CHAPTER 6

DISCUSSION AND CONCLUSION OF EXPERIMENTS

6.1 Discussion

6.1.1 Initial Moisture Content of Veneer

In this experiment, samples of veneer to be used were peeled from Parawood which is normally used in furniture making of Thai Industries. From Table 5-1 moisture of veneer is about 84-86 % (dry basis). Using the average value of 85.034% (dry basis), the experiment is to study decrement of moisture content during drying period at each drying condition.

6.1.2 Drying Samples of Veneer with Continuous Dryer

This experiment has objectives to study the characteristic of wood veneer drying by continuous dryer and to study the influence of drying temperature, hot air velocity pass over veneer and thickness of veneer over drying rate.

6.1.2.1 Thickness of Veneer

From graphs shown in Table & Fig. 6.1 to 6.3 and also in Appendix D which present moisture content of veneer during drying compare between sample veneer 1.5 mm. and 2.0 mm. at the same drying condition. Drying rate of veneer 2.0 mm. is lower than that of 1.5 mm.

The first section of graph that is the increasing temperature period of 2.0 mm. veneer is longer than that of 1.5 mm. because by the same specific heat capacity, heat required to heat up mass of 2.0 mm. veneer to evaporation temperature is more than 1.5 mm. veneer.

6.1.2.2 Hot Air Velocity

Table & Fig. 6.4 to 6.7 and Appendix B will present the progress of drying by showing moisture content of veneer during drying at constant hot air temperature and at hot air velocity of 1.5, 2.0 and 2.5 m/s. Graphs show that the drying rate will be increased by increasing of hot air velocity. This can be explained that increasing air velocity is meaningly increasing moisture movement coefficient and capacity of air to get moisture .

6.1.2.3 Temperature of Hot Air in Dryer

Table & Fig. 6.8 to 6.13 Appendix C presents moisture content of veneer during drying at constant hot air velocity and at temperature of hot air 100°C, 90°C, 80°C, 70°C and 60°C. Graphs show that drying rate will increase when increasing hot air temperature.

Drying with higher temperature will take short period than lower temperature at the "temperature increasing period" of graph. Also at "initial drying period", drying rate of higher temperature is more than lower temperature. This also can easily explained that increasing temperature of hot air is increasing the heat energy that occupied by air. This energy will increase temperature of moisture in veneer and also increase coefficient of moisture movement.

6.1.2.4 Relative Humidity of Hot Air in Dryer

Table & Figure 6.20 to 6.25 present moisture content of veneer during drying at constant hot air velocity and at varying of relative humidity of hot air according to hot air temperature. Graphs show that drying rate will be decreased when increasing relative humidity of hot air.

Higher relative humidity cause vapour pressure of water in air close to vapour pressure of moisture in veneer that make more difficult for moisture to be removed out.

6.1.3 Experimental Equations

6.1.3.1 Moisture Content and Time

From the results of experiment and by using least square approximation method, equation of moisture content during drying period can be determined. Those equations and their coefficient of determination are shown in Table E-1.01 to E-1.10. The value of coefficients of determination are almost about 1 which show the best fit of equations.

The best equations for each drying condition are shown as follows:

1) Hot air drying temperature = 100°C

Hot air velocity = 1.5

$$U = 1E\text{-}05t_d^6 - 0.0002t_d^5 - 0.0052t_d^4 + 0.1603t_d^3 - 1.0602t_d^2 - 5.9223t_d + 85.050$$

2) Hot air drying temperature = 100°C

Hot air velocity = 2.0

$$U = -1E\text{-}05t_d^6 + 0.0008t_d^5 - 0.0172t_d^4 + 0.2049t_d^3 - 0.9221t_d^2 - 7.3113t_d + 85.041$$

3) Hot air drying temperature = 100°C

Hot air velocity = 2.5

$$U = 3E\text{-}06t_d^6 + 0.0001t_d^5 - 0.0103t_d^4 + 0.1992t_d^3 - 0.9669t_d^2 - 8.6848t_d + 85.035$$

4) Hot air drying temperature = 90°C

Hot air velocity = 1.5

$$U = 5E\text{-}06t_d^6 - 0.0003t_d^5 + 0.0048t_d^4 + 0.0070t_d^3 - 0.5921t_d^2 - 2.4243t_d + 85.028$$

5) Hot air drying temperature = $90^{o}C$

Hot air velocity = 2.0

$$U = -1E\text{-}05t_d^6 + 0.0006t_d^5 + 0.0097t_d^4 + 0.0599t_d^3 - 0.2282t_d^2 - 2.7327t_d + 85.218$$

6) Hot air drying temperature = $90^{o}C$

Hot air velocity = 2.5

$$U = 2E\text{-}05t_d^6 - 7E\text{-}05t_d^5 + 0.0003t_d^4 + 0.0333t_d^3 - 0.5941t_d^2 - 2.0192t_d + 84.980$$

7) Hot air drying temperature = $80^{o}C$

Hot air velocity = 1.5

$$U = -1E\text{-}06t_d^6 + 8E\text{-}05t_d^5 - 0.0021t_d^4 + 0.0339t_d^3 - 0.3878t_d^2 - 1.5006t_d + 85.151$$

8) Hot air drying temperature = $80^{o}C$

Hot air velocity = 2.0

$$U = 2E\text{-}06t_d^6 - 0.0002t_d^5 + 0.0086t_d^4 - 0.1416t_d^3 + 0.8081t_d^2 - 3.1311t_d + 86.060$$

9) Hot air drying temperature = $80^{o}C$

Hot air velocity = 2.5

$$U = 1E\text{-}06t_d^6 - 9E\text{-}05t_d^5 + 0.0031t_d^4 - 0.0350t_d^3 + 0.0112t_d^2 - 3.0807t_d + 84.577$$

10) Hot air drying temperature = $70^{o}C$

Hot air velocity = 1.5

$$U = 3E\text{-}07t_d^6 - 3E\text{-}05t_d^5 + 0.0013t_d^4 - 0.0201t_d^3 - 0.0729t_d^2 + 0.3175t_d + 85.983$$

11) Hot air drying temperature = 70°C

Hot air velocity = 2.0

$$U = 8E\text{-}07t_d^6 - 9E\text{-}05t_d^5 + 0.0038t_d^4 - 0.0675t_d^3 + 0.3450t_d^2 - 1.4912t_d + 85.138$$

12) Hot air drying temperature = 70°C

Hot air velocity = 2.5

$$U = 1E\text{-}06t_d^6 - 0.0001t_d^5 + 0.0039t_d^4 - 0.0580t_d^3 + 0.1972t_d^2 - 1.5766t_d + 84.844$$

13) Hot air drying temperature = 60°C

Hot air velocity = 1.5

$$U = 2E\text{-}06t_d^6 - 0.0002t_d^5 + 0.0058t_d^4 - 0.0895t_d^3 + 0.4809t_d^2 - 1.1090t_d + 85.014$$

14) Hot air drying temperature = 60°C

Hot air velocity = 2.0

$$U = -1E\text{-}07t_d^6 + 2E\text{-}05t_d^5 - 0.0005t_d^4 + 0.0082t_d^3 - 0.1797t_d^2 - 0.0572t_d + 84.919$$

15) Hot air drying temperature = 60°C

Hot air velocity = 2.5

$$U = 2E\text{-}07t_d^6 - 1E\text{-}05t_d^5 + 1E\text{-}04t_d^4 + 0.0069t_d^3 - 0.2306t_d^2 - 0.4288t_d + 84.773$$

6.1.3.2 Moisture content and Hot Air Temperature

From Table & Figure 6.14 to 6.19 show relation between moisture content of veneer during drying and hot air temperature at drying time of 5, 10, 15, 20, 25 and 30 minutes. Again by least square approximation, equations of these relations can be determined as shown in Table E-1.11 to E-1.16

From the graphs , consideration each drying time. At the short period of drying time when moisture content in veneer is high the drying rate is higher than that of for the long period of drying time which moisture content in veneer is low and going to reach equilibrium moisture content. This can be explained that at the begining of drying moisture to be removed out of veneer is free water which can be easily evaporated. But when all of free water is removed off from veneer furthermore evaporation is of bound water which more difficult to be removed than free water.

6.1.3.4 Moisture Content and Relative Humidity

From Table & Figure 6.20 to 6.25 that show relation between moisture content of veneer during drying and relative humidity of hot air. Experimental equations of these relations can be determined and shown in Table E-1.17 to E-1.22

6.2 Conclusion

6.2.1 From drying curve of experiment, curves are same as general curve by theory. The curve can be devided into 3 parts as follows:

- Temperature increasing period ; represents that heat energy applied to veneer in this period is used to rise the temperature of veneer and its moisture content
- Initial drying period ; Drying rate do sometimes only change to a small degree over this period, and so approximate in magnitude to the rate of evaporation from a free liquid surface under the same drying conditions.
- Falling rate period ; The average moisture content of the body at the transition between these period is called the critical point or the critical moisture content

6.2.2 The of moisture content of veneer during drying is to reach that of the equilibrium moisture content. But by the open system of dryer and also the hygroscopic properties of veneer that make veneer cannot be dried to nearly equilibrium moisture content. Furthermore, this experiment is only require to get appropriate moisture content for furniture making that is about 8-10%.

6.2.3 From the experiment to study effects of important parameters over drying rate we can conclude those parameters as follows:

- Temperature of hot air drying ; Drying rate will increase by increasing temperature of hot air.
- Hot air velocity pass through dryer ; Drying rate will increase by increasing hot air velocity.
- Thickness of veneer ; The more the thickness of veneer, the less the drying rate we can get.

Drying time and final moisture content of veneer for each conditon of drying are shown as follows:

Veneer Thickness 1.5 mm.

Temperature of Hot air drying (Deg. C)	Hot air Velocity (m/s.)	Drying Time (min.)	Final Moisture Content (% dry basis)
100	1.5	16	7.719
	2.0	16	6.721
	2.5	16	6.193
90	1.5	20	9.279
	2.0	20	8.029
	2.5	20	6.021
80	1.5	30	8.875
	2.0	30	7.481
	2.5	30	6.491
70	1.5	30	9.923
	2.0	30	8.068
	2.5	30	6.280
60	1.5	30	10.557
	2.0	30	9.862
	2.5	30	7.318

Veneer Thickness 2.0 mm.

Temperature of Hot air drying (Deg. C)	Hot air Velocity (m/s.)	Drying Time (min.)	Final Moisture Content (% dry basis)
100	1.5	16	9.678
	2.0	16	7.017
	2.5	16	6.241
90	1.5	20	11.217
	2.0	20	9.522
	2.5	20	7.602
80	1.5	30	10.954
	2.0	30	8.850
	2.5	30	5.019
70	1.5	30	12.221
	2.0	30	11.856
	2.5	30	10.006
60	1.5	30	13.624
	2.0	30	11.541
	2.5	30	11.440

6.2.4 We can also conclude the advantages of continuous dryer compare to the conventional drying room. as follows:

- Quality of veneer ; Veneer to be dried by continuous process dryer is almost zero wavy and crack because of the mechanical system and drying-pressing system do not allow for any free shrinkage of veneer.
- Working space ; Continuous dryer does not require large area for operation. It can be designed to the size appropriate for the area of factory.
- Capacity ; The average capacity of conventional drying room is that it can dry veneer of about 1200 sq. m. (by thickness of 1.5 - 2.0 mm.) by using 35 hours of all process. First 11 hours for seasoning veneer in open air before drying and 24 hours in drying room. By this capacity and the same period of time, assume using hot air temp. of 70^{0} C for continuous dryer to reach this capacity the size of dryer is only about 2 m. wide by 6 m. length. Furthermore, the capacity is easily increased by increasing hot air temperature or hot air velocity and also by use the bigger size of dryer.
- Workmanship in manufacturing process ; This continuous dryer require only few worker to feed in the veneers and some for pick veneers off. The dryer can be designed to be automatically feeding in and out.

6.3 Recommendation

There are many errors occur during drying because the hygroscopic property of veneer and the thickness of veneer is thin. Veneer gain moisture from air when it is brought out for measuring its weight

Furthermore, this model of dryer is mainly for purpose of stydying the effects of those parameters mentioned before. So, less consideration is given to the method of energy conservation. All the recommendations here are based on much more consideration of energy conservation to improve efficiency of dryer. For example, by using more recirculation of hor air in dryer.

The recommendations are as follows;

6.3.1 In future experiments, attempts should be made to study more about these parameters by increase range of experimental to obtain the best relations of moisture content and time.

6.3.2 Consideration should be given to others parameters, by setting experiment to get the results of general formula which can be used to determined drying at every condition of drying.

6.3.3 The financial value of the benefits should be studied to evaluate economic feasibility.

TABLE 6-1

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	1.5 m/s
Resident time	1.0 min.

Time	Moisture content of veneer	
(min.)	Thickness of veneer ; t	
Time	t = 1.5 mm.	t = 2.0 mm.
0	85.034	85.034
1	80.247	83.791
2	77.553	80.759
3	72.040	78.881
4	67.335	75.086
5	60.414	72.751
6	54.147	69.897
7	48.974	62.392
8	42.001	59.375
9	36.009	55.499
10	31.067	49.044
11	27.483	45.878
12	23.984	38.776
13	20.795	34.042
14	18.736	27.352
15	15.693	22.699
16	15.021	20.590
17	12.545	17.292
18	11.953	14.054
19	10.033	12.450
20	9.279	11.217

Fig. 6.1

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	1.5 m/s
Resident time	1.0 min.

