CHAPTER - III

FIELD MEASUREMENTS

In this chapter we have presented the data collected on temperature Brix, soil type, sugarcane variety and time of preparation at 23 different sites in Satara and Kolhapur Districts.

3.1 Introduction :

We have divided the present work in to two parts- Field measurements and Development of an electronic device.

Field measurements :

In order to study the role of physical parameters such as temperature and Brix of juice in jaggery manufacturing process, we have selected 11 jaggery manufacturing units froms satara district and 12 units from Kolhapur district. From each unit we have recorded the following information/data.

1. Time of prepration - Morning/Noon/Evening,
2. Total cane juice taken for jaggery prepration.
3. Total time required for prepration.
4. Cane type.
5. Soil type.
6. Temperature and Brix readings for,

i) Initial stage

ii) First Scum stage

iii) Kakavi stage

iv) Striking point stage

We have studied the effect of each parameter in jaggery manufacturing process.

For Brix measurement we have used two Brix hand refractometers of EARMA makes having ranges (0-32%) and (56-92%). For temperature measurements, murcury thermometer is used.

3.2 Brix Hand Refractometer

3.2.1 Brix Definition :

The Brix of a solution is the concentration of a solution of pure sucrose in water (expressed as parts by weight of sucrose per 100 parts by weight of solution) having the same density as the solution at the same temperature. This definition is general in form. The Brix of a solution of pure sucrose in water is a direct measure of the percentage of sucrose or solid matter by weight in the solution. For an impure solution the Brix represents the apparent percentage of solid matter as determined by densimetric method. The Brix is then numerically the same as the percentage of solid matter in a pure sucrose solution of the same density. In practiacal determination of Brix it is assumed that test solution has the same temperature coefficient of density as the corresponding sucrose solution. If refractive index be adopted instead of density as a basis of computation the value derived is known as refratometer Brix.

3.2.2 Refractometer Brix :

The precent of weight of solids in solution as indicated by sugar refractometer, or as derived from the refractive index and reference to table of equivalents of percent sucrose & refractive indices.

The refractometer may be used not only for the determinaton of percent solids, in the laboratory or in the vacuum pan, but also for that of the fine grain molasses. The conversion of refractive indices into percent solids is to be effected by means of the International scale (1956), of the International commission for uniform methods of sugar analysis. If sugar refractometer is used it should be calibrated according to International scale.

3.2.3. The Refractometer :

The optical properties of sugar solution afford rapid and convenient methods for their analysis. Refractometer is used in the limited degree for the rapid determination of total solids in juice, syrup etc. At present moment, its use is increasing day by day.

Physical Principle :

When a ray of light travelling in one medium is obliquely incident on a surface separating this medium from another medium, part of light is reflected back into the first medium while generally the remaining part continues to travel into the second medium in a direction which is incident the original direction. The first part of the light obeys the low of reflection while the second, part, which is said to be refracted into the second medium obeys the laws of refraction. These lows are stated as fcllows :

(i) The incident and the refracted rays lie in one and the same plane with the normal to the surface at the point of incidence, and

(ii) The sine of the angle of incidence to the sine and the angle of refraction is a constant ratio.

This constant ratio is called the index of refraction between the first and second media and its value depends only on

a) The nature of the two media

b) The nature of light (wave length) and

c) The temperature of the media

The index of refraction between an optically

rarer medium is an important fraction, and as the sine of an angle increases or decreases with the angle this shows that when refraction takes place between denser and the rarer medium, the refracted ray is more inclined to the normal to the surface than the incident ray. As the angle of incidence increases the angle of refraction increases in the same direction ultimately a point is reached when for a particular angle of incidence (which is called the critical angle) the retracted ray just grazes the surface of the two media. For angle of incidence greater than the critical angle no light is refracted into the second medium but all the light is reflected back into first medium. This phenomenon is called the total internal reflection and the phonomenon is the basis of the construction of all the refractometers.

In a homogeneous medium, light travels in straight lines. If, however, a beam of light passing through one medium should meet the surface of second medium, it will, in general, be deflected or bent from its original path. It is found that there is a definite relationship between the angle of refraction. It is given by

$$\frac{\text{Sin } i}{\text{Sin } r} = n$$

Where,

i=angle of incidence

r= angle of refracton

and 'n' is called the refractive index between the two media.

