics were pre-weighed, washed and allowed to air dry on a table down to predetermined moisture contents, and were then placed in the tumble dryer to complete the drying operation. Again, Miss Mbeya's graphs have been redrawn and are given as *Figures 9-12*.

These indicate that, when fabrics are flat dried down to as low as 10% moisture based on regain weight (total moisture content of 16-17%) and then placed in the tumble dryer, they will largely attain their full potential tumble dry shrinkage.

## Conclusions

Due to a number of factors this preliminary investigation was somewhat incomplete but, nevertheless, some interesting observations have come out of it and the need for a more thorough study has been highlighted.

1. The Hoover domestic tumble dryer is far from suitable for such a study. It would be desirable to have a machine with better temperature control, variable air flow and the possibility to inject live steam into the drying chamber.
2. It would appear that fabrics can be placed in the tumble dryer with as little as 20% moisture present and still attain their full potential tumble dry shrinkage.
3. Mercerised fabrics shrink very little in the washing machine and develop most of their potential shrinkage in the tumble dryer. Unmercerised fabrics however can develop a considerable amount of their potential shrinkage in the washing machine.
4. One of the problems of a two-stage drying operation is the measurement of moisture content after the first stage of drying. A moisture content of 20% is difficult and expensive to measure since a conductivity technique cannot be used. Infra-red and microwave techniques require a great deal of calibration work and β-gauges are expensive.

This preliminary study has shown that full potential shrinkage occurs with relatively low amounts of moisture present and therefore this raises the question as to whether full potential shrinkage can be induced by tumbling in an atmosphere of steam. If this is the case, then fabrics could be dried down to as low as 10-12% residual moisture on a conventional dryer (a conductivity instrument would measure this) and then mechanically agitated in an atmosphere of steam.

Unfortunately, this kind of investigation cannot be carried out with a domestic tumble dryer.

The observation that mercerised fabrics shrink very little in a washing machine warrants further study.