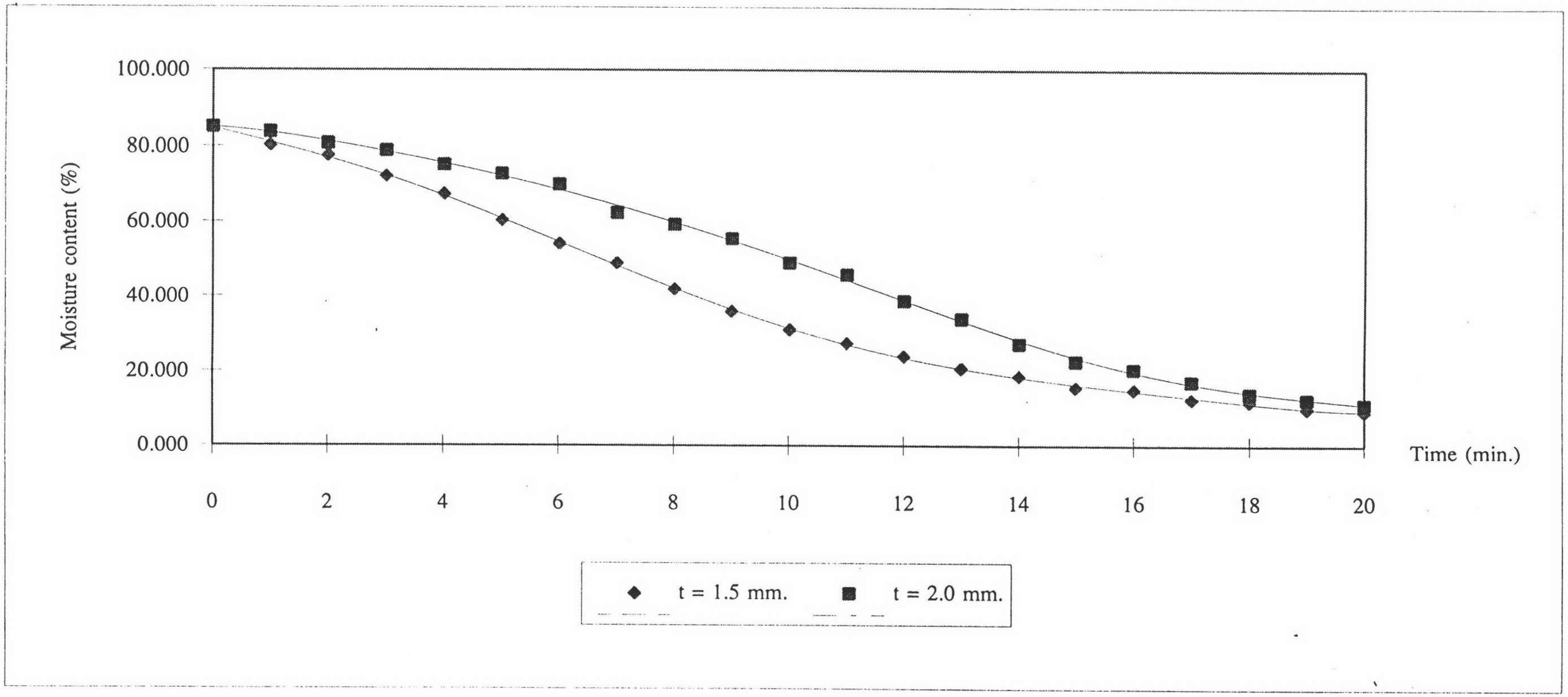

TABLE 6-2

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	2.0 m/s
Resident time	1.0 min.

Time	Moisture content of veneer	
(min.)	Thickness of veneer ; t	
Time	t = 1.5 mm.	t = 2.0 mm.
0	85.034	85.034
1	80.409	82.511
2	76.375	79.812
3	70.634	75.009
4	65.755	72.789
5	58.069	68.479
6	52.431	65.289
7	45.166	61.685
8	38.752	54.105
9	33.238	51.953
10	27.776	44.767
11	24.133	40.655
12	20.734	33.238
13	18.260	28.118
14	15.012	22.127
15	13.134	19.692
16	10.896	17.309
17	10.589	13.323
18	9.813	11.393
19	8.410	10.451
20	8.029	9.522

Fig. 6.2

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	2.0 m/s
Resident time	1.0 min.

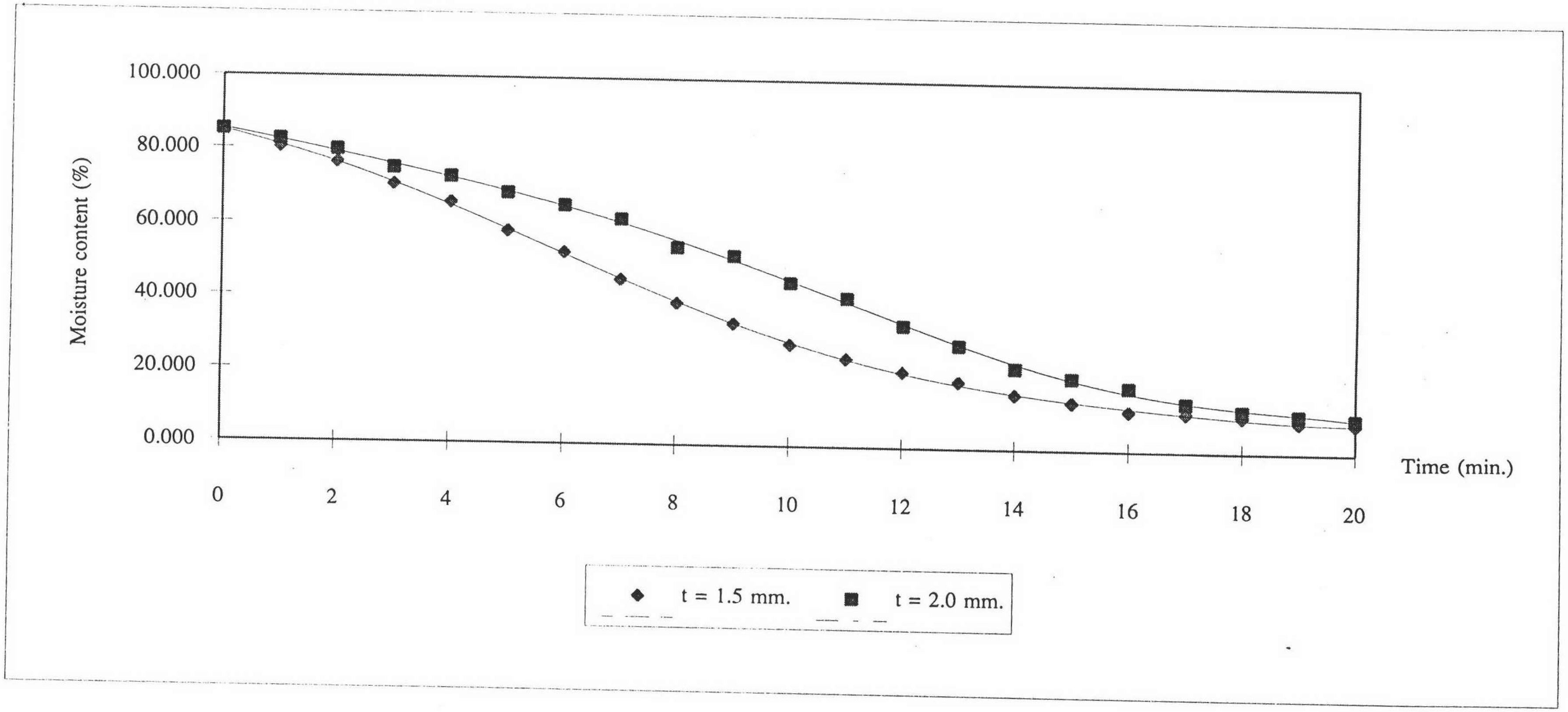

TABLE 6-3

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	2.5 m/s
Resident time	1.0 min.

Time	Moisture content of veneer	
(min.)	Thickness of veneer ; t	
Time	t = 1.5 mm.	t = 2.0 mm.
0	85.034	85.034
1	80.501	81.258
2	75.966	77.451
3	69.933	73.297
4	63.572	68.055
5	56.135	63.220
6	49.217	59.798
7	40.948	54.959
8	34.685	49.491
9	28.309	43.242
10	22.539	38.407
11	19.831	32.308
12	14.148	26.197
13	13.075	21.352
14	10.282	18.558
15	9.505	14.591
16	7.106	12.262
17	6.819	11.741
18	6.437	9.361
19	6.222	8.793
20	6.021	7.602

Fig. 6.3

Show comparision of moisture content of veneer 1.5 and 2.0 mm. at the same drying condition.

Hot air drying temperature	90.0 Deg. C
Hot air velocity	2.5 m/s
Resident time	1.0 min.

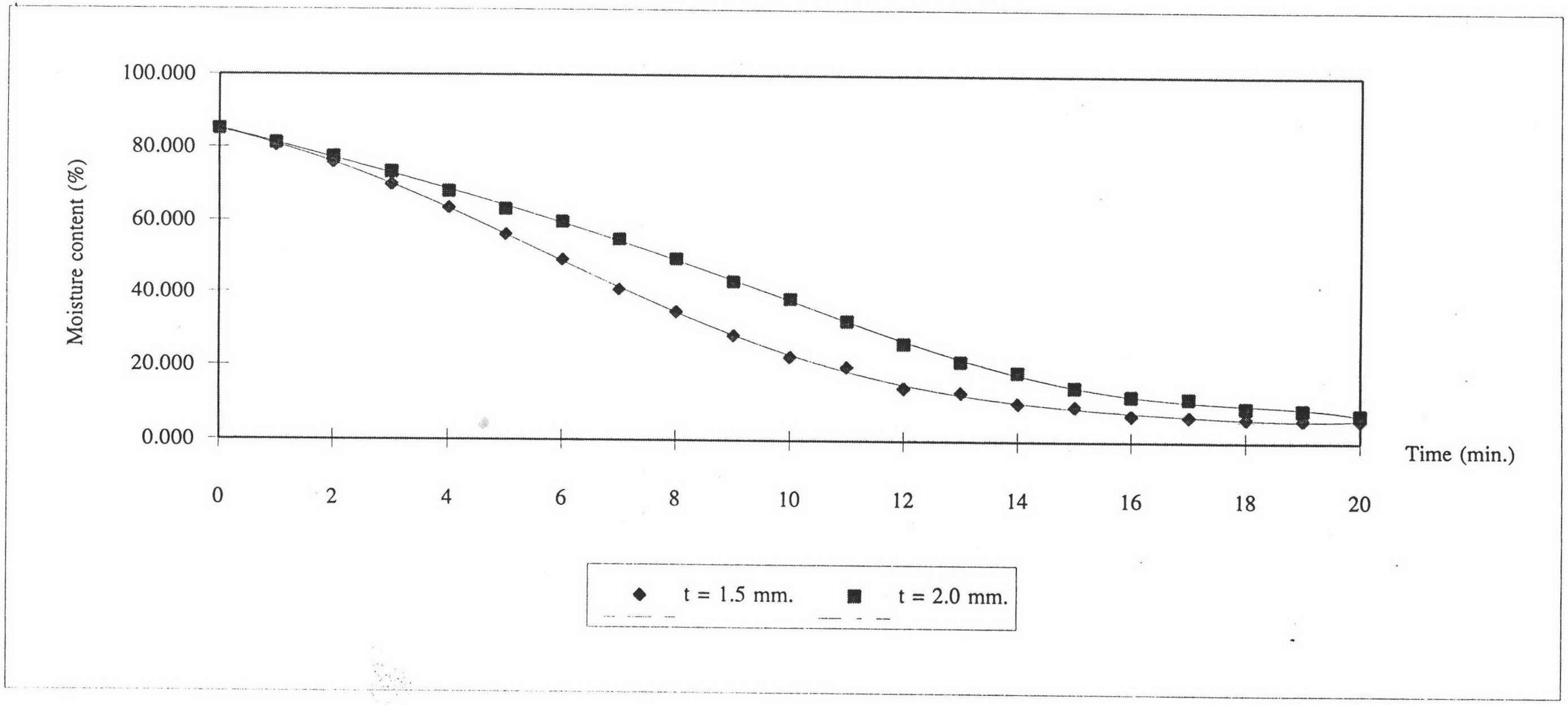

TABLE 6-4

Show comparision of moisture content of veneer during drying at each velocity of hot air ; Va

Hot arir temp. ; T = 90.0 Deg. C

Thickness of veneer ; t = 1.5 mm.

Resident time ; dt = 1.0 min.

Time (min.)	Moisture content (%) Hot Air Velocity		
Time	Va = 2.5 m/s	Va = 2.0 m/s	Va = 1.5 m/s
0	85.034	85.034	85.034
1	80.501	80.409	80.247
2	75.966	76.375	77.553
3	69.933	70.634	72.040
4	63.572	65.755	67.335
5	56.135	58.069	60.414
6	49.217	52.431	54.147
7	40.948	45.166	48.974
8	34.685	38.752	42.001
9	28.309	33.238	36.009
10	22.539	27.776	31.067
11	19.831	24.133	27.483
12	14.148	20.734	23.984
13	13.075	18.260	20.795
14	10.282	15.012	18.736
15	9.505	13.134	15.693
16	7.106	10.896	15.021
17	6.819	10.589	12.545
18	6.437	9.813	11.953
19	6.222	8.410	10.033
20	6.021	8.029	9.279

Fig. 6.4

Show comparision of moisture content of veneer during drying at velocity of hot air ; Va = 2.5, 2.0 and 1.5 m/s

Hot arir temp. ; T = 90.0 Deg. C

Thickness of veneer ; t = 1.5 mm.