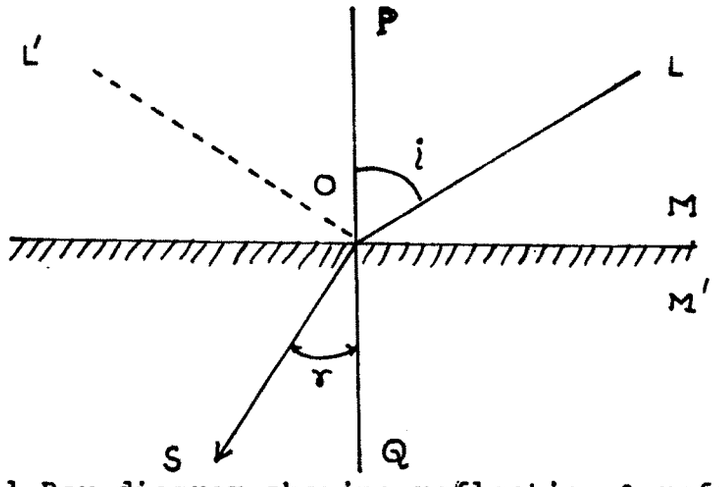

Fig 3.1 Ray diagram showing reflection & refraction.

In fig.3.1 LO represents the incident ray, which meets the interface between the media M and M' at an angle LOP. Portion of light is reflected along OL', while the remainder is transmitted along the path OS, which makes with perpendicular the angle SOQ(r). If refracted ray is bent towards the perpendicular, the medium M' is said to be of greater optical density than M. It is found that the refractive index varies with wave length of light, and therefore ordinary white light is decomposed into light of the different prismatic colour, this is known as dispersion.

There are a number of methods for determination of the refractive index, but the most commonly employed

is the method of total reflection. The principle of method is illustrated fig. 3.2

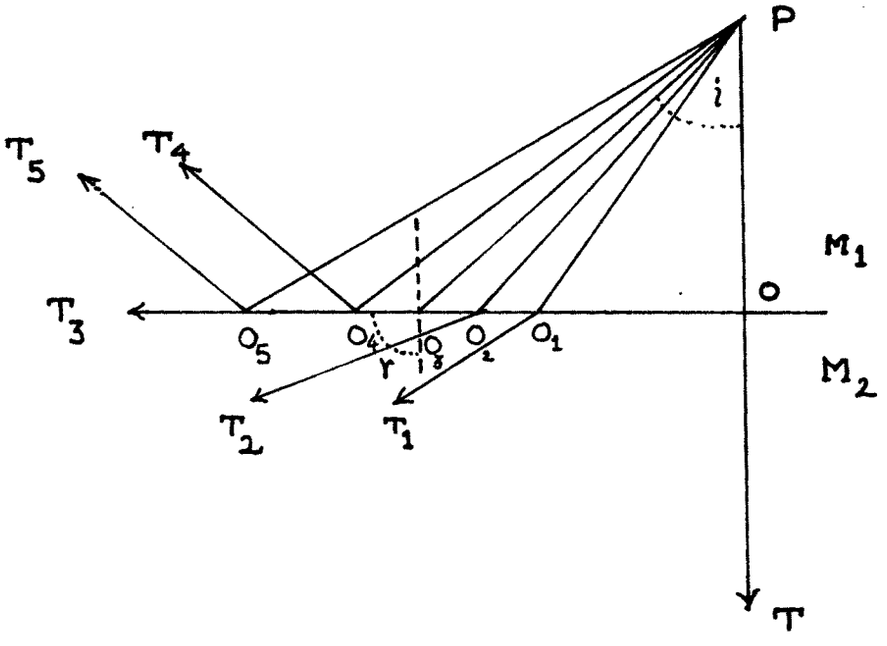

Fig. 3.2 Principle of total reflection.

M_1 & M_2 are two media, of which the former is optically more dense. Beam of light from the source P Strike the interface at various angles. Those meeting the surface at right angles are transmitted without refraction. The ray PO is refracted along O_1T_1; PO_2 emerges along the path O_2T_2, and as the angle of incidence increases the emergent ray approximates progressively more closely to the interface between the two media. Finally, the point is reached where the emergent ray coincides with the surface and the angle of refraction is 90^o. If the

angle of incidence be increased beyond the value (i), the beam is no longer transmitted through M_2, but suffers total reflection as shown by $PO_4 T_4$.

For the critical value of (r), the equation-

$$n = \frac{\text{Sin } i}{\text{sin } r} \qquad \frac{\text{Sin } i}{\text{Sin}90^{\circ}}$$

$n = \text{Sin } i$ $\quad \because \text{Sin}90^{\circ} = 1$

It will be clear that total reflection takes place only when light passes into an optically rarer medium. This principle is employed in the construction of the Abbe retractometer, which is the best instrument for the determination of refractive index of sugar solutions.

In sugar refractometer the denser medium used is flint glass whose index of refraction with respect of air is about 1.75 for a light of given colour which is sodium. The instruments are so calibrated as to give directly the indices of refraction direct from the critical angle. Some instruments are calibrated with the refractive index and the corresponding Brix degrees.