**Figure 1**

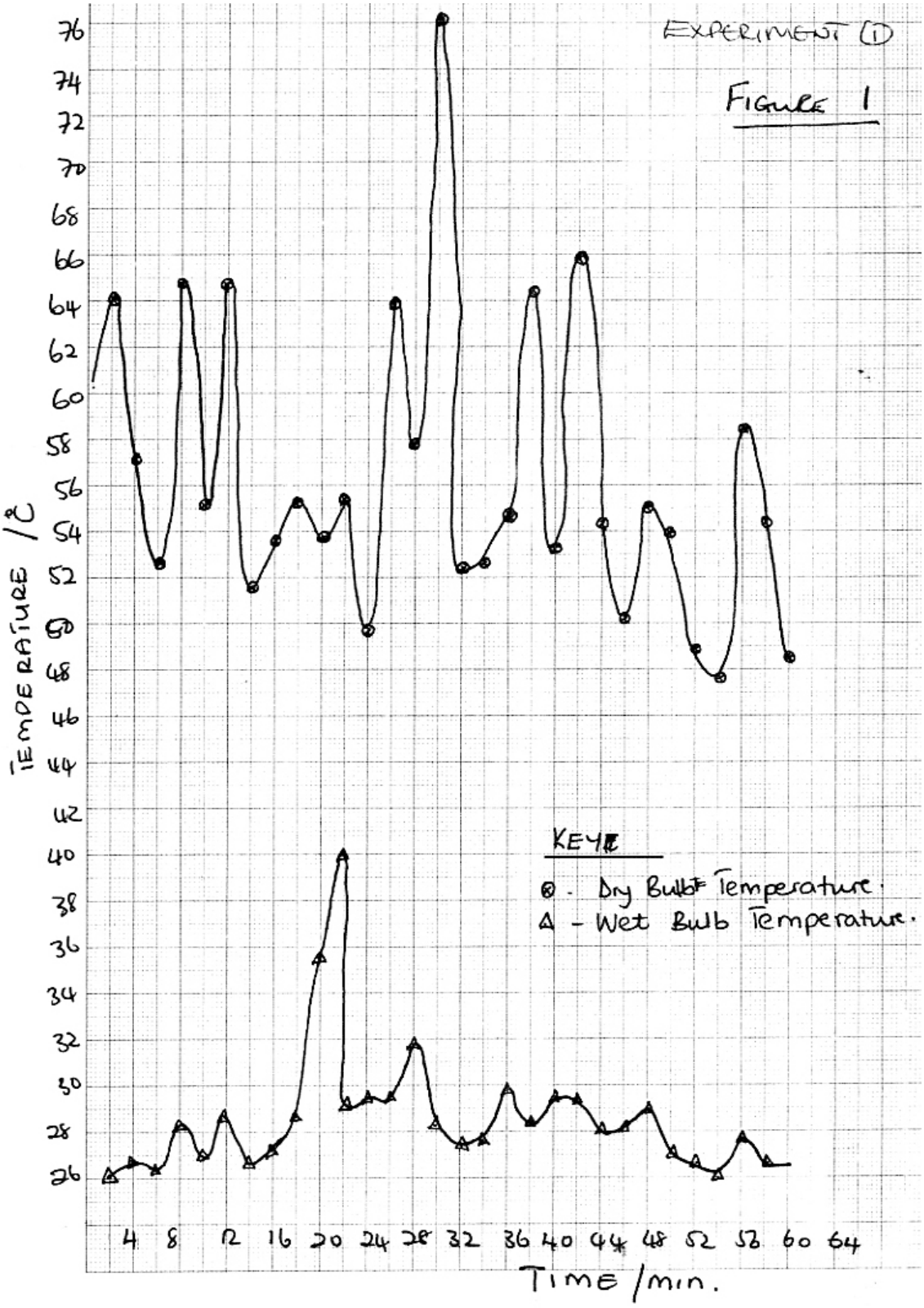

EXPERIMENT (1)
FIGURE 1
TEMPERATURE /°C
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
KEY
⊗ - Dry Bulb Temperature.
Δ - Wet Bulb Temperature.
4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64
TIME /min.

**Figure 2**

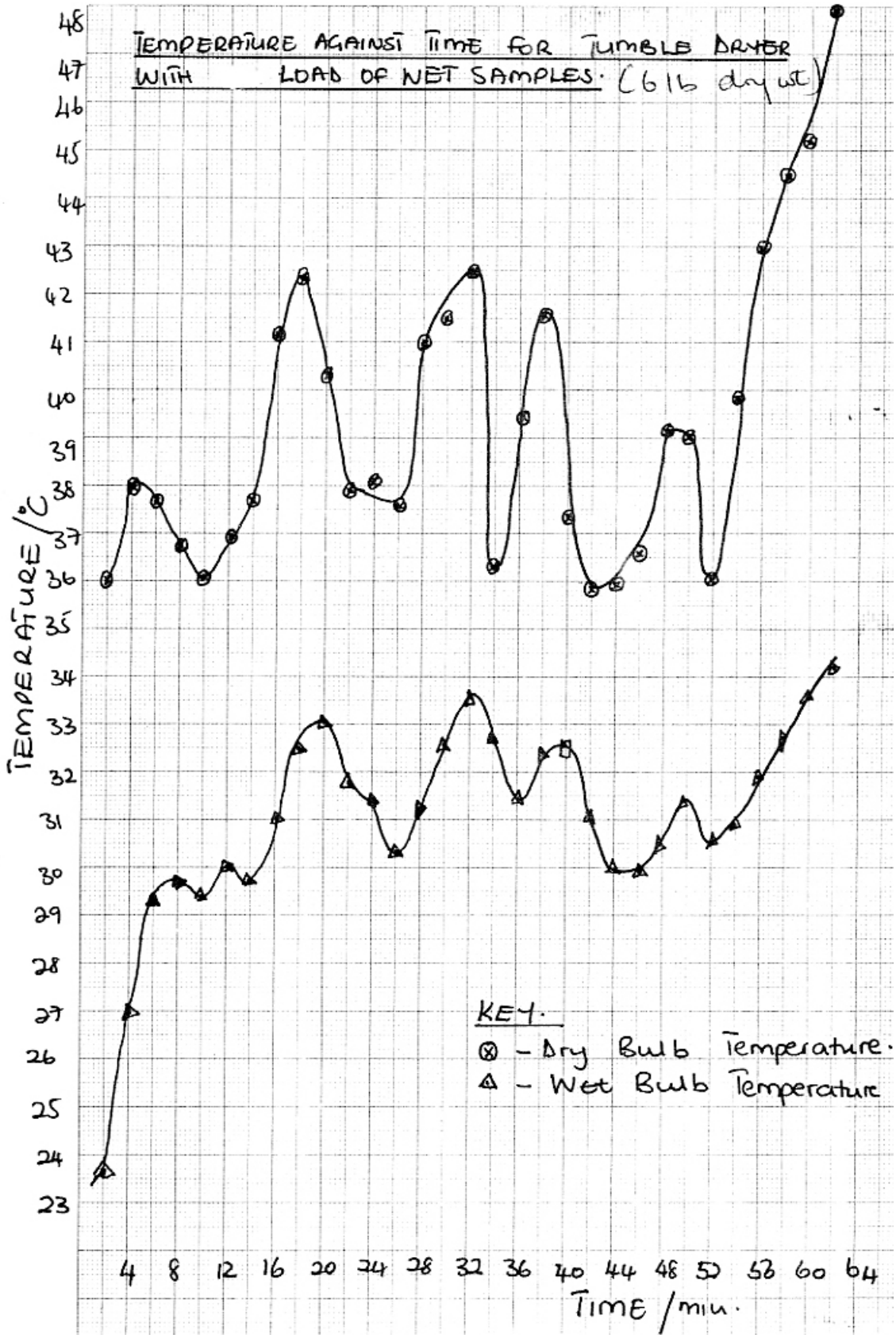

TEMPERATURE AGAINST TIME FOR TUMBLE DRYER
WITH LOAD OF WET SAMPLES. (6lb dry wt)
TEMPERATURE /°C
TIME /min.
KEY.
⊗ - Dry Bulb Temperature.
△ - Wet Bulb Temperature