Resident time ; dt = 1.0 min

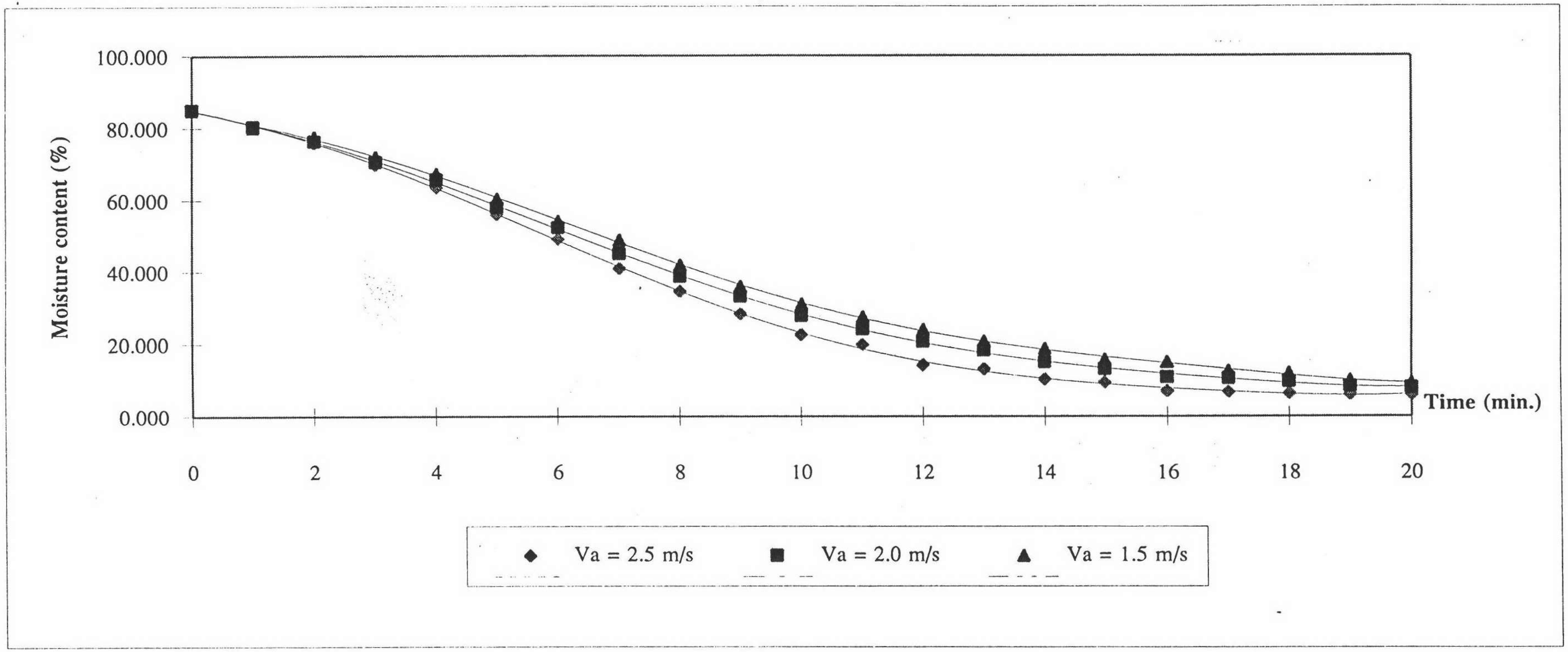

TABLE 6-5

Show comparision of moisture content of veneer during drying at each velocity of hot air ; Va

Hot arir temp. ; T = 70.0 Deg. C

Thickness of veneer ; t = 1.5 mm.

Resident time ; dt = 1.0 min.

Time (min.)	Moisture content (%)		
	Hot Air Velocity		
Time	Va = 2.5 m/s	Va = 2.0 m/s	Va = 1.5 m/s
0	85.034	85.034	85.034
1	83.175	84.378	84.747
2	81.959	83.023	83.840
3	79.188	81.003	82.495
4	78.771	79.014	80.251
5	73.506	78.221	79.754
6	70.055	75.507	77.034
7	69.581	72.895	75.715
8	65.771	70.140	72.139
9	62.729	67.422	69.788
10	58.617	63.059	67.543
11	53.442	59.257	66.993
12	50.050	55.856	60.418
13	48.364	53.789	57.190
14	44.116	51.655	55.561
15	40.551	47.393	52.946
16	37.860	42.241	48.194
17	32.759	39.850	45.959
18	28.604	35.703	40.553
19	25.016	32.361	36.392
20	21.521	28.545	32.253
21	18.816	25.154	27.544
22	15.711	20.623	24.663
23	12.959	18.684	20.171
24	10.320	15.645	17.192
25	9.531	13.943	15.455
26	8.941	10.797	12.981
27	8.348	9.691	10.813
28	7.749	9.243	10.345
29	7.154	8.805	9.955
30	6.280	8.068	9.923

Fig. 6.5

Show comparision of moisture content of veneer during drying at velocity of hot air ; Va = 2.5, 2.0 and 1.5 m/s

Hot arir temp. ; T = 70.0 Deg. C

Thickness of veneer ; t = 1.5 mm.

Resident time ; dt = 1.0 min

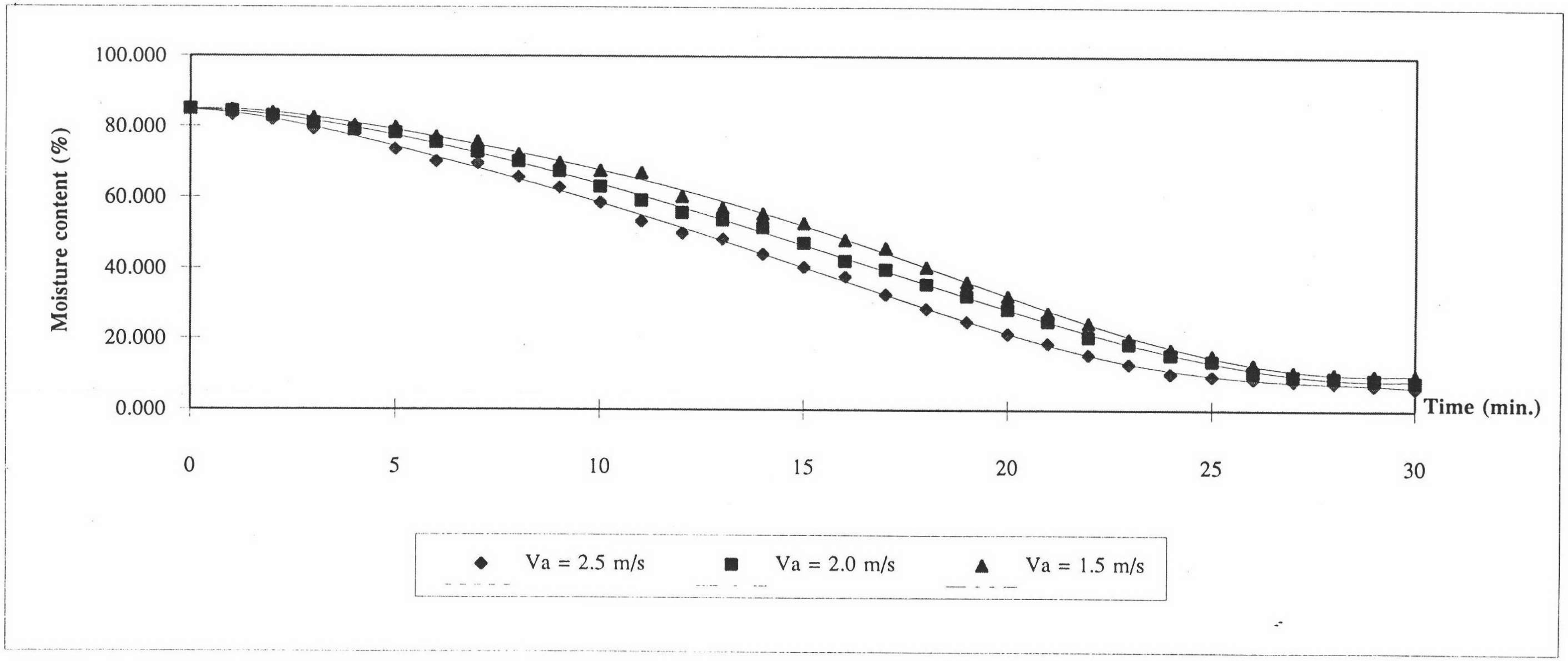

TABLE 6-6

Show comparision of moisture content of veneer during drying at each velocity of hot air ; Va

Hot arir temp. ; T = 90.0 Deg. C

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

Time	**Moisture content (%)**		
(min.)	**Hot Air Velocity**		
Time	**Va = 2.5 m/s**	**Va = 2.0 m/s**	**Va = 1.5 m/s**
0	85.034	85.034	85.034
1	81.258	82.511	83.791
2	77.451	79.812	80.759
3	73.297	75.009	78.881
4	68.055	72.789	75.086
5	63.220	68.479	72.751
6	59.798	65.289	69.897
7	54.959	61.685	62.392
8	49.491	54.105	59.375
9	43.242	51.953	55.499
10	38.407	44.767	49.044
11	32.308	40.655	45.878
12	26.197	33.238	38.776
13	21.352	28.118	34.042
14	18.558	22.127	27.352
15	14.591	19.692	22.699
16	12.262	17.309	20.590
17	11.741	13.323	17.292
18	9.361	11.393	14.054
19	8.793	10.451	12.450
20	7.602	9.522	11.217

Fig. 6.6

Show comparision of moisture content of veneer during drying at velocity of hot air ; Va = 2.5, 2.0 and 1.5 m/s

Hot arir temp. ; T = 90.0 Deg. C

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min

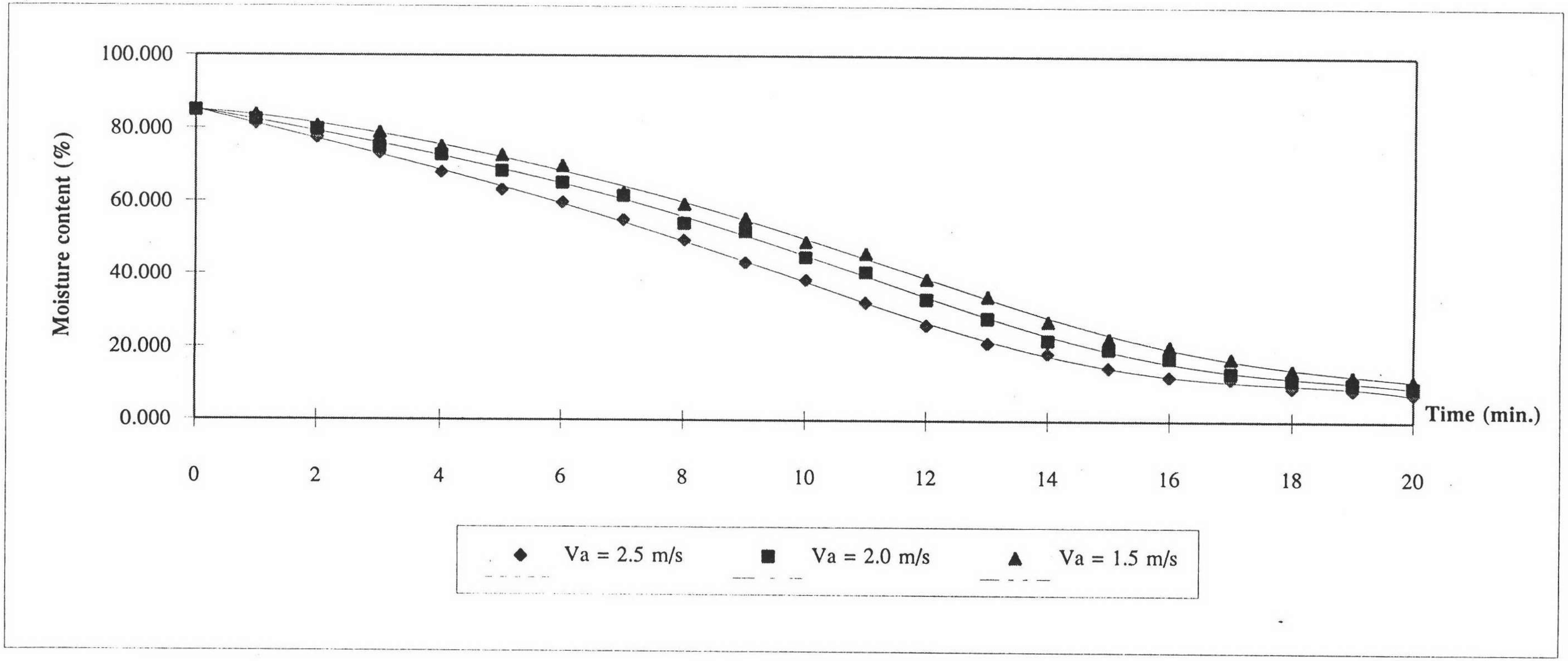

TABLE 6-7

Show comparision of moisture content of veneer during drying at each velocity of hot air ; Va

Hot arir temp. ; T = 70.0 Deg. C

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

Time (min.)	**Moisture content (%)**		
	Hot Air Velocity		
Time	**Va = 2.5 m/s**	**Va = 2.0 m/s**	**Va = 1.5 m/s**
0	85.034	85.034	85.034
1	83.303	84.540	84.646
2	82.980	83.558	84.296
3	80.719	82.742	83.882
4	80.217	81.316	82.149
5	78.913	80.492	81.417
6	76.448	78.783	80.156
7	74.526	76.033	78.523
8	72.993	74.593	77.920
9	69.940	72.938	75.704
10	64.486	68.953	74.494
11	60.830	64.034	70.695
12	57.700	60.140	66.636
13	54.704	57.846	65.559
14	50.253	54.921	63.734
15	47.400	50.639	59.249
16	44.996	47.594	54.085
17	40.740	44.254	50.900
18	36.155	40.355	46.306
19	32.816	38.540	42.751
20	28.300	34.253	38.684
21	26.877	31.349	34.044
22	23.818	28.395	30.353
23	20.608	25.105	28.827
24	18.190	22.731	24.157
25	16.560	20.652	22.842
26	14.957	18.700	20.498
27	12.649	16.136	17.708
28	11.516	15.375	15.898
29	10.759	12.624	13.257
30	10.006	11.856	12.221

Fig. 6.7

Show comparision of moisture content of veneer during drying at velocity of hot air ; Va = 2.5, 2.0 and 1.5 m/s