3.2.4 Hand sugar refractometer :

Hand sugar refractometer are optical instruments for the rapid and precise determinations of the dry substance (sugar) content of juices fruits and other sugar products.

The manipulation is very simple, the consumption of material amounts to only a few drops, and the result of measurement is obtained in a few seconds. The numerous fields of application of the hand sugar refractometer call for a large range of measurement, 0-85.

First juice is extracted from the cane by squeezing. A few drops of juice are placed on the surface of the measuring prism. The illuminating prism is then swung into contact and the instrument directed to the bright sky, or when used in the laboratory, towards a window or artificial light source (incandescent lamp). One sees the scale in the field of view of the ocular as a bright and a dark field. This dividing line of the two field indicates directly on the scale with an accuracy of 0.2% [Banerji (1958)].

By using Brix hand refractometer one thus gets directly the total number of solids in solution. The

values of measured Brix and temperatures from all 23 units are presented in the following observation designated as $K_1, K_2, K_3, \ldots\ldots, K_{12}$ for Kolhapur and $S_1, S_2, \ldots\ldots, S_{11}$ for Satara.

Brix hand refractometer is shown in plate No.1

Plate No.1 : Brix hand refractometer

3.3 Data collection and Tabulation :

I) Observations from Kolhapur districts.

K1)

Name : Shripati Ganu Vazge
Place : Wadange
Date : 7-12-94.
Time of preparation: Morning
Total time : 170 min
Cane type : co-671
cane juice : 1000 litre
soil type : Black Soil

Stage	Time hrs	Temp. °C	Brix
Inital	9.00	27°c	18%
Ist Scum	9.30	80°c	20%
Kakavi	11.40	106°c	66%
Striking point.	11.50	118°c	88%

K2)

Name : K.R.Patil
Place : wadange
Date : 7-12-94
Time of preparation : Noon
Total time : 2.17hrs;137 min
Cane type : co 7704 + 8014
Soil type : Black
Cane juice : 1000 litre

Stage	Time hrs	Temp. °c	Brix %
Initial	1.20	25	14
First Scum	1.50	80	20
Kakavi	3.25	105	65
Striking Pt.	3.37	117.5	88

K 3)

Name : Pandurang Shivaji Patil.
Place : Wadange
Date : 8-12-94
Time of preparation : Noon
Total time : 135 min
Cane type :Co-8014
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time (hrs)	Temp. (°c)	Brix (%)
Initial	11.30	28	14
First Scum	12.15	82	21
Kakavi	1.35	105	65
Striking pt	1.45	118	88

K 4)

Name : Shamu Maruti Devane
Place : Wadange
Date : 9-12-94
Time of preparation : Noon
Total time : 147 min
Cane type :Co-671
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time (hrs)	Temp. (°c)	Brix (%)
Initial	1.00	29	14.5
First Scum	1.30	81	20
Kakavi	3.15	105	72
Striking pt.	3.27	118.5	88

K 5)

Name Sampat Sripati Barale
Place : Wadange
Date : 10-12-94
Time of preparation : Noon
Total time : 145 min.
Cane type :Co-8014
Soil type : Black soil
Cane juice : 1000 litre

Stage	Time(hrs)	Temp. (°c)	Brix (%)
Initial	1.50	32	18
First Scume	2.20	85	20
Kakavi	4.00	105	66.5
Striking pt.	4.15	118	88

K 6)

Name : Shankar Ganpati Devane
Place : wadange
Date : 10-12-94
Time of preparation : Evening
Total time : 160 min
Cane type :Co-8014
Cane juice : 1000 litre
Soil type : Black

Stage	Time(hrs)	Temp. (°c)	Brix(%)
Initial	2.15	29	13
First Scum	2.47	80	17
Kakavi	4.40	105	72
Striking pt.	4.55	118	88

K 7)

Name : Dilip Bandopantt Shelar
Place : Wadange
Date : 11-12-94
Time of preparation : Evening
Total time : 137 min.
Cane type : Co-671
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time(hrs)	Temp.(°c)	Brix(%)
Initial	2.00	31	12
First Scum	3.00	97	20
Kakavi	4.00	105	66
Striking pt.	4.17	118	89

K 8)

Name : Bapusaheb Shripati Devane
Place : Wadange Mala.
Date : 12-12-94
Time of preparation : Morning
Total time : 145 min.
Cane type : Co(8014+671)
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time(hrs)	Temp.(°c)	Brix(%)
Initial	9.15	25	15.5
First Scum	9.45	93	21
Kakavi	11.45	105	75
Striking pt.	11.40	118	88

K 9)

Name : Shripat Abasaheb Dinde
Place : Nigwee
Date : 12-12-94
Time of prepration : Noon
Total time : 140 min.
Cane type :Co-7704
Cane juice : 1000 litre
Soil type : Black soil

