CHAPTER VI

USE OF MULTIPLE REGRESSION EQUATION IN DATA ANALYSIS

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In the past few years there has been an increasing interest in the use of modern statistical methods in chemistry. Hunter et al[1] have illustrated the advantages of statistically designed experiments. They have shown that it is relatively simple, with factorial and fractional factorial designs, to determine the effects of separable variables even though several variables are changed at the same time. Davies[2] and Barnett et al[3] have mentioned various statistical methods which can be of importance in chemistry and chemical technology. Gore[4] described a general scheme, which is useful for investigating multivariate phenomena. A process where a compromise between improvement in one property and deterioration of the other has to be reached, a vector addition of these has been used by Bigler[5] to predict the advantages of the process. Driver[6] has given some introductory account of basic statistical methods, recent developments and their applications.

Cooke et al[7] have reported results of an extensive study of the application of urea, modified urea, melamine and modified melamine formaldehyde resins using ammonium, alkanolamine and metallic inorganic salt catalysts to cotton fabric. The effect of variation in resin concentration, curing temperature and time on the wrinkle recovery, tensile strength, tear strength and discolouration of the treated fabric before and after washing are discussed. This work was designed and analysed statistically on a high speed electronic computer. Ferrante[8] applied statistical techniques to evaluate a new crease proofing agent and to determine conditions for its application. The effects of selected operating conditions were studied in regard to crease recovery, strength loss and whiteness. Catalyst and resin concentration, curing time and curing temperature were varied through five levels.

Following factors play an important role in cross-linking of cellulose with DMEU.

(i) temperature of drying
(ii) time of drying
(iii) temperature of curing
(iv) time of curing
(v) concentration of catalyst
(vi) concentration of resin
(vii) pH of pad bath.

In most of the earlier studies attempts have been made to correlate one or two of the above variables with fabric properties such as tensile strength and crease recovery. In the present work, multiple regression equations have been derived to estimate correlation between various processing variables and fabric properties.

EXPERIMENTAL

Even a single 2-level experiment with seven variables would need 128 individual experiments and a proper "second order design" of the kind used by Gerald[8] would need over 60 individual experiments. Since lack of time prevented undertaking such extensive experimentation, the present series of experiments was planned with only a limited objective in view. In planning this series, no attempt was made to estimate (i) how the changes in level of one variable would influence the effect of other (ii) whether the effect of the variables are curvilinear.

Twelve random combinations of the variables were formed by using 3 levels of each of the seven variables. Table XXVI lists the 7 variables and table XXVII gives the detailed experimental plan. The properties (y_1, y_2, y_3 and y_4) of the fabrics measured after treatment according to plan in table XXVII are given in table XXVIII. These data were analysed by using the available IBM programme on linear regression analysis on an IBM 1620 computer.

TABLE XXVI

VARIABLES AND THEIR RANGE

S.No.	Variables	Levels of the variables
X_1	Resin (DMEU) concentration in the pad bath	4, 6, 8% (w/v)
X_2	Temperature of drying	60^{o}, 70^{o}, $80^{o}C$
X_3	Time of drying	1, 2, 3 minutes
X_4	Temperature of curing	120^{o}, 140^{o}, $160^{o}C$.
X_5	Time of curing	3, 4, 5 minutes
X_6	Catalyst ($ZnCl_2$) concentration in the pad bath	0.04, 0.06, 0.08 molar
X_7	pH of the pad bath (adjusted with HCl)	2.0, 2.5, 3.0