Hot arir temp. ; T = 70.0 Deg. C

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min

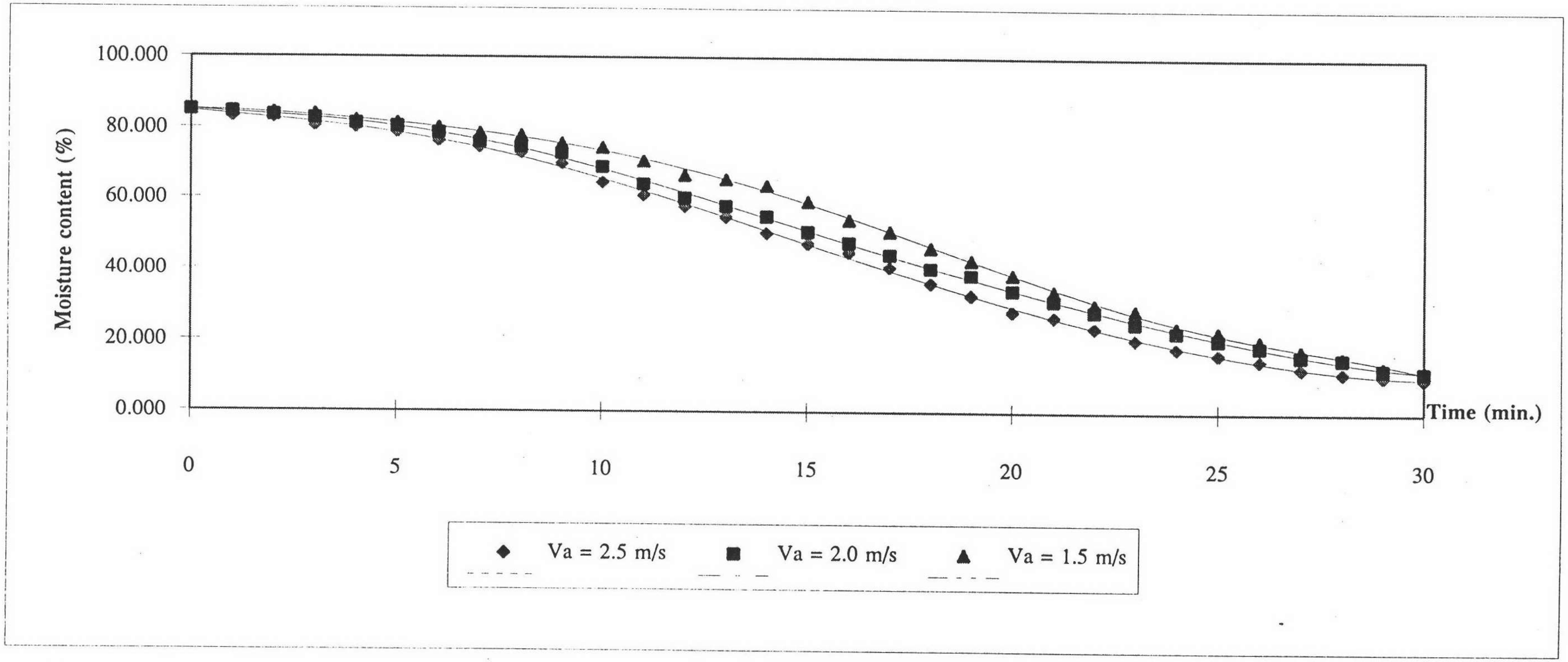

TABLE 6-8

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 1.5 m/s.
Thickness of veneer ; t = 1.5 mm.
Resident time ; dt = 1.0 min.

Time	Moisture content (%)				
(min.)	Hot Air Temperature (Deg. C)				
	T = 100 C	T = 90 C	T = 80 C	T = 70 C	T = 60 C
0	85.034	85.034	85.034	85.034	85.034
1	78.922	80.247	83.041	84.747	84.511
2	72.485	77.553	81.512	83.840	84.112
3	63.999	72.040	77.949	82.495	83.854
4	54.973	67.335	74.653	80.251	83.257
5	45.010	60.414	70.818	79.754	82.957
6	39.110	54.147	67.291	77.034	82.471
7	32.396	48.974	63.085	75.715	81.985
8	28.302	42.001	59.635	72.139	79.959
9	22.634	36.009	55.412	69.788	78.897
10	18.595	31.067	50.109	67.543	75.253
11	15.883	27.483	46.212	66.993	72.317
12	12.231	23.984	42.656	60.418	69.419
13	10.855	20.795	38.362	57.190	67.655
14	9.745	18.736	34.542	55.561	63.119
15	8.496	15.693	30.128	52.946	58.603
16	7.719	15.021	26.727	48.194	57.853
17		12.545	22.317	45.959	54.944
18		11.953	19.159	40.553	48.247
19		10.033	16.321	36.392	45.609
20		9.279	12.771	32.253	41.641
21			11.575	27.544	39.230
22			10.735	24.663	35.894
23			10.475	20.171	31.409
24			10.128	17.192	28.499
25			9.939	15.455	24.823
26			9.615	12.981	21.492
27			9.321	10.813	19.293
28			9.024	10.345	15.836
29			8.898	9.955	13.356
30			8.875	9.923	10.557

Fig. 6.8

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 1.5 m/s.

Thickness of venee ; t = 1.5 mm.

Resident time ; dt = 1.0 min.

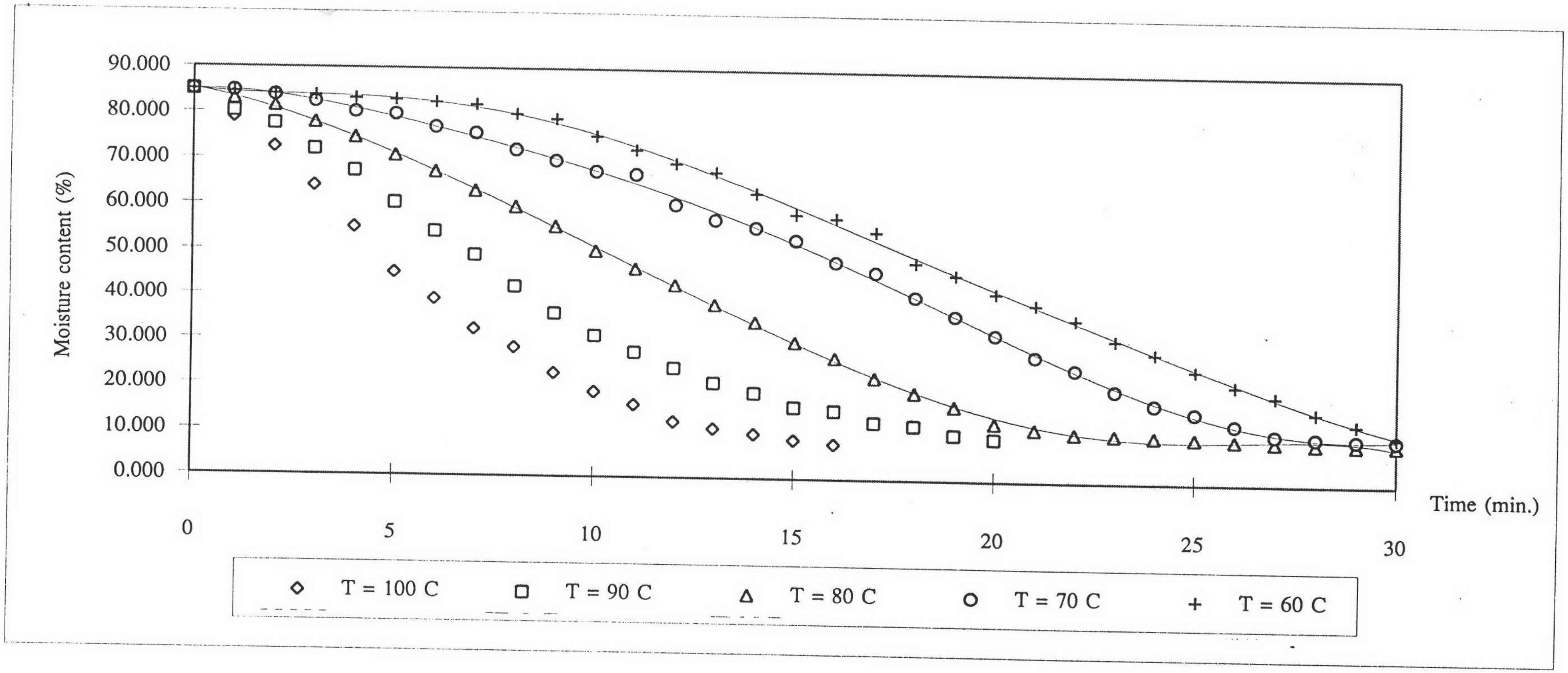

TABLE 6-9

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.0 m/s.
Thickness of veneer ; t = 1.5 mm.
Resident time ; dt = 1.0 min.

Time	Moisture content (%)				
(min.)	Hot Air Temperature (Deg. C)				
	T = 100 C	T = 90 C	T = 80 C	T = 70 C	T = 60 C
0	85.034	85.034	85.034	85.034	85.034
1	77.640	80.409	83.097	84.378	84.353
2	68.643	76.375	80.705	83.023	83.314
3	60.877	70.634	76.426	81.003	82.000
4	50.126	65.755	72.994	79.014	81.707
5	42.964	58.069	68.641	78.221	81.109
6	35.593	52.431	64.399	75.507	80.749
7	29.392	45.166	60.242	72.895	77.753
8	22.034	38.752	55.470	70.140	75.708
9	19.240	33.238	51.402	67.422	72.293
10	15.865	27.776	47.203	63.059	70.542
11	13.922	24.133	42.058	59.257	67.638
12	10.539	20.734	38.366	55.856	63.146
13	9.535	18.260	35.375	53.789	61.446
14	8.543	15.012	30.733	51.655	58.418
15	7.193	13.134	27.588	47.393	56.498
16	6.721	10.896	23.906	42.241	53.158
17		10.589	19.837	39.850	49.398
18		9.813	16.914	35.703	44.730
19		8.410	13.764	32.361	41.441
20		8.029	10.256	28.545	37.357
21			9.835	25.154	33.770
22			9.703	20.623	27.816
23			9.510	18.684	24.950
24			9.475	15.645	22.244
25			9.284	13.943	19.399
26			8.613	10.797	16.007
27			8.465	9.691	14.125
28			8.208	9.243	12.119
29			8.060	8.805	11.520
30			7.481	8.068	9.862

Fig. 6.9

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.0 m/s.

Thickness of venee ; t = 1.5 mm.

Resident time ; dt = 1.0 min.

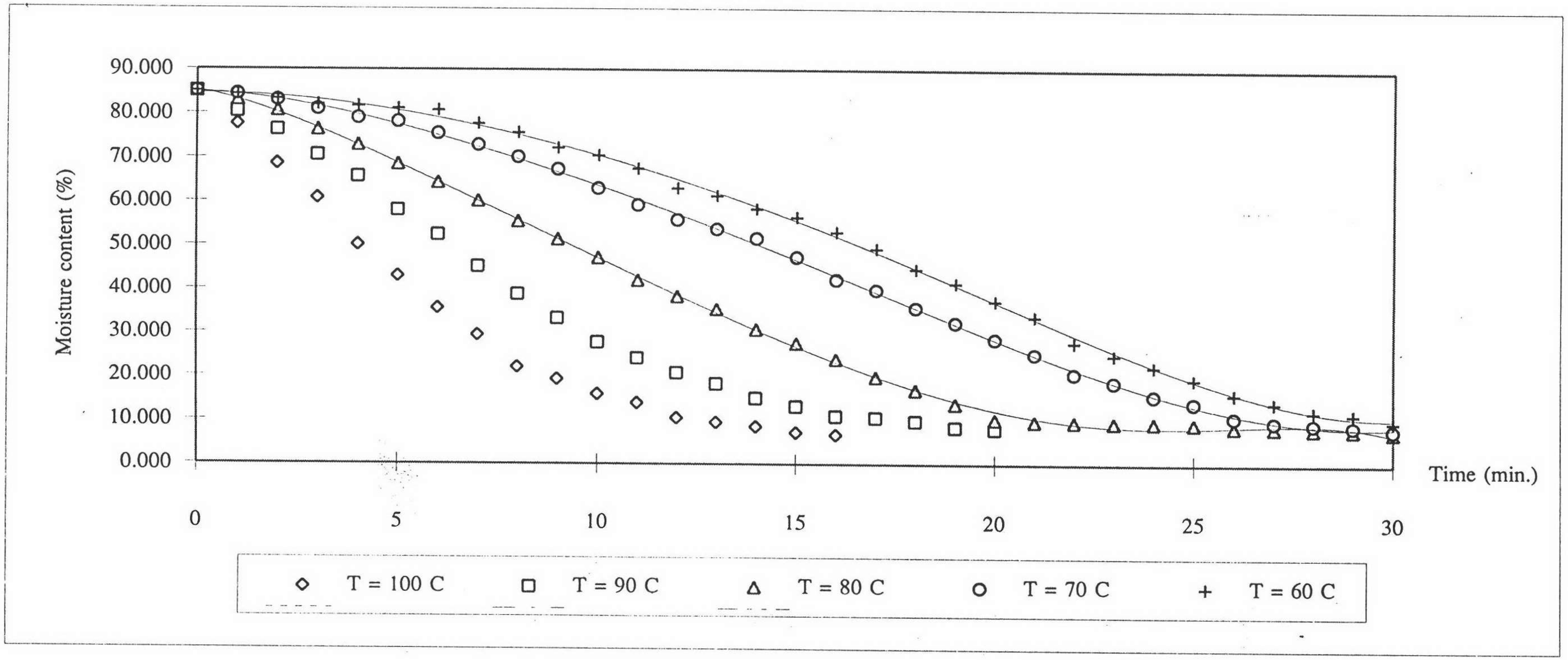

TABLE 6-10

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.5 m/s.
Thickness of veneer ; t = 1.5 mm.
Resident time ; dt = 1.0 min.