**Figure 3**

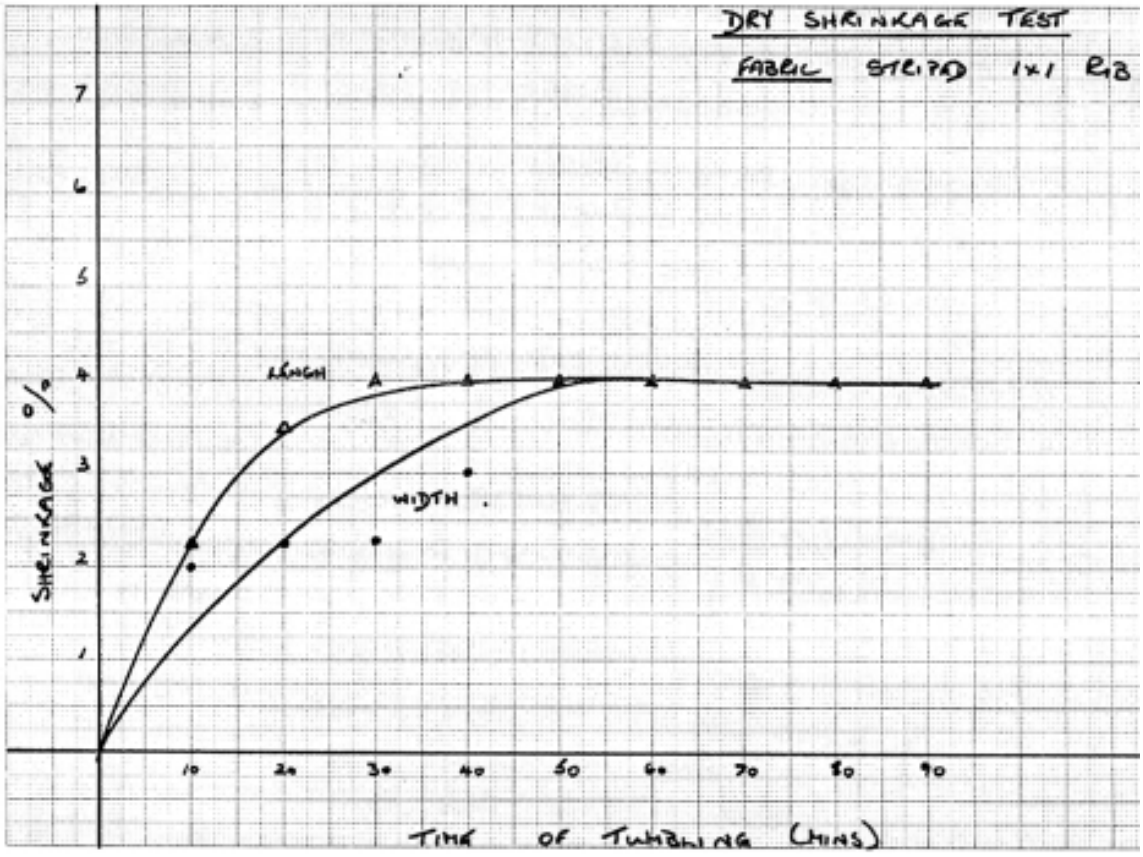



**Figure 4**

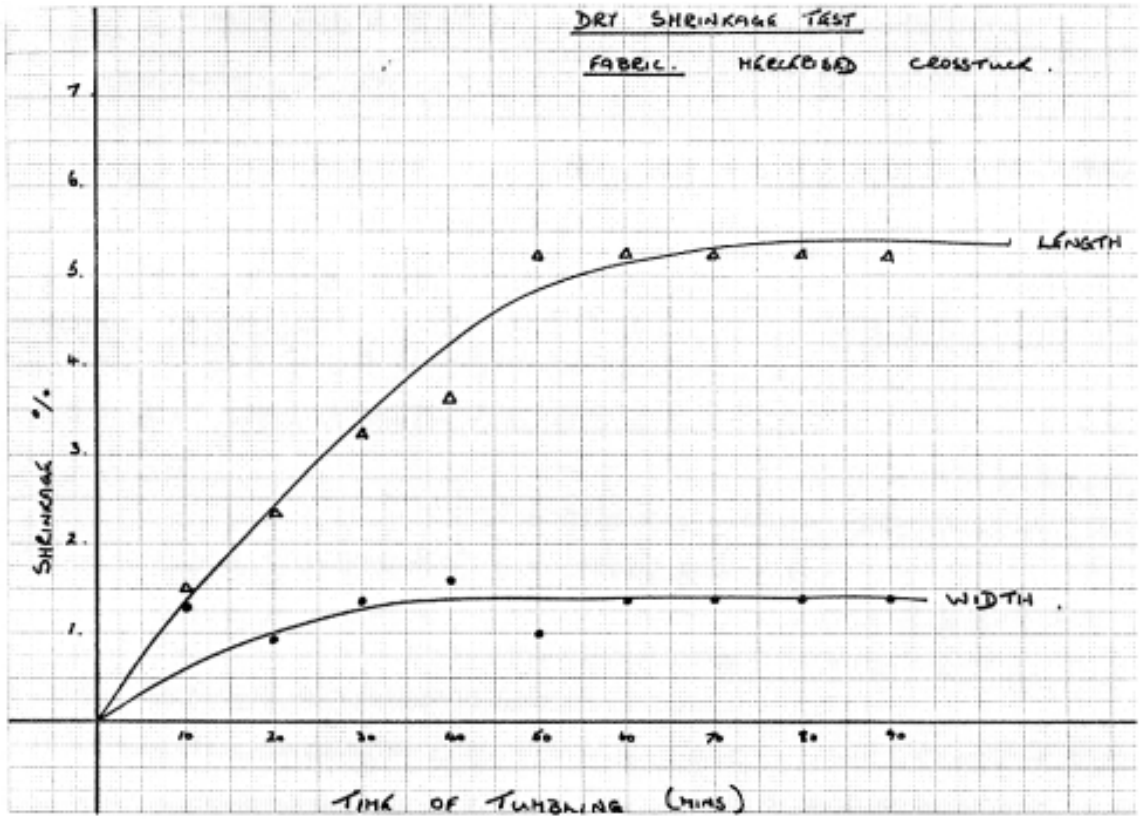


**Figure 5**

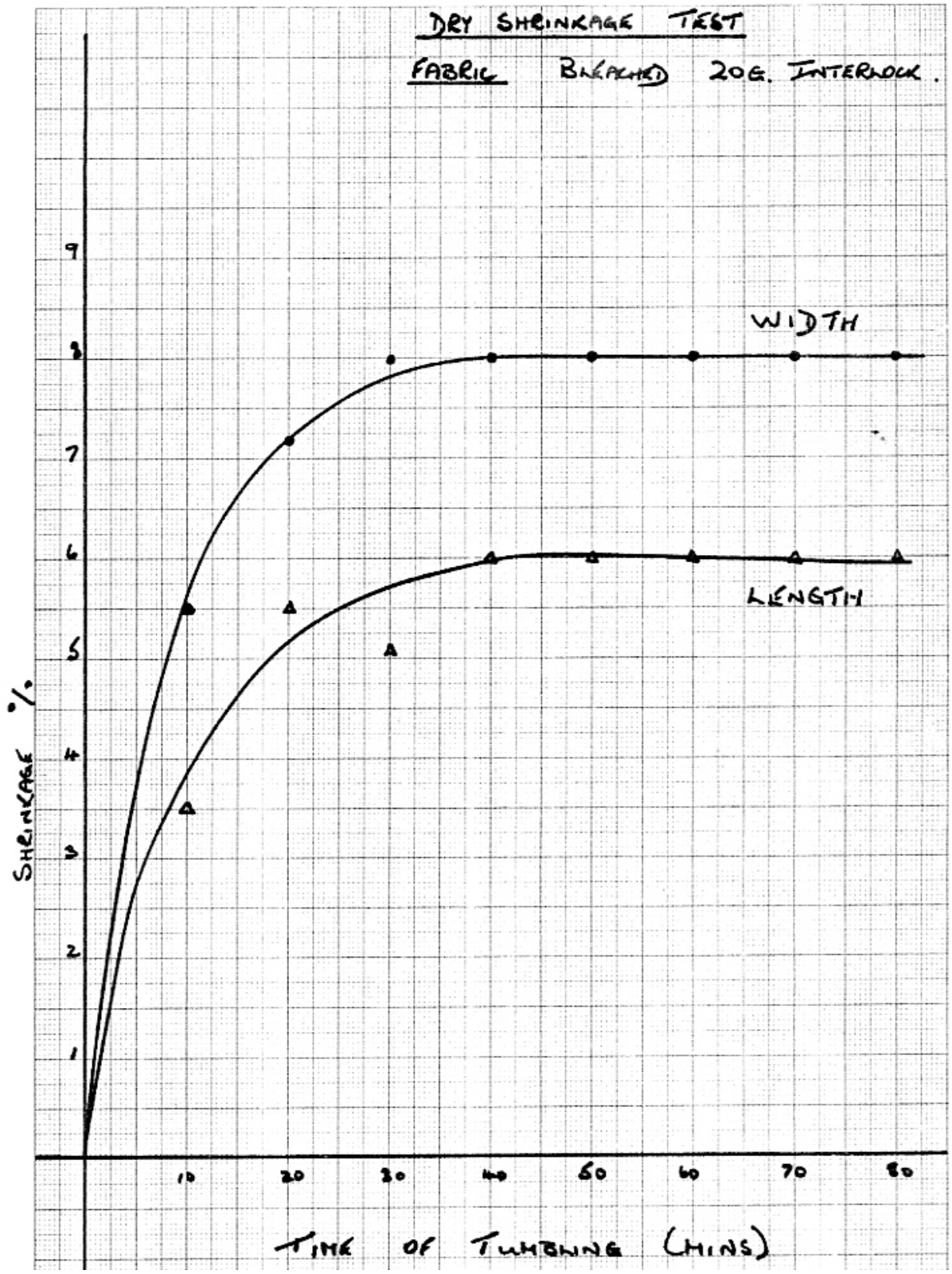

DRY SHRINKAGE TEST
FABRIC BLEACHED 20G. INTERLOCK.
WIDTH
LENGTH
SHRINKAGE %
TIME OF TUMBLING (MINS)
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80