TABLE XXVII

EXPERIMENTAL PLAN OF PROCESSING VARIABLES

Experiment No.	DMEU conc. (w/v) (x_1)	Temp. of Drying °C (x_2)	Time of Drying (min) (x_3)	$ZnCl_2$ conc. (mole) (x_6)	pH of pad bath (x_7)	Temp. of curing (x_4)	Time of curing (x_5)
1	4	60	1	.04	2.0	120	3
2	6	70	1	.06	2.5	140	4
3	8	80	3	.08	3.0	140	5
4	4	70	2	.06	2.5	160	5
5	6	70	3	.08	3.0	160	4
6	8	60	2	.04	2.5	120	5
7	4	80	2	.06	2.0	160	3
8	6	60	3	.04	3.0	120	4
9	8	80	1	.06	2.0	140	3
10	4	60	2	.08	2.0	120	3
11	6	70	3	.08	2.5	140	4
12	8	80	1	.04	3.0	160	5

TABLE XXVIII

PHYSICAL PROPERTIES OF COTTON POPLIN TREATED
AS PER DETAILS GIVEN IN TABLE XXVII

(Wet pick up 75%)

Experiment No.	Tensile strength (on curing) (W+F)	Crease Recovery (on curing) W + F		% Nitrogen (on curing)
		Wet	Dry	
	(y_1)	(y_2)	(y_3)	(y_4)
1	33.2	224	229	0.56
2	30.7	244	262	0.77
3	25.9	262	283	1.00
4	26.5	230	248	0.61
5	25.3	249	266	0.88
6	30.0	235	248	0.79
7	26.6	239	251	0.59
8	29.3	224	243	0.77
9	23.5	260	279	1.10
10	29.2	226	241	0.60
11	26.0	232	251	0.84
12	24.9	250	269	1.10

The equation used was

$$y = Bo + B_1 X_1 + B_2 x 2 + \quad ...... \quad + B_7 x 7$$

where y represents the particular response (property) measured and X_1, X_2.... represent the variables. Bo, B_1, B_2 .... are the coefficients obtained by the method of least square, which gives the line of best fit to the data.

DISCUSSION

After obtaining the equations for various properties, they were scanned to pick out the significant variables i.e. those variables which show a regression coefficient substantially higher than the error associated with its estimation. The results of regression analysis are summarised in Table XXIX.

CONCLUSIONS

Table XXIX permits the following conclusions to be drawn about the effect of processing variables on the properties of DMEU treated fabrics.

1. Tensile strength decreases with the increase in temperature and in time of drying (Fig. 38).

2. Wet crease recovery increases with increase in resin concentration (Fig. 39) and in temperature of drying.

TABLE XXIX

COMPUTERISED REGRESSION ANALYSIS OF DATA

Variables	Tensile strength		Wet Crease Recovery		Dry Crease Recovery		Percentage Nitrogen	
	Regression coefficient	Error of coefficient	Regression coefficient	Error of coefficient	Regression coefficient	Error of coefficient	Regression coefficient	Error of coefficient
X_1 Resin concentration	-	-	3.61	1.13	5.38	1.02	0.089	0.013
X_2 Temperature of drying	- 0.273	.06	1.00	0.22	0.97	0.21	0.006	0.002
X_3 Time of drying	- 1.06	.60	-	-				
X_6 Catalyst concentration	-	-	-	-	270.74	98.54	-	-
Constant	48.85		147.61		139.14		-0.202	
R. Square	0.70		0.83		0.92		0.89	