Time	**Moisture content (%)**				
(min.)	**Hot Air Temperature (Deg. C)**				
	T = 100 C	**T = 90 C**	**T = 80 C**	**T = 70 C**	**T = 60 C**
0	85.034	85.034	85.034	85.034	85.034
1	75.831	80.501	82.917	83.175	83.746
2	64.823	75.966	80.510	81.959	81.450
3	54.064	69.933	75.810	79.188	80.813
4	42.466	63.572	70.177	78.771	79.857
5	35.006	56.135	66.210	73.506	78.696
6	29.047	49.217	62.738	70.055	76.917
7	23.290	40.948	58.092	69.581	72.761
8	19.476	34.685	52.670	65.771	69.700
9	13.093	28.309	48.469	62.729	68.240
10	12.670	22.539	42.315	58.617	64.209
11	10.399	19.831	38.503	53.442	61.208
12	8.745	14.148	33.139	50.050	60.588
13	8.292	13.075	29.106	48.364	56.293
14	7.574	10.282	25.160	44.116	53.110
15	6.854	9.505	21.262	40.551	48.943
16	6.193	7.106	18.570	37.860	48.106
17		6.819	15.058	32.759	44.271
18		6.437	12.380	28.604	40.341
19		6.222	10.637	25.016	36.661
20		6.021	9.774	21.521	31.314
21			8.752	18.816	30.430
22			8.272	15.711	25.896
23			7.917	12.959	22.350
24			7.710	10.320	19.135
25			7.594	9.531	15.792
26			7.444	8.941	12.390
27			7.350	8.348	11.950
28			7.211	7.749	10.234
29			6.787	7.154	8.940
30			6.491	6.280	7.318

Fig. 6.10

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.5 m/s.

Thickness of venee ; t = 1.5 mm.

Resident time ; dt = 1.0 min.

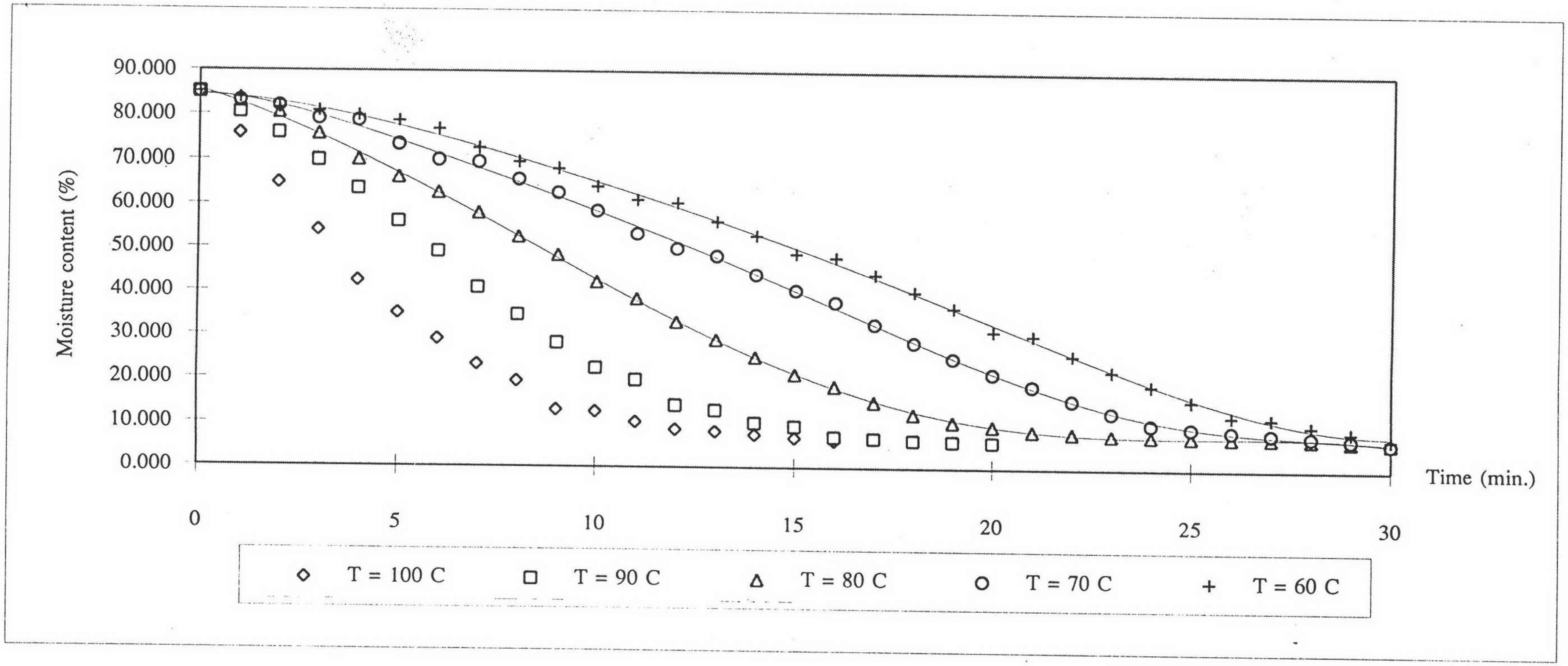

TABLE 6-11

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 1.5 m/s.

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

Time (min.)	Moisture content (%)				
	Hot Air Temperature (Deg. C)				
	T = 100 C	T = 90 C	T = 80 C	T = 70 C	T = 60 C
0	85.034	85.034	85.034	85.034	85.034
1	83.567	83.791	84.782	84.646	85.034
2	79.736	80.759	83.052	84.296	85.000
3	73.282	78.881	82.859	83.882	84.610
4	68.562	75.086	81.698	82.149	83.907
5	62.687	72.751	79.799	81.417	83.356
6	56.504	69.897	77.203	80.156	82.194
7	50.066	62.392	75.100	78.523	81.351
8	44.792	59.375	71.715	77.920	80.517
9	37.699	55.499	68.353	75.704	77.841
10	32.845	49.044	64.401	74.494	76.854
11	28.100	45.878	60.699	70.695	73.529
12	23.296	38.776	55.846	66.636	71.099
13	19.020	34.042	50.715	65.559	69.361
14	16.809	27.352	44.556	63.734	67.297
15	12.403	22.699	41.914	59.249	63.601
16	9.678	20.590	34.423	54.085	60.552
17		17.292	32.443	50.900	58.610
18		14.054	27.455	46.306	53.995
19		12.450	24.689	42.751	50.479
20		11.217	21.345	38.684	48.148
21			18.954	34.044	44.078
22			15.021	30.353	40.883
23			14.718	28.827	36.836
24			12.577	24.157	33.695
25			12.313	22.842	30.474
26			12.006	20.498	26.725
27			11.228	17.708	22.991
28			11.204	15.898	19.389
29			11.117	13.257	16.133
30			10.954	12.221	13.624

Fig. 6.11

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 1.5 m/s.

Thickness of venee ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

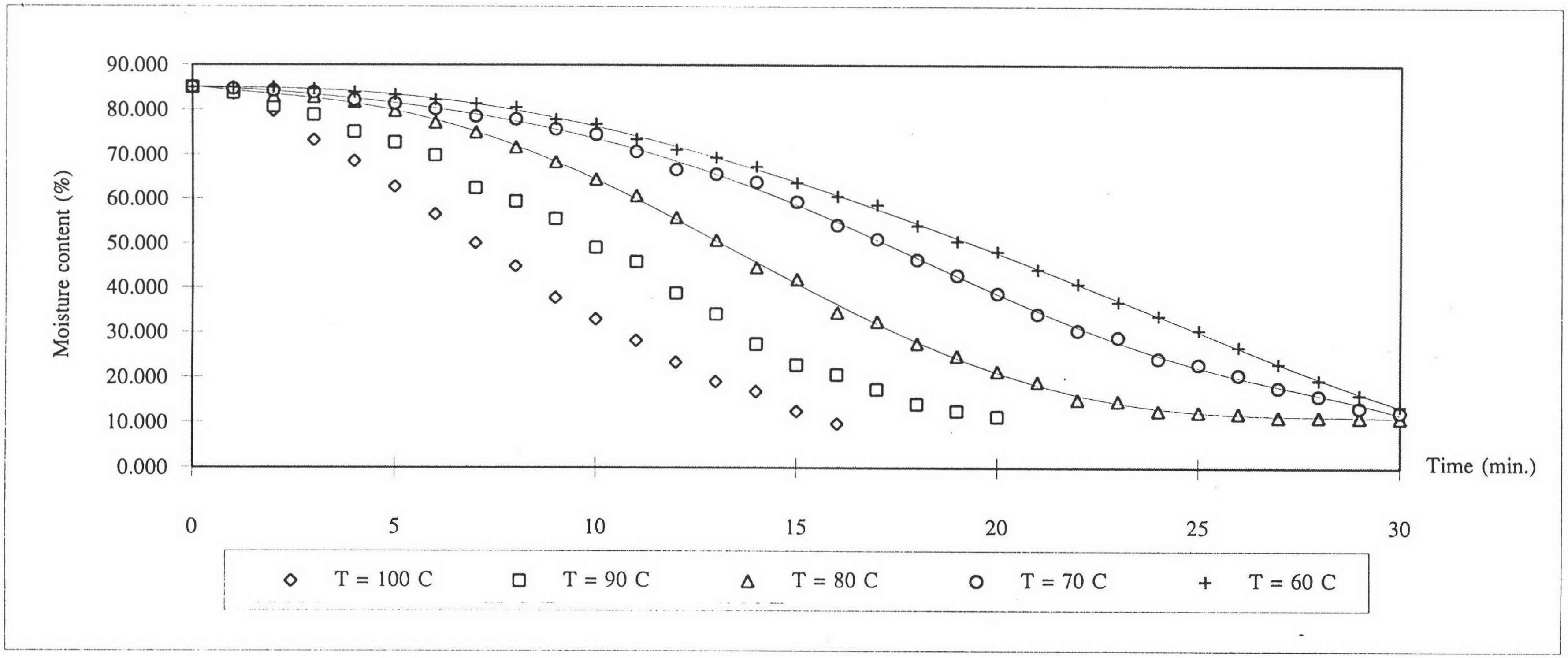

TABLE 6-12

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.0 m/s.

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

Time	**Moisture content (%)**				
(min.)	**Hot Air Temperature (Deg. C)**				
	T = 100 C	**T = 90 C**	**T = 80 C**	**T = 70 C**	**T = 60 C**
0	85.034	85.034	85.034	85.034	85.034
1	81.616	82.511	84.630	84.540	84.909
2	77.541	79.812	83.069	83.558	84.523
3	71.143	75.009	80.814	82.742	84.102
4	65.518	72.789	79.519	81.316	83.443
5	59.412	68.479	76.718	80.492	82.098
6	51.398	65.289	74.096	78.783	82.207
7	46.150	61.685	70.608	76.033	80.002
8	40.495	54.105	69.881	74.593	78.596
9	33.993	51.953	65.083	72.938	76.407
10	26.112	44.767	60.742	68.953	74.905
11	24.007	40.655	55.206	64.034	72.789
12	19.554	33.238	50.308	60.140	70.809
13	15.109	28.118	45.012	57.846	67.875
14	11.072	22.127	38.908	54.921	65.643
15	8.236	19.692	33.493	50.639	61.313
16	7.017	17.309	28.692	47.594	58.548
17		13.323	24.103	44.254	54.196
18		11.393	19.618	40.355	50.339
19		10.451	18.316	38.540	46.536
20		9.522	17.117	34.253	43.752
21			15.733	31.349	40.231
22			11.670	28.395	36.134
23			10.510	25.105	32.001
24			9.671	22.731	29.016
25			9.266	20.652	24.732
26			8.997	18.700	20.613
27			8.927	16.136	17.393
28			8.909	15.375	14.601
29			8.811	12.624	12.995
30			8.850	11.856	11.541

Fig. 6.12

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.0 m/s.

Thickness of venee ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

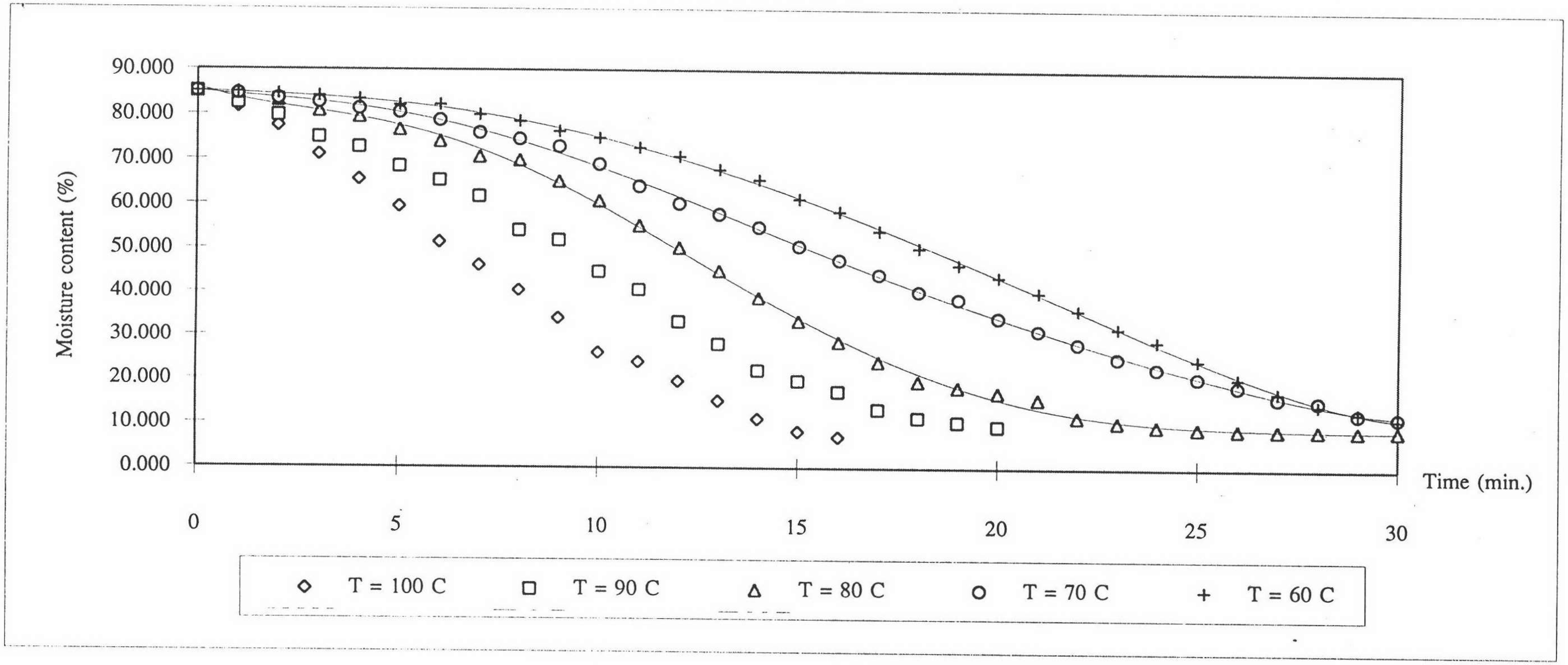

TABLE 6-13

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.5 m/s.