Stage	Time(hrs)	Temp: (°c)	Brix(%)
Initial	1.17	25	14
First Scum	1.50	80	20
Kakavi	3.25	105	65
Striking pt.	3.37	117.5	88

K 10)

Name : Chandrakant Bodake (Patil)
Place : Wadange
Date : 13-12-94
Time of prepration : Morning
Total time : 170 min.
Cane type :Co-671
Cane juice : 1000 litre
Soil type : Black

Stage	Time(hrs)	Temp: (°c)	Brix(%)
Initial	9.00	27	18
First Scum	9.30	80	20
Kakavi	11.40	106	66
Striking pt.	11.50	118	88

K 11)

Name : dinakar Bhadulkar
Place : Nigwee
Date : 13-12-94
Time of prepration : Evening
Total time : 137 min.
Cane type : Co-671
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time(hrs)	Temp. (°c)	Brix(%)
Initial	2.00	29	12
First Scum	2.40	95	20
Kakavi	4.00	105	66
Striking pt.	4.15	118	88

K 12)

Name : D.K.Patil
Place : Nigwee Dumala
Date : 14-12-94
Time of prepration : Noon
Totaltime : 135 min.
Cane type : Co-8014
cane juice : 1000 litre
Soil type : Black

Stage	Time(hrs)	Temp. (°c)	Brix(%)
Initial	12.00	32	14.5
First Scum	12.43	95	21.5
Kakavi	2.03	105	71
Striking pt.	2.15	119	89

II) Observations from Satara region.

S 1)

Name : Rajaram Govind surve
Place : Vasantgad Tal : Karad
Date : 15-12-94
Time of prepration : Noon
Total time : 120 min.
Cane type : Co-8014
Cane juice : 1000 litre
Soil type : Laterite

Stage	Time(hrs)	Tempt.(°c)	Brix(%)
Initial	1.30	34	15
First Scum	2.00	93	22
Kakavi	3.15	106	71
Striking pt.	3.13	119	89

S 2)

Name : Arun Bhanudas Chavan
Place : Supane Tal : Karad
Date : 16-12-94
Time of prepration : Noon
Total time : 135 min
Cane type : Co-740
cane juice : 1000 litre
Soil type : Black soil

Stage	Time(hrs)	Tempt.(°c)	Brix(%)
Initial	1.30	34	15
First Scum	2.30	93	21
Kakavi	3.32	107	73
Striking pt.	3.45	120	89

S 3)

Name : Pandurang Mancogi Katkar
Place : Khodashi Tal : Karad
Date : 16-12-94
Time of prepration : Morning
Total time : 120 min.
cane type :Co-671
Cane juice : 1000 litre
Soil type : Laterite

Stage	Time(hrs)	Tempt (°c)	Brix(%)
Initial	3.45	29	17
First Scum	4.15	93	22
Kakavi	5.13	106	72
Striking pt.	5.45	120	89

S 4)

Name : Ramchandra B. Panaskar
Place : Nisare Tal : Patan
Date : 17-12-94
Time of prepration : Evening
Total time : 137
Cane type :Co-671
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time(hrs)	Tempt (°c)	Brix(%)
Initial	2.00	29	12
First Scum	2.40	97	21
Kakavi	4.00	107	71
Striking pt,	4.17	120	89

S 5)

Name : R.R.Katkar
Place : Khodashi Tal: karad
Date : 18-12-94
Time of prepration : Evening
Total time : 140 min.
Cane type :Co-419
Cane juice : 1000 litre
Soil type : Aluvial

Stage	Time(hrs)	Temp.(°c)	Brix(%)
Initial	4.00	28	17
First Scum	4.30	97	26
Kakavi	6.10	107	73
Striking pt.	6.20	120	89

S 6)

Name : Raghunathe Bapu chavan
Place : Malharpeth Tal : Patan
Date : 17-12-94
Time of prepration : Morning
Total time : 135 min.
Cane type :Co-8014
Cane juice : 1000 litre
Soil type : Black soil

Stage	Time (hrs)	Temp.(°c)	Brix(%)
Initial	9.15	25	18
First Scum	9.45	93	22
Kakavi	11.45	106	75
Striking pt.	11.25	121	89

S 7)

Name : Atmaram sakharam salunkhe
Place : saidapur Tal : Karad
Date : 19-12-94
Time of prepration : Evening
Total time : 138 min.
Cane type :Co-8014
Cane juice : 1000 litre
Soil type : Black soil

Stage	Time(hrs)	Temp.(°c)	Brix(%)
Initial	4.00	30	14
First Scum	4.35	94	22
Kakavi	6.05	107	76
Striking pt.	6.18	120	89

S 8)

Name : Ramesh Rajaram Katkar
Place : Khodashi Tal : karad
Date : 18-12-94
Time of prepration : Morning
Total time : 145 min.
Cane type :Co-419
Soil type : Black

ob No	Time in (min)	Temp.(°c)	Brix(%)
1	0	28	17
2	20	50	19
3	40	97	20.5
4	50	97	24
5	60	97	26
6	80	97	32
7	100	102	-
8	120	102	67
9	140	120	89
10	145	121	89

S 9)

Name : R.B.Panaskar
Place : Nisare Tal : Patan
Date : 20-12-94
Cane type :Co-419
Cane juice : 1000 litre
Soil type : Aluvial
Total time : 130 min.