**Figure 6**

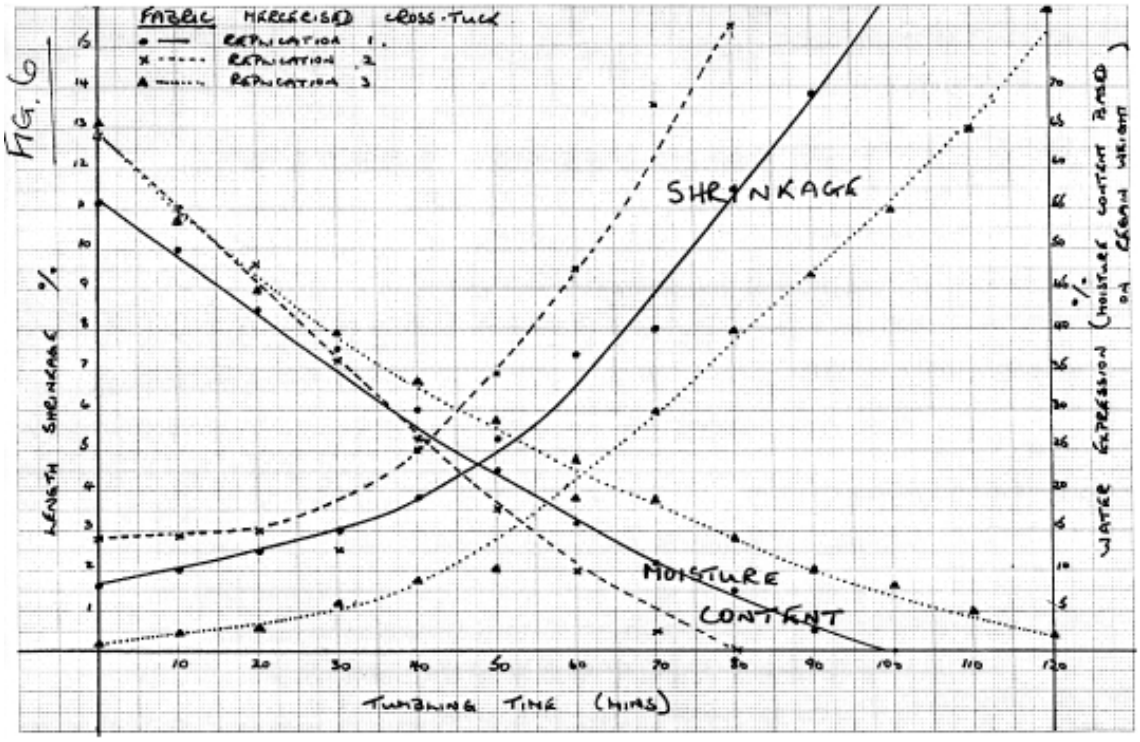



**Figure 7**

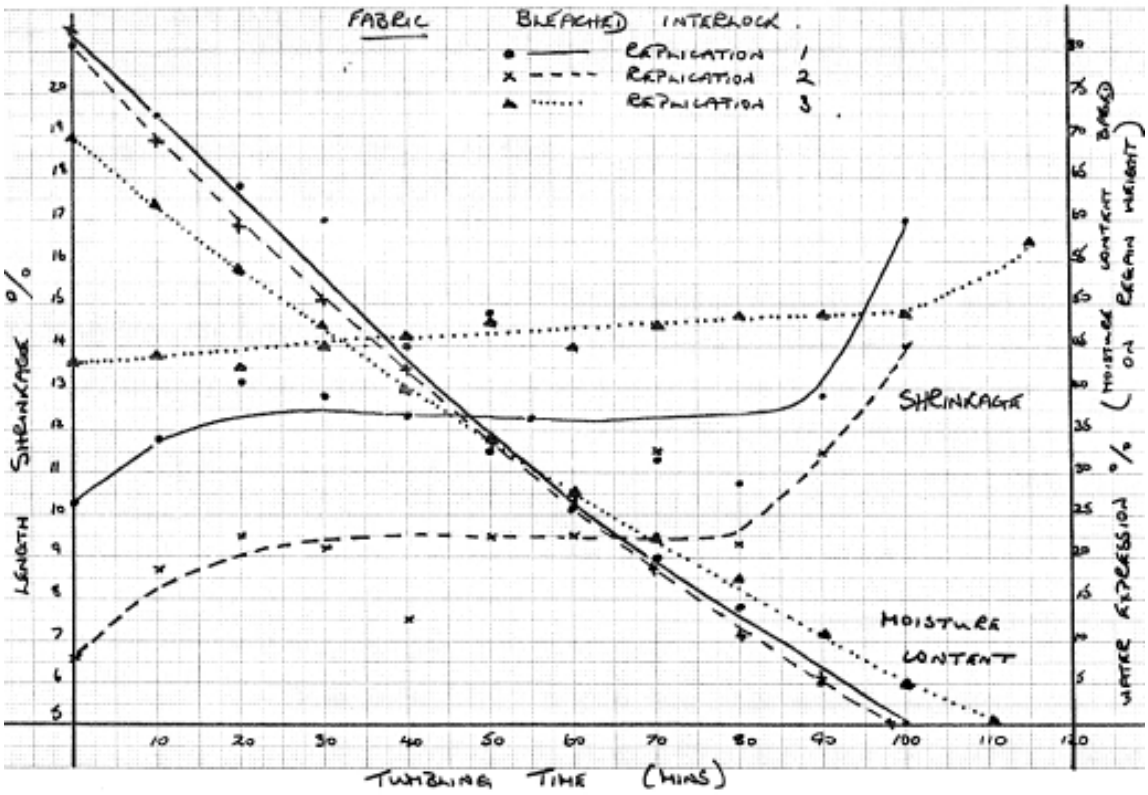


**Figure 8**

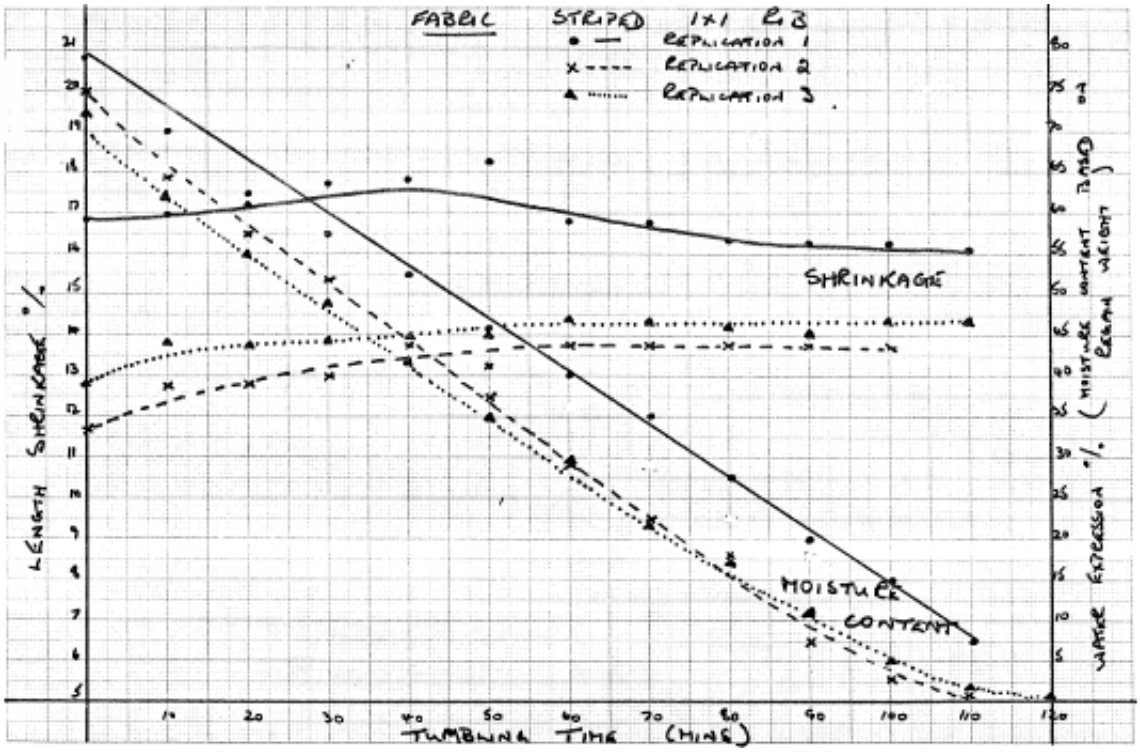