Thickness of veneer ; t = 2.0 mm.

Resident time ; dt = 1.0 min.

Time (min.)	Moisture content (%)				
	Hot Air Temperature (Deg. C)				
	T = 100 C	T = 90 C	T = 80 C	T = 70 C	T = 60 C
0	85.034	85.034	85.034	85.034	85.034
1	79.212	81.258	83.530	83.303	84.730
2	75.167	77.451	81.216	82.980	83.938
3	67.292	73.297	79.658	80.719	82.502
4	60.125	68.055	76.020	80.217	81.568
5	52.397	63.220	74.606	78.913	80.047
6	46.657	59.798	69.982	76.448	78.188
7	40.411	54.959	65.261	74.526	76.214
8	34.585	49.491	62.005	72.993	74.747
9	28.100	43.242	55.734	69.940	72.524
10	23.356	38.407	51.546	64.486	69.084
11	18.612	32.308	45.017	60.830	66.025
12	14.995	26.197	40.106	57.700	64.693
13	12.234	21.352	35.592	54.704	61.402
14	9.418	18.558	29.208	50.253	58.702
15	7.582	14.591	26.903	47.400	55.449
16	6.241	12.262	22.453	44.996	52.902
17		11.741	20.649	40.740	48.855
18		9.361	15.021	36.155	45.488
19		8.793	12.521	32.816	42.448
20		7.602	12.013	28.300	38.216
21			11.193	26.877	34.552
22			9.600	23.818	30.605
23			8.642	20.608	28.756
24			8.394	18.190	25.385
25			7.520	16.560	22.644
26			7.520	14.957	18.046
27			7.011	12.649	15.330
28			6.707	11.516	13.254
29			6.428	10.759	12.709
30			5.019	10.006	11.440

Fig. 6.13

Show comparison of moisture content of veneer during drying at each hot air temperature ; T

Hot air velocity ; Va = 2.5 m/s.
Thickness of venee ; t = 2.0 mm.
Resident time ; dt = 1.0 min.

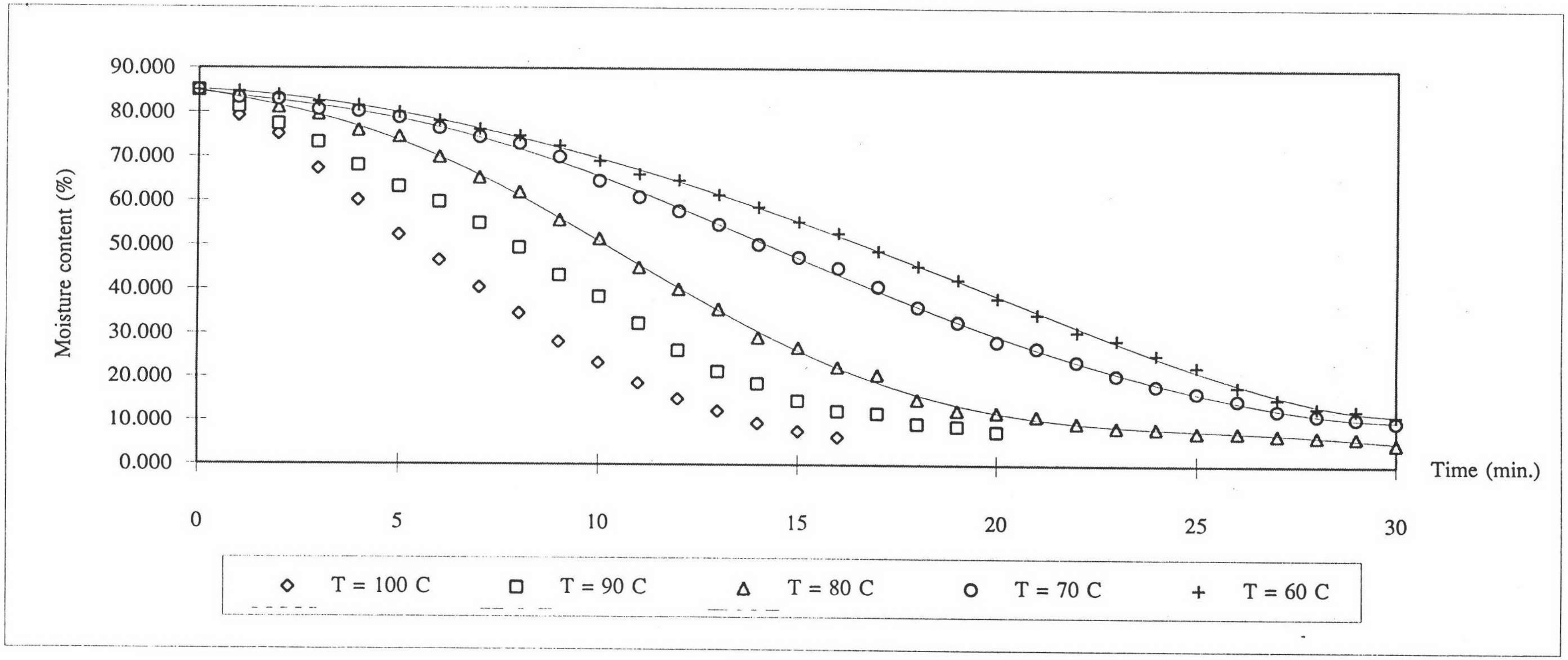

TABLE 6-14

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 1.5 m/s.

Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	82.957	75.253	58.603	41.641	24.823	10.557
70	79.754	67.543	52.946	32.253	15.455	9.923
80	70.818	50.109	30.128	12.771	9.939	8.875
90	60.414	31.067	15.693	9.279		
100	45.010	18.595	8.496			

TABLE 6-15

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.0 m/s.

Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	81.109	70.542	56.498	37.357	19.399	9.862
70	78.221	63.059	47.393	28.545	13.943	8.068
80	68.641	47.203	27.588	10.256	9.284	7.481
90	58.069	27.776	13.134	8.029		
100	42.964	15.865	7.193			

TABLE 6-16

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.5 m/s.

Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	78.696	64.209	48.943	31.314	15.792	7.318
70	73.506	58.617	40.551	21.521	9.531	6.280
80	66.210	42.315	21.262	9.774	7.594	6.491
90	56.135	22.539	9.505	6.021		
100	35.006	12.670	6.854			

TABLE 6-17

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 1.5 m/s.

Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	83.356	76.854	63.601	45.148	24.474	10.624
70	81.417	70.443	51.112	31.096	16.044	10.599
80	79.799	64.401	41.914	21.345	12.313	10.954
90	72.751	49.044	22.699	11.217		
100	62.687	32.845	12.403			

TABLE 6-18

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.
Hot air velocity = 2.0 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	82.098	71.905	57.313	37.752	19.732	9.541
70	80.492	67.740	46.694	26.925	13.533	9.894
80	76.718	60.742	33.493	17.117	9.266	8.850
90	68.479	44.767	19.692	9.522		
100	59.412	26.112	8.236			

TABLE 6-19

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.
Hot air velocity = 2.5 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Hot air Temp.	Moisture content (%) Drying time ; td					
(Deg. C)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
60	77.047	64.084	48.449	32.216	16.644	8.440
70	76.913	61.486	37.400	22.290	9.560	8.006
80	74.606	51.546	26.903	12.013	7.520	5.019
90	63.220	38.407	14.591	7.602		
100	52.397	23.356	7.582			

Figure 6.14

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 1.5 m/s.

Hot air drying temperature ; = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

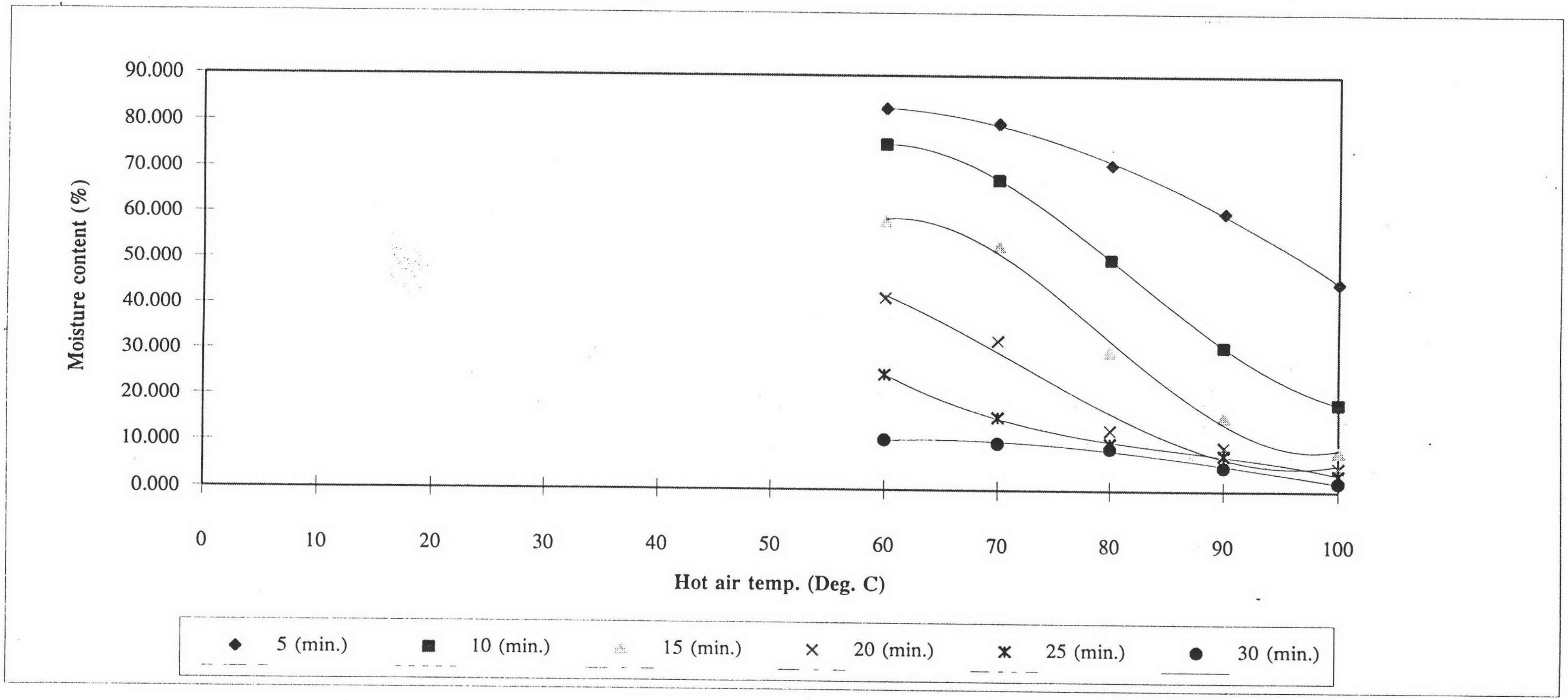

Figure 6.15

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.0 m/s.

Hot air drying temperature ; = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

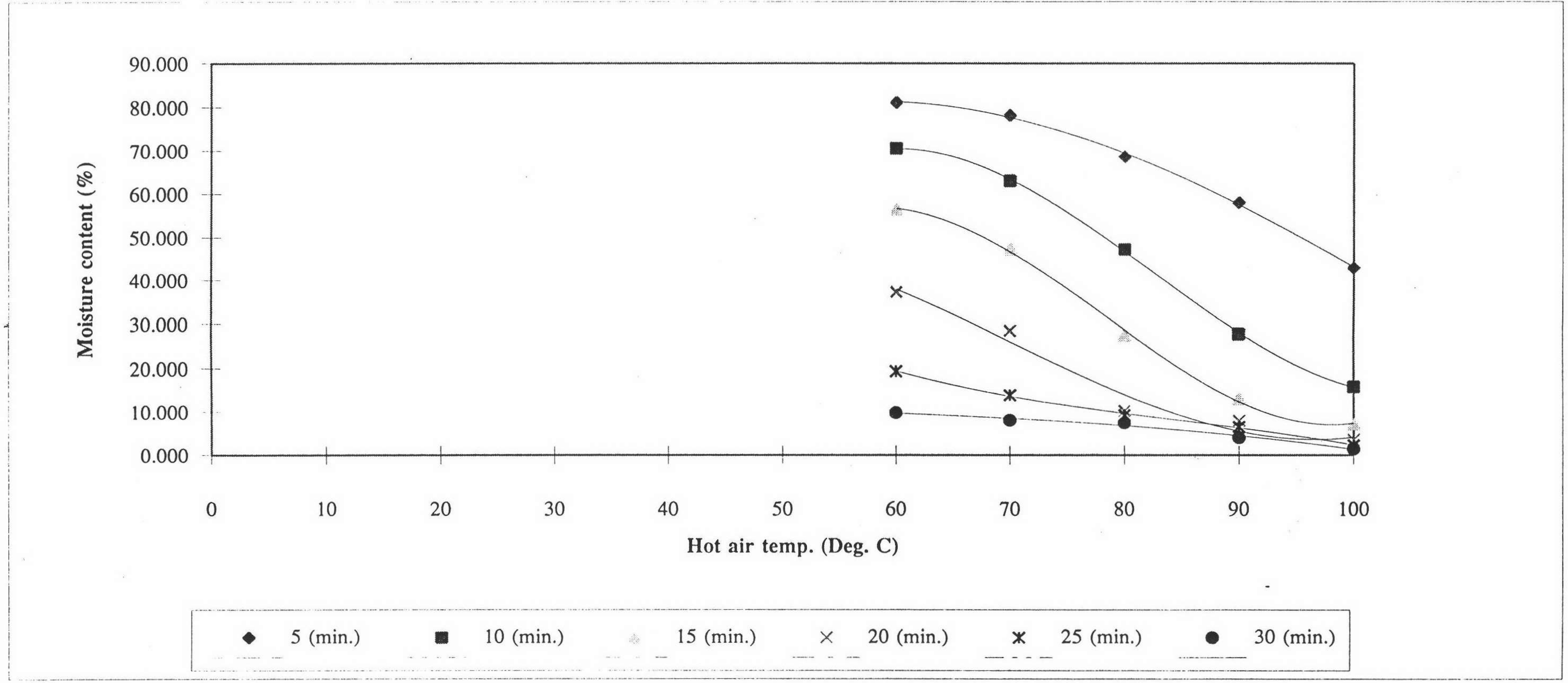

Figure 6.16

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.5 m/s.