Ob No	Time(min)	Temp.(°c)	Brix(%)
1	0	29	16
2	20	50	19
3	40	97	21
4	60	24	24
5	80	97	32
6	100	102	-
7	120	103	68
8	140	120	89
9	143	120	89

S 10)

Name : R.B. Chavan
Place : Malharpeth Tal : Patan
Cane type :Co-671
Soil type : Laterite
Total time : 140 min(Evening)
cane juice : 1000 litre
Date : 21-12-94

Ob No.	Time(min)	Temp.(°c)	Brix(%)
1	0	28	14
2	20	50	17
3	40	97	19
4	60	97	24
5	80	97	31
6	100	102	-
7	120	102	67
8	140	121	89

S 11)

Name : V.T.Desai
Place : Kirpe Tal : Karad
Date : 19-12-94
Time of preparation : Morning
Total time : 140 min.
Cane type : Co-671
Cane juice : 1000 Litre
soil type : Aluvial

Ob No.	Time (min)	Temp. (°C)	Brix (%)
1	0	29	15
2	20	51	18
3	40	96	20
4	60	97	25
5	80	97	32
6	100	102	-
7	120	102	68
8	130	106	72
9	140	120	89
10	160	88	-
11	180	70	-

3.4 Data Analysis and graphs

The following tables give unit wise striking points for Kakavi and Jaggery stages.

Table 3.4.1

Unit No	Liquid jaggery(Kakavi) Temperature in ^{o}c	Striking point Temperature in ^{o}c
K1	105	118
K2	105	117.5
K3	105	118
K4	105	118.5
K5	105	118
K6	105	118
K7	105	118
K8	105	118
K9	105	117.5
K10	106	118
K11	105	118
K12	105	119

The following table gives unit wise variation in initial brix and final brix along with cane type and total time required for complete process.

Table 3.4.2

Unit No	Initial Brix (H.R)	Final Brix (HR)	cane Type	Total time Required(min)
K1	18%	88%	671	170
K2	14%	88%	7704+8014	137
K3	14%	88%	8014	135
K4	14%	88%	671	147
K5	18%	88%	8014	145
K6	13%	88%	8014	160
K7	12%	89%	671	137
K8	15.5%	88%	8014+671	145
K9	14%	88%	7704	140
K10	18%	88%	671	170
K11	12%	88%	671	137
K12	14.5%	89%	8014	135

The following table gives jaggery production per 1000 litre cane juice for different cane and soil types.

Table 3.4.3

Cane juice inlitre	jaggery (kg)	Cane type	Soil type
1000	225	671	I
1000	250	8014	II
1000	205	8014	II
1000	170	671	I
1000	230	8014+671	I
1000	215	7704	II
1000	225	671	II
1000	190	671	I
1000	160	8014	II

Soil type

I - Aluvial soil

II-Black soil

III- Laterite soil

The following table gives unit wise prepration time and total time required to attain striking points.

Table 3.4.4

Unit No	Prepration time	Total time in(min.)
K1	Morning	170
K2	Noon	137
K3	Noon	135
K4	Noon	147
K5	Noon	145
K6	Evening	160
K7	Evening	137
K8	Morning	145
K9	Noon	140
K10	Morning	170
K11	Evening	137
K12	Noon	135

The following table gives unitwise striking points for Kakavi and jaggery stages for Satara region.

Table 3.4.5

Unit No	Liquid jaggery (Kakavi) Temperature(°c)	Striking Point Temperature(°c)
S1	106	119
S2	107	120
S3	106	120
S4	107	120
S5	107	120
S6	106	121
S7	107	120
S8	105	121
S9	106	120
S10	106	121
S11	106	120
	Ave =106°c	Ave=120°c

The following table gives variation in initial Brix & final Brix along with cane type, soil type, preparation time and total time required for complete process.