**Figure 9**

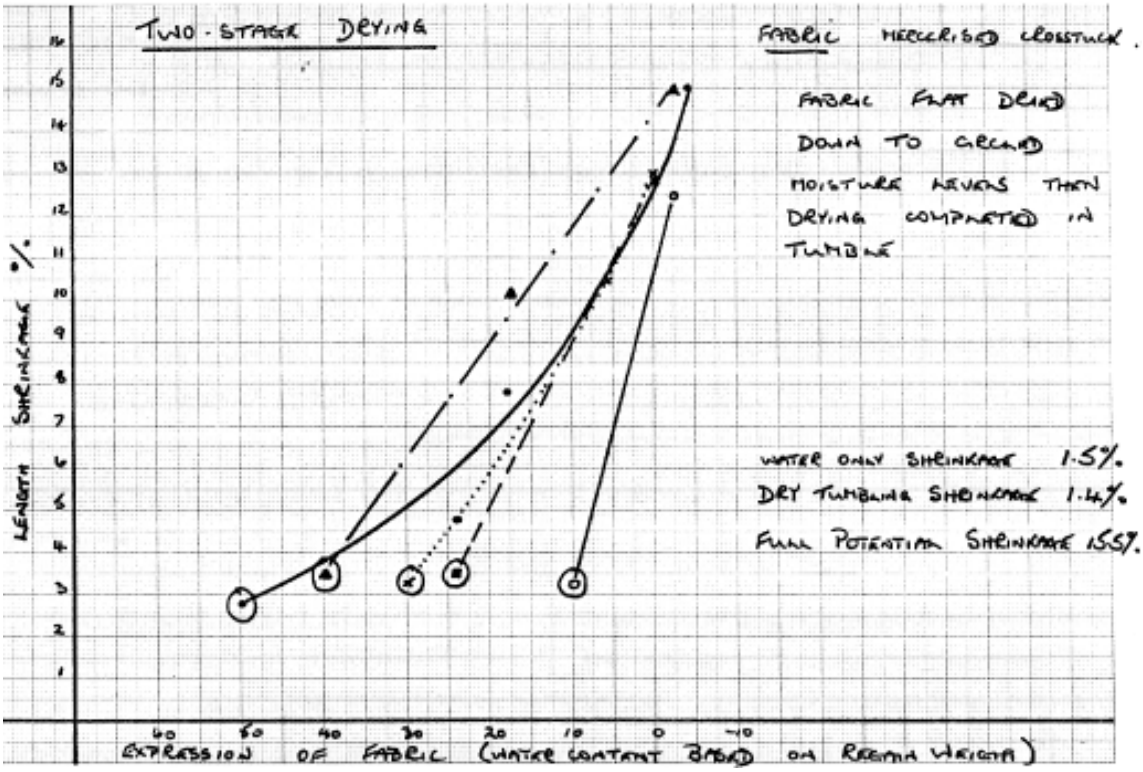


**Figure 10**

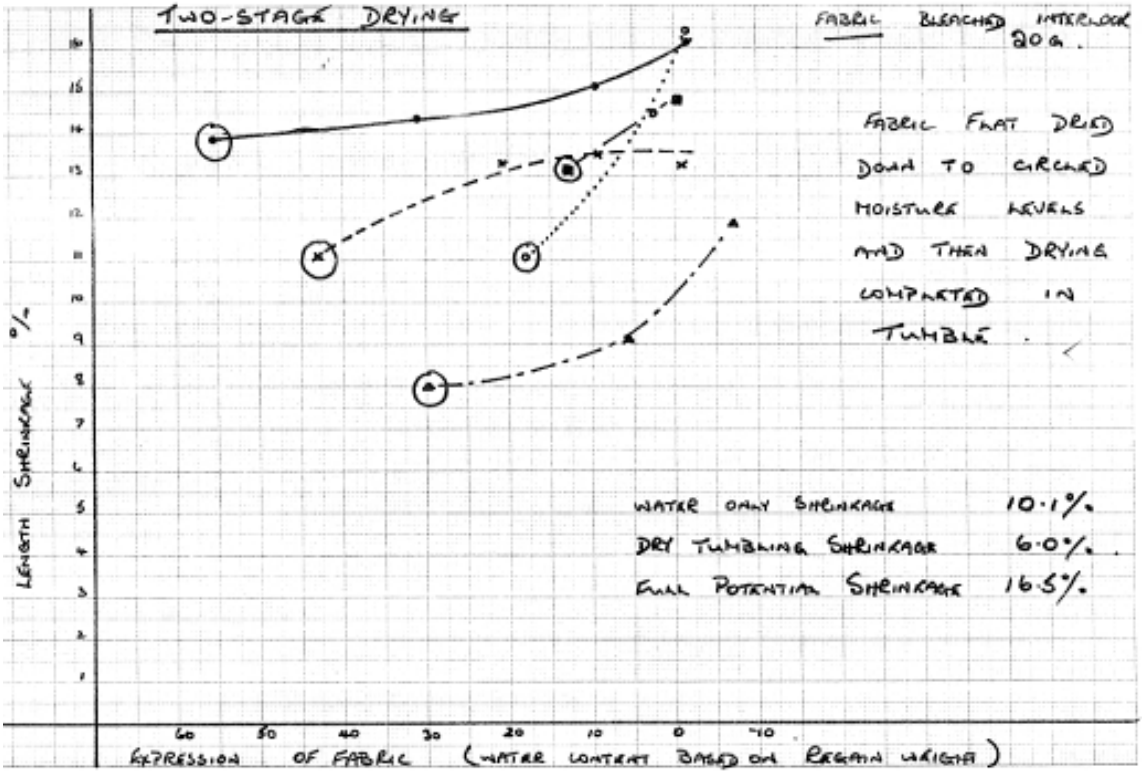



**Figure 11**

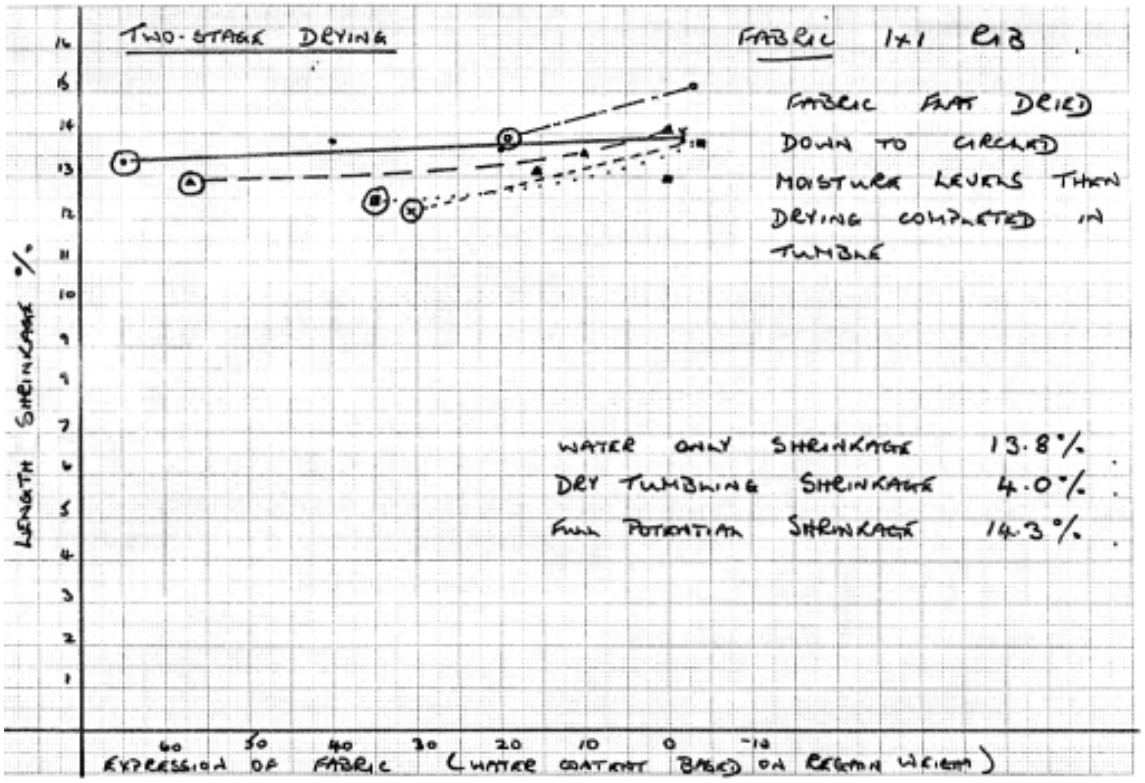