Hot air drying temperature ; = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

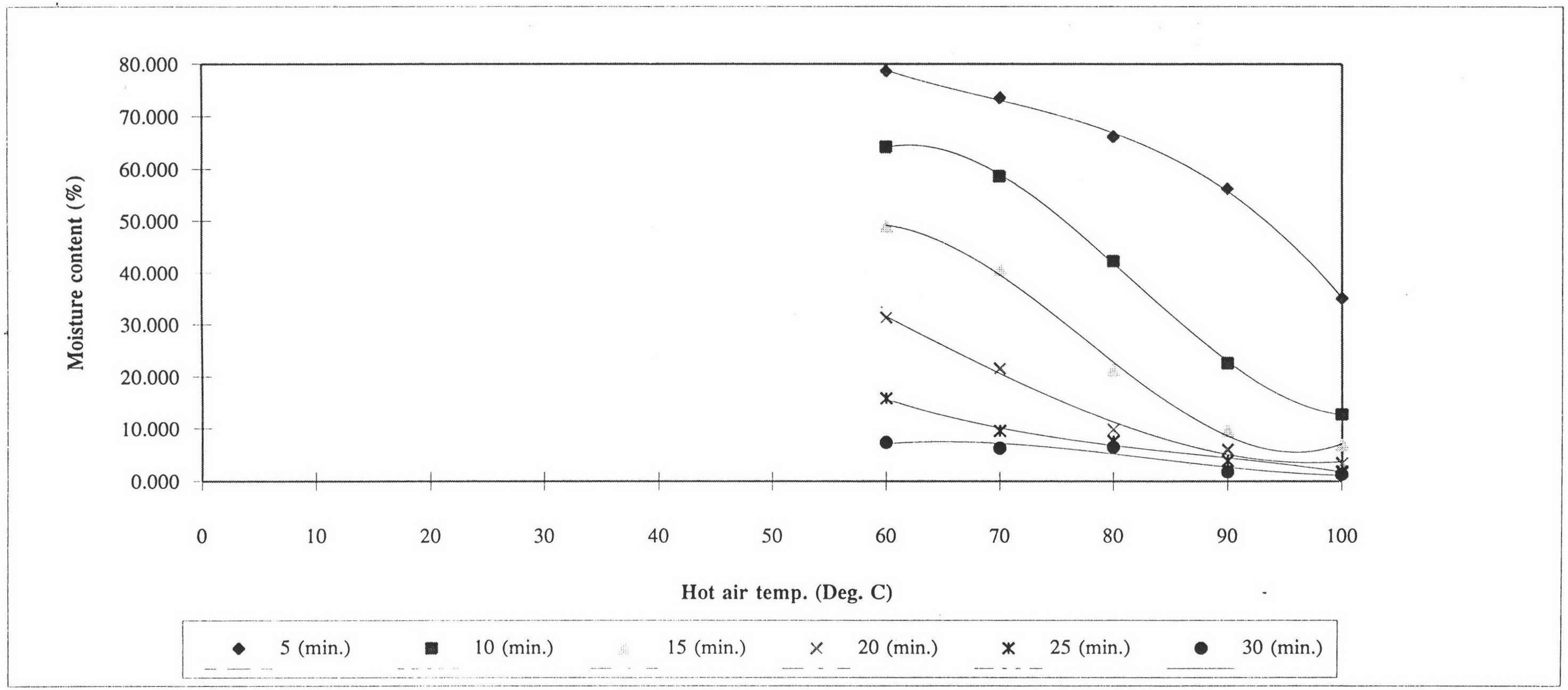

Figure 6.17

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 1.5 m/s.

Hot air drying temperature ; = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

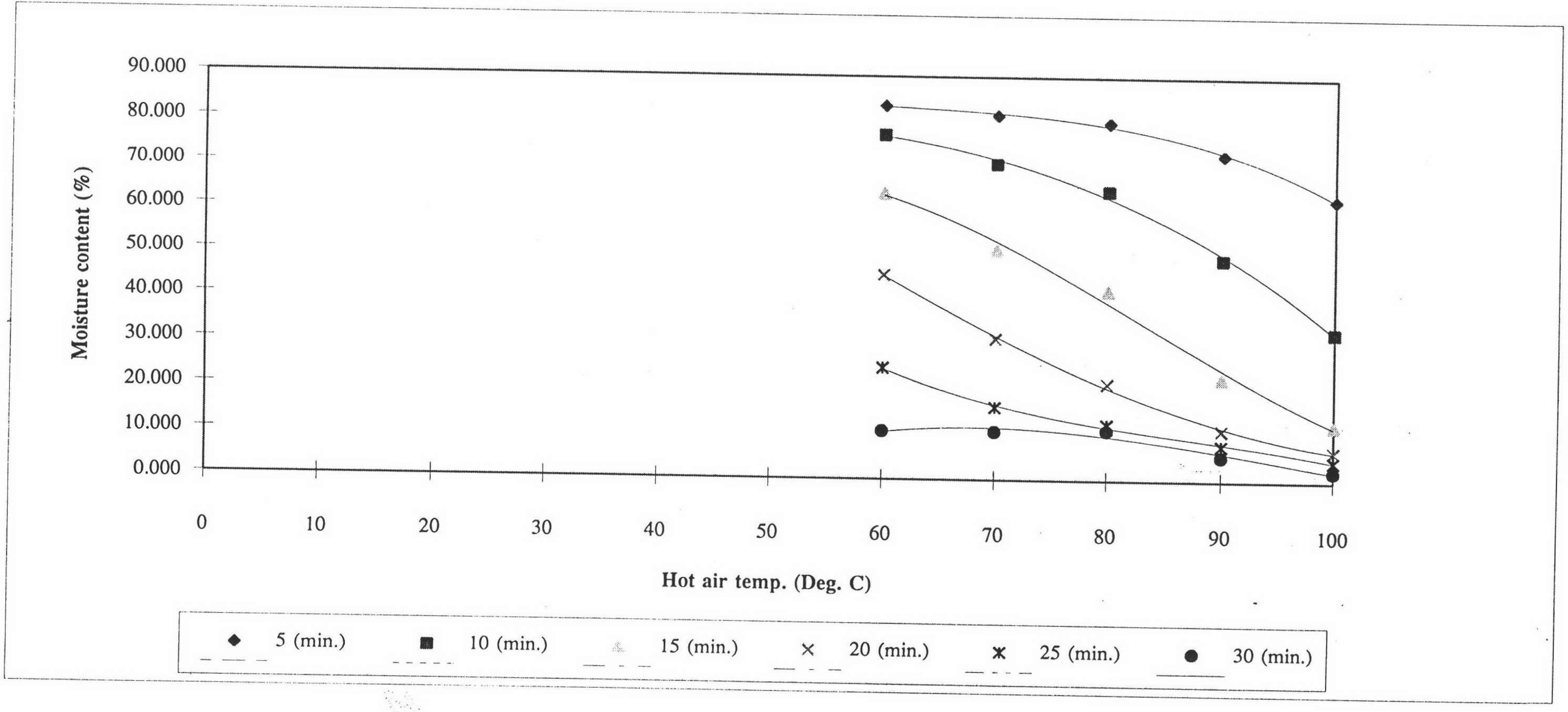

Figure 6.18

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 2.0 m/s.

Hot air drying temperature ; .= 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

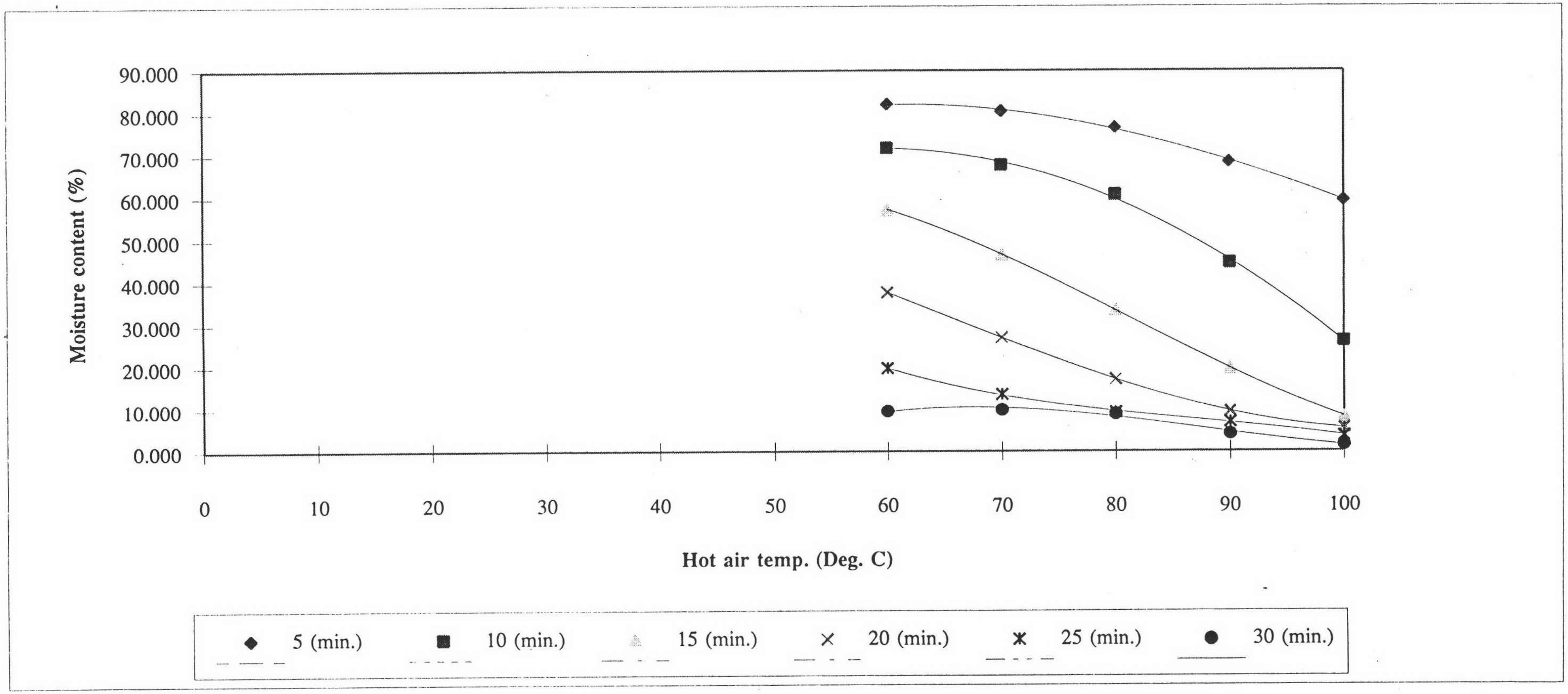

Figure 6.19

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 2.5 m/s.

Hot air drying temperature ; = 60, 70, 80, 90 and 100 Deg. C

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

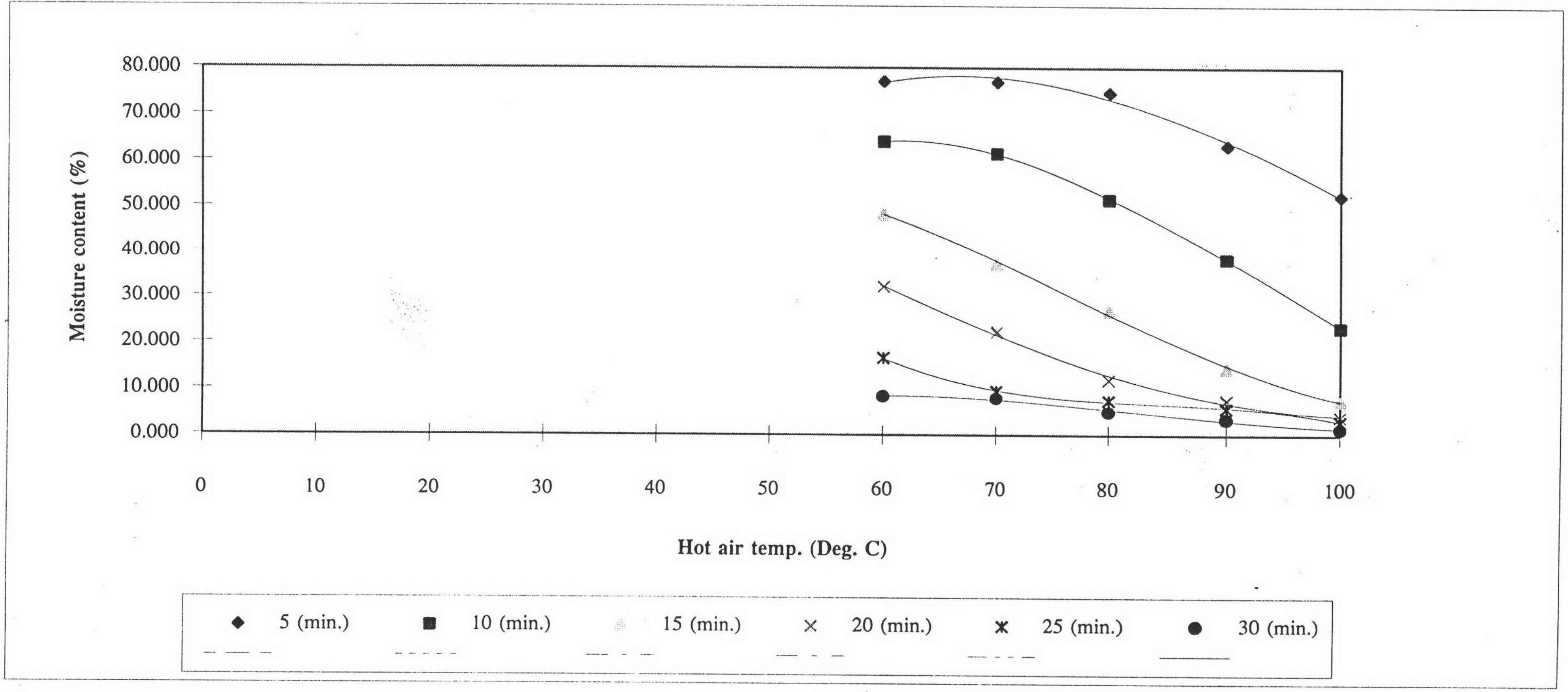

TABLE 6-20

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.
Hot air velocity = 1.5 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
11.3	82.957	75.253	58.603	41.641	24.823	10.557
8.48	79.754	67.543	52.946	32.253	15.455	9.923
6.68	70.818	50.109	30.128	12.771	9.939	8.875
6.07	60.414	31.067	15.693	9.279		
4.86	45.010	18.595	8.496			