Table 3.4.6

Unit No	Initial Brix (H.R)	Final Brix (H.R)	Total time min	Preparation time	cane Type	soil Type
S1	15%	89%	120	Noon	8014	III
S2	15%	89%	135	Noon	740	II
S3	17%	89%	120	Morning	671	III
S4	12%	89%	137	Morning	671	I
S5	17%	89%	140	Evening	419	I
S6	18%	89%	135	Morning	8014	II
S7	14%	89%	138	Evening	8014	II
S8	17%	89%	145	Evening	419	I
S9	16%	89%	143	Evening	419	I
S10	14%	89%	140	Noon	671	III
S11	15%	89%	140	Evening	671	I

* Soil type I-Aluvial soil

II-Black soil

III-Laterite soil

From the preceding measurement and observations we have arrived at the certain important conclusions which are summerised in the last chapter. These observations also helped us to draw following graphs. It is seen that the two important stages in jaggery manufacturing process can also be indicated by studying variation of temperature with time. Such type of graph for observation S_9 unit is presented in fig no. 3.1. Variation of temperature with time for complete process of jaggery manufacturing can be understood by observing a graphical presentation as shown is fig. 3.2. This variation gives an idea of striking point as well as addition of stage wise vegetable and chemical clarificants. It also indicates that, striking point occurs after 140-145 min.

A complete jaggery manufacturing process can be described by using Fig. 3.2 as follows :

In the initial stage juice is taken into boiling pan and lime and mucilage of Bhendi or Ambadi is added. The aim of addition of vegetable clarificants is to make juice clear as well as light in colour. Mucilage gave excellent jaggery as compaired to other vegetable clarificants. After half hour first scum is removed. Then boiling of juice starts after 40 min. After one hour, vigorous boiling starts and at this stage chemical clarificant

hydros is added. After this second scum called 'Sonmali' is removed. Then vigorous boiling continues upto about 120 minutes, during this time water in juice is removed due to evaportion process. During this process constant stirring is done to avoid overflow of juice from boiling pan. After two hours boiling, forthing starts and at this stage sweet oil is added into the pan. After 10 min. of addition of sweet oil forthing stops. Then a Kakavi stages attained at about 130 min. with bubbling and at about 140 to 145 minutes final striking stage (Golli stage) is reached. After this pan is removed from direct heating furnace and liquid mass is allowed to cool in another rectangular pan by constant stirring. At 180 minute when temperature of liquid mass or syrup is about $70^{o}c$, the moulds are filled.

The variation in the Brix of juice with the time has been studied by drawing a graph of Brix versus time fcr one perticular unit. This graph is presented in Fig.3.3. From the graph it is noticed that initially for about one and half hour there is a slow increase in Brix of juice. However just after this time there is rapid increase in Brix, indicating that, at this stage sugar percentage increases.