FIG. 38

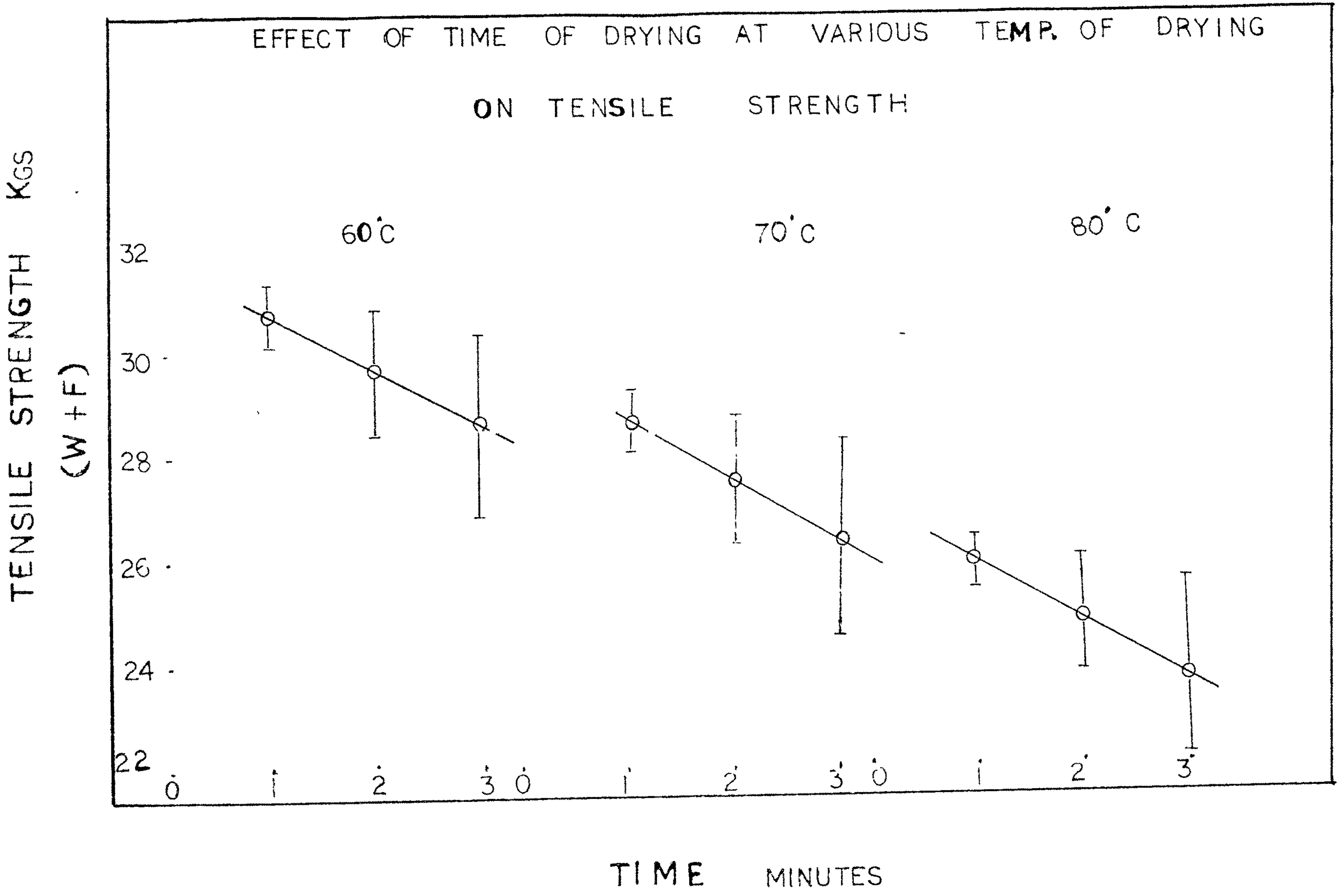
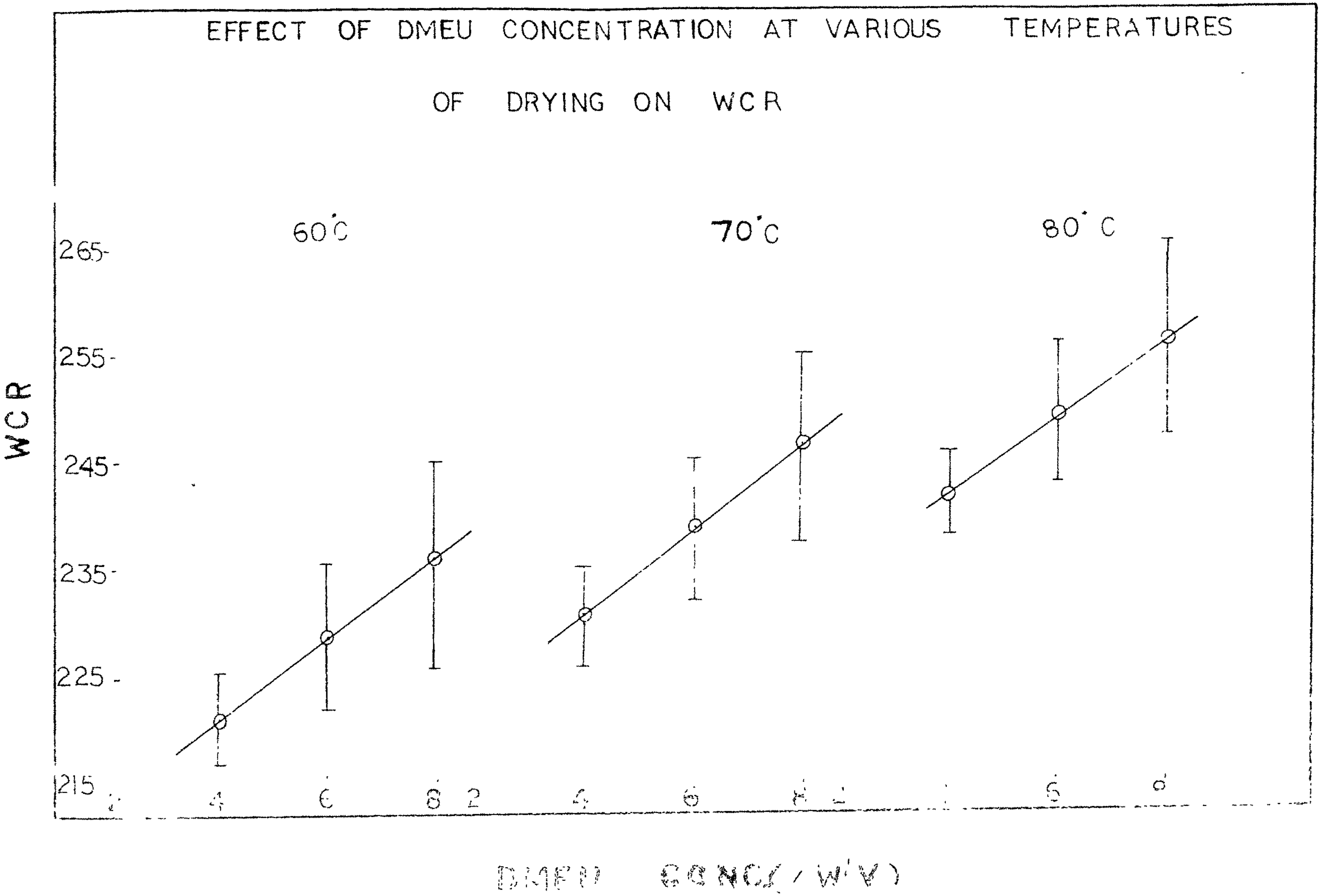

EFFECT OF TIME OF DRYING AT VARIOUS TEMP. OF DRYING
ON TENSILE STRENGTH
TENSILE STRENGTH KGS
(W + F)
60°C
70°C
80°C
32
30
28
26
24
22
0
1
2
3
TIME MINUTES

FIG. 39



EFFECT OF DMEU CONCENTRATION AT VARIOUS TEMPERATURES
OF DRYING ON WCR
60°C
70°C
80°C
WCR
265
255
245
235
225
215
4
6
8
4
6
6
DMEU CONC(W/V)

3. Dry crease recovery increases with increase in concentration of the catalyst and of the resin, and with time of drying.

4. Bound nitrogen in the treated samples increases with increasing resin concentration and with increasing temperature of drying.

These conclusions should be considered tentative since experiments were planned with a limited objective in view. If a complete second order design is used for planning and analysis of experiments, some of these conclusions drawn above may get modified.

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