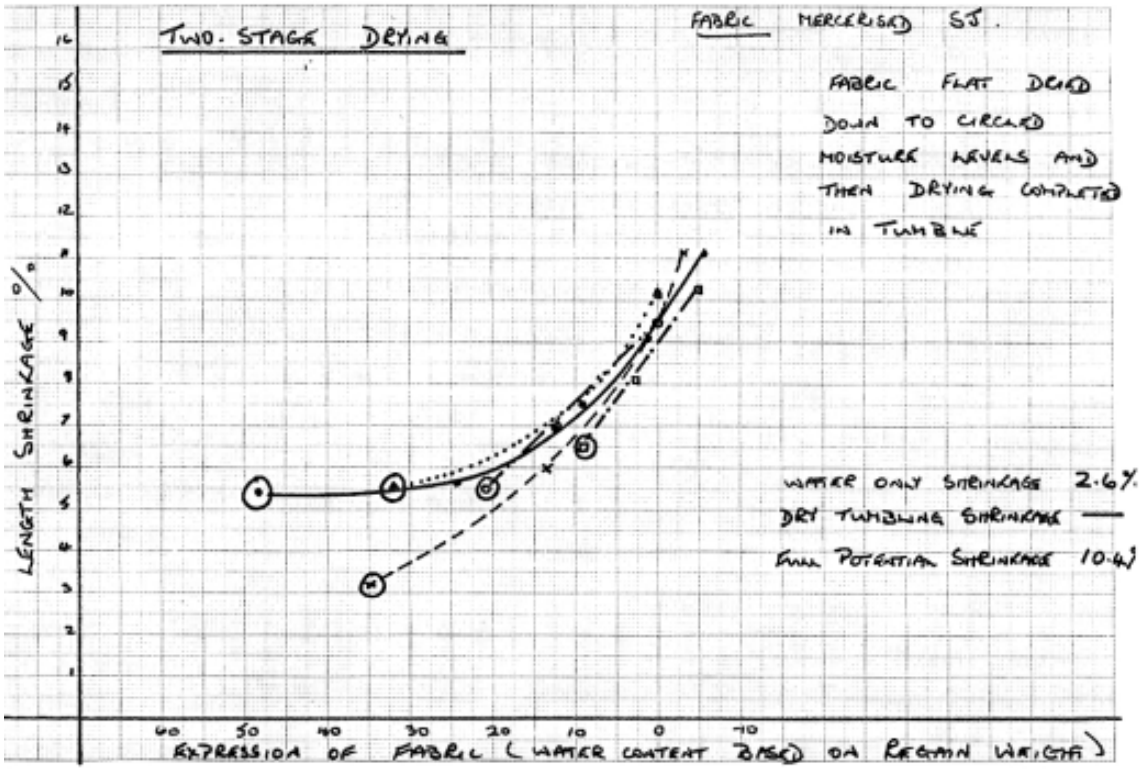


**Figure 12**


TWO-STAGE DRYING
FABRIC MERCERISED SJ.
FABRIC FLAT DRIED DOWN TO CIRCA MOISTURE LEVELS AND THEN DRYING COMPLETED IN TUMBLE
LENGTH SHRINKAGE %
WATER ONLY SHRINKAGE 2.6%
DRY TUMBLING SHRINKAGE
FULL POTENTIAL SHRINKAGE 10.4%
EXPRESSION OF FABRIC (WATER CONTENT BASED ON REGAIN WEIGHT)