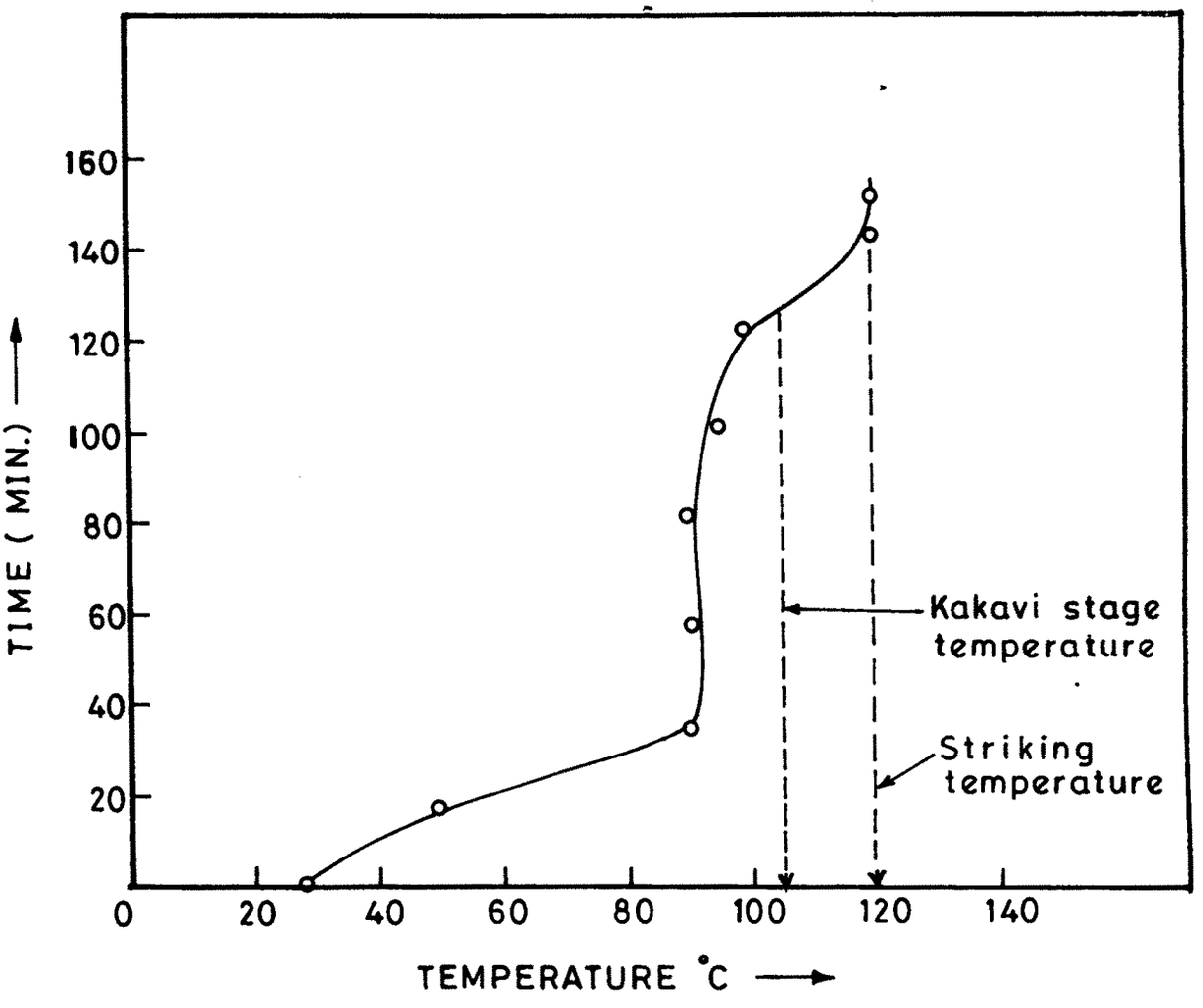

FIG. 3·1– TIME VS TEMPERATURE .

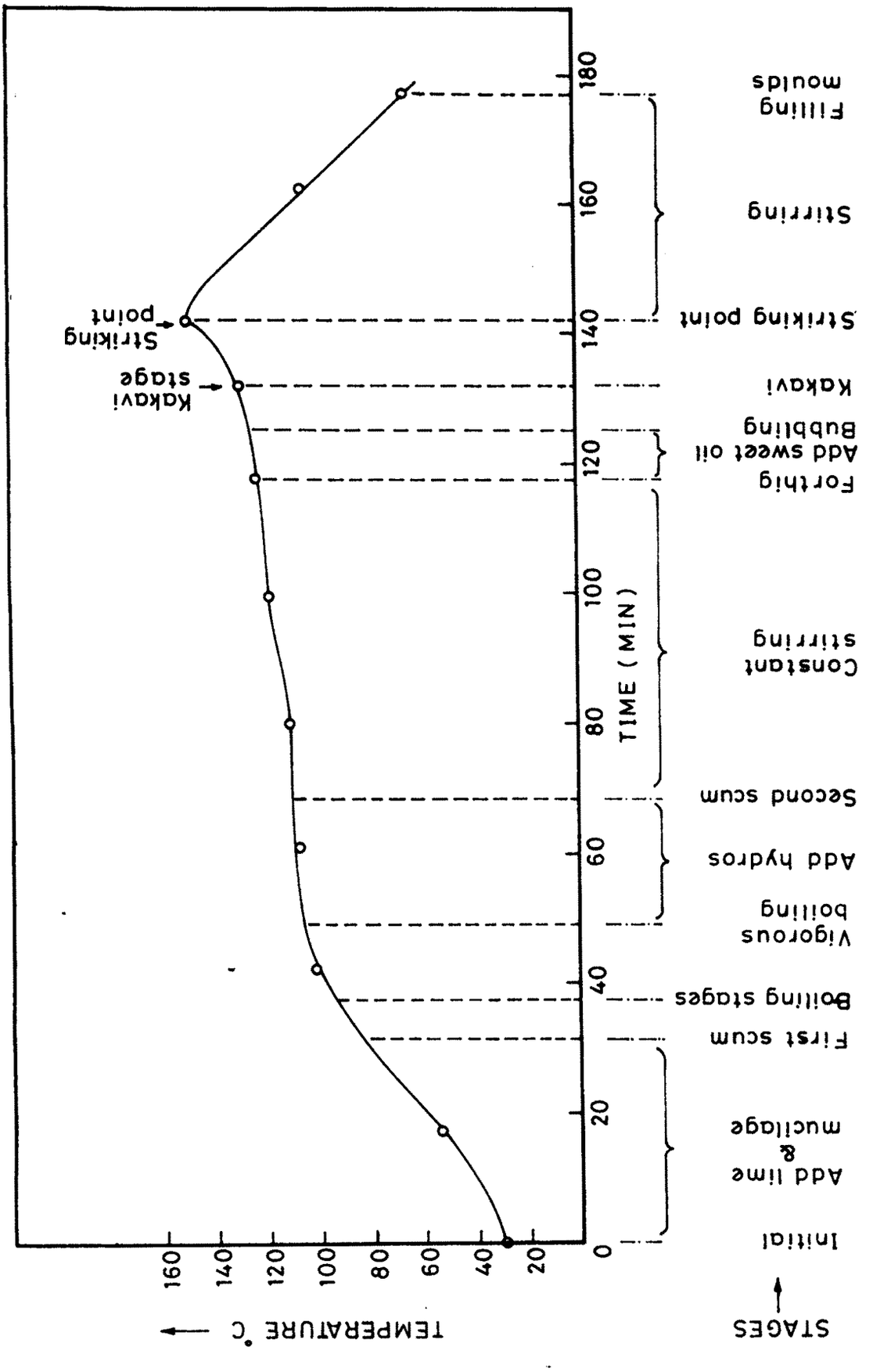

FIG. 3.2 - GRAPH OF TEMPERATURE VS TIME SHOWING STAGES DURING JAGGERY MANUFACTURING PROCESS.

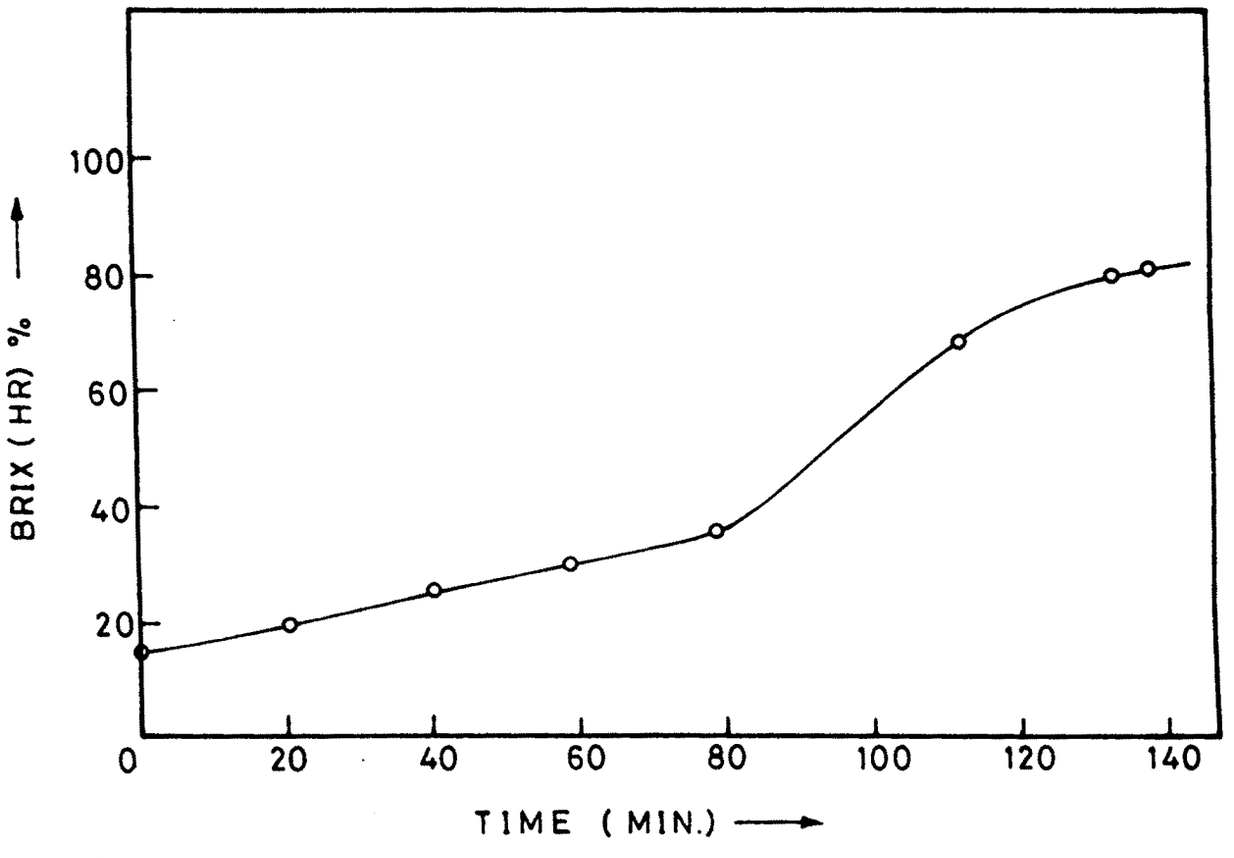

FIG. 3·3 – BRIX VS TIME .

REFERENCE

Banerji, K.C. 1958: Cane sugar factory control
Technical Literature Co.
40, Hazratganj, Lucknow.