TABLE 6-21

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.
Hot air velocity = 2.0 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
10.92	81.109	70.542	56.498	37.357	19.399	9.862
7.97	78.221	63.059	47.393	28.545	13.943	8.068
6.50	68.641	47.203	27.588	10.256	9.284	7.481
5.62	58.069	27.776	13.134	8.029		
4.86	42.964	15.865	7.193			

TABLE 6-22

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 1.5 mm.
Hot air velocity = 2.5 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
10.55	78.696	64.209	48.943	31.314	15.792	7.318
7.48	73.506	58.617	40.551	21.521	9.531	6.280
6.31	66.210	42.315	21.262	9.774	7.594	6.491
5.48	56.135	22.539	9.505	6.021		
4.30	35.006	12.670	6.854			

TABLE 6-23

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.
Hot air velocity = 1.5 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
12.01	83.356	76.854	63.601	45.148	24.474	10.624
9.03	81.417	70.443	51.112	31.096	16.044	10.599
7.47	79.799	64.401	41.914	21.345	12.313	10.954
6.38	72.751	49.044	22.699	11.217		
4.61	62.687	32.845	12.403			

TABLE 6-24

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.
Hot air velocity = 2.0 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
11.23	82.098	71.905	57.313	37.752	19.732	9.541
7.98	80.492	67.740	46.694	26.925	13.533	9.894
7.07	76.718	60.742	33.493	17.117	9.266	8.850
6.23	68.479	44.767	19.692	9.522		
4.40	59.412	26.112	8.236			

TABLE 6-25

Show moisture content during drying at each temperture of hot air drying by constant drying time

Thickness of veneer ; t = 2.0 mm.
Hot air velocity = 2.5 m/s.
Hot air drying temperature ; T = 60, 70, 80, 90 and 100 Deg. C
Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

Relative Humidity	Moisture content (%) Drying time ; td					
R.H. (%)	5 (min.)	10 (min.)	15 (min.)	20 (min.)	25 (min.)	30 (min.)
10.19	77.047	64.084	48.449	32.216	16.644	8.440
7.48	76.913	61.486	37.400	22.290	9.560	8.006
6.88	74.606	51.546	26.903	12.013	7.520	5.019
5.93	63.220	38.407	14.591	7.602		
4.63	52.397	23.356	7.582			

Figure 6.20

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 1.5 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

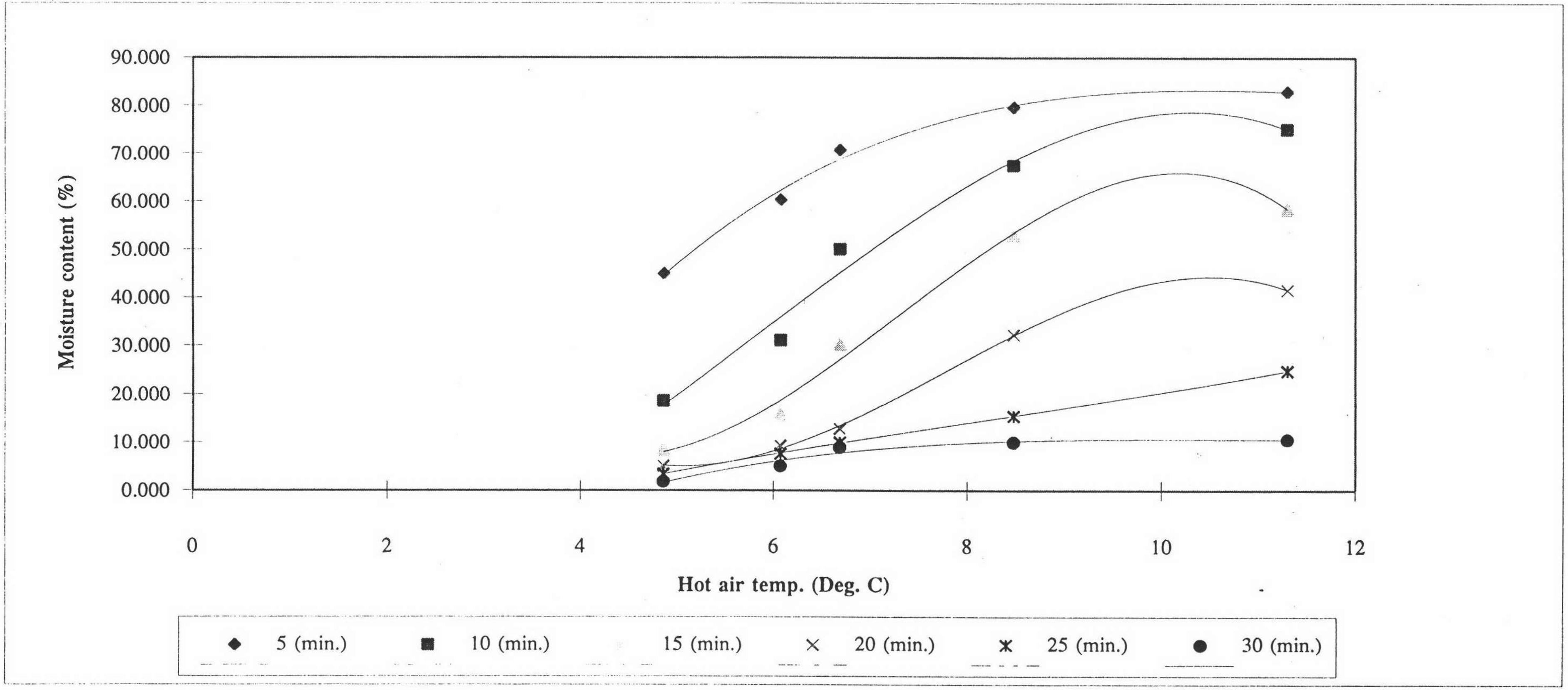

Figure 6.21

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.0 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

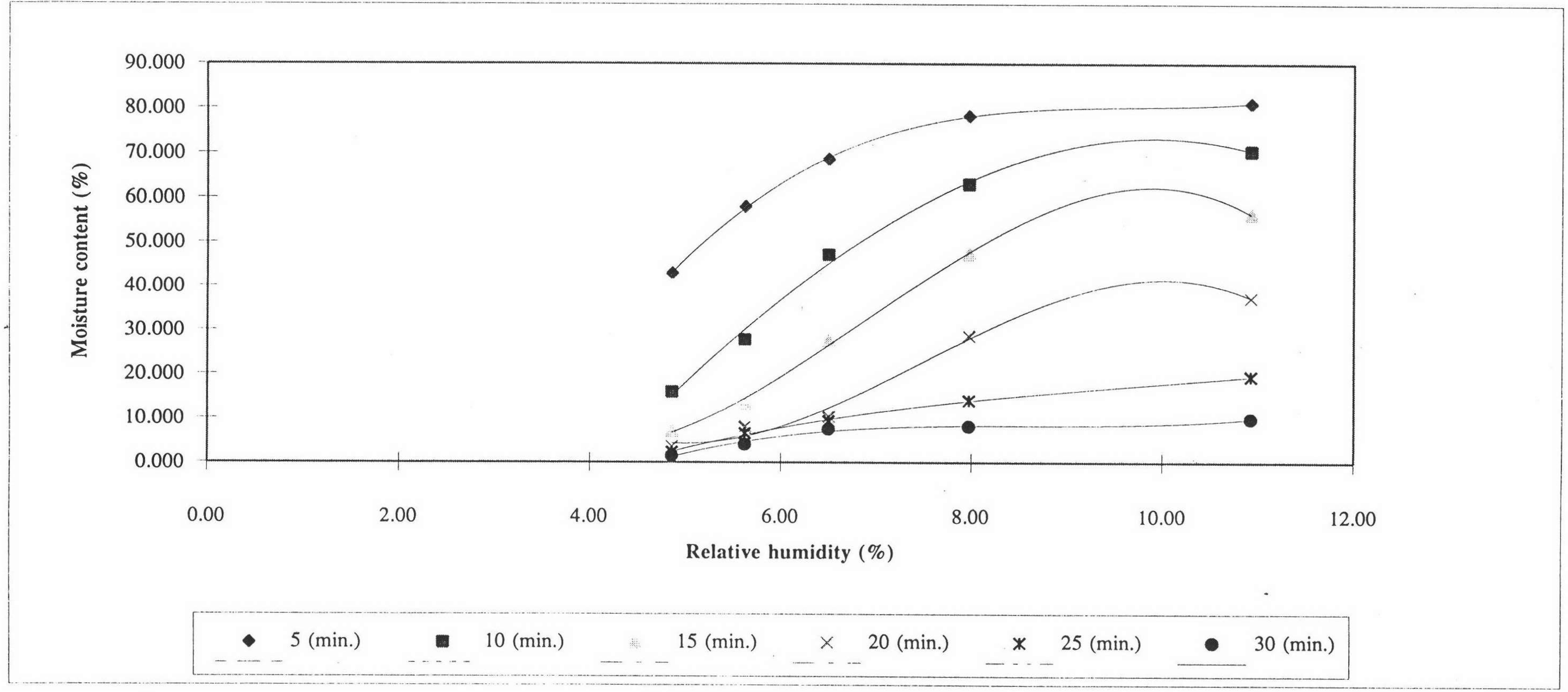

Figure 6.22

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 1.5 mm.

Hot air velocity = 2.5 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

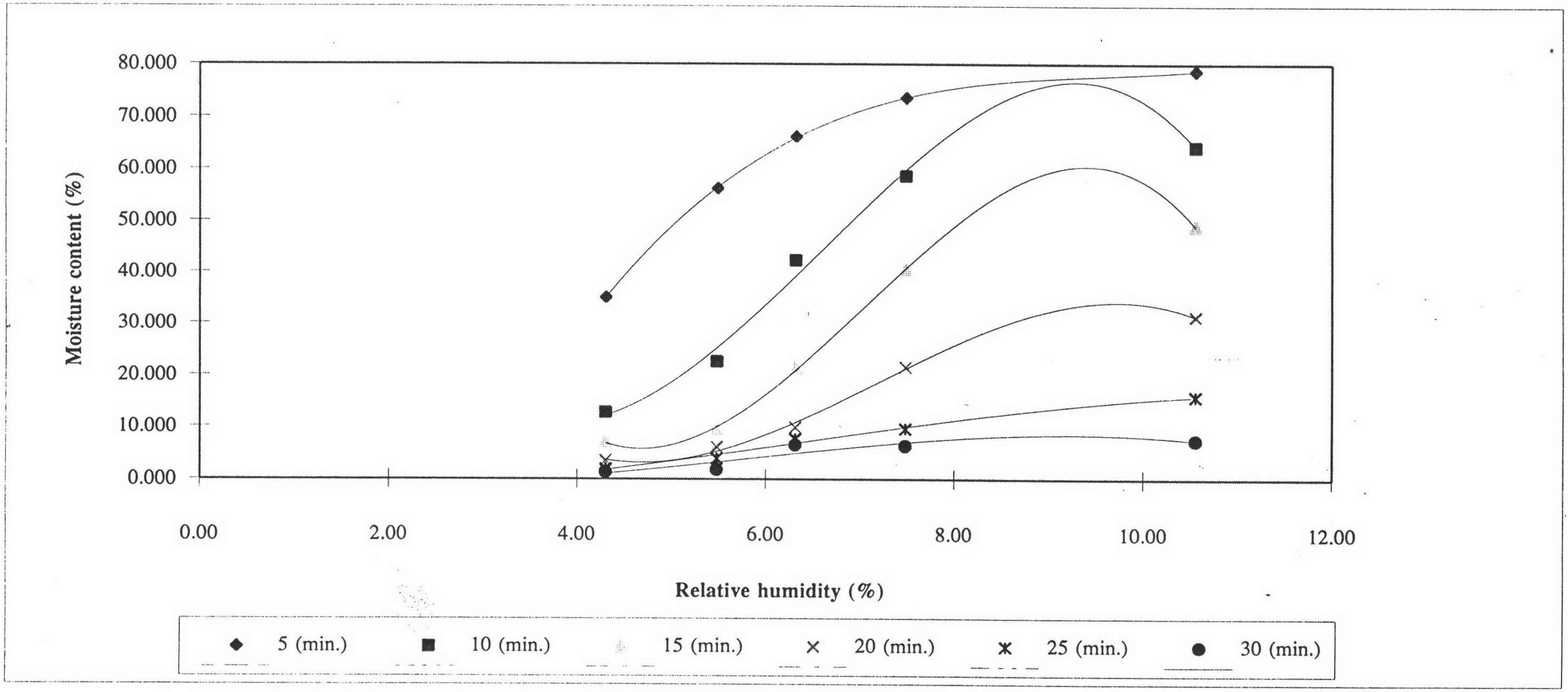

Figure 6.23

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 1.5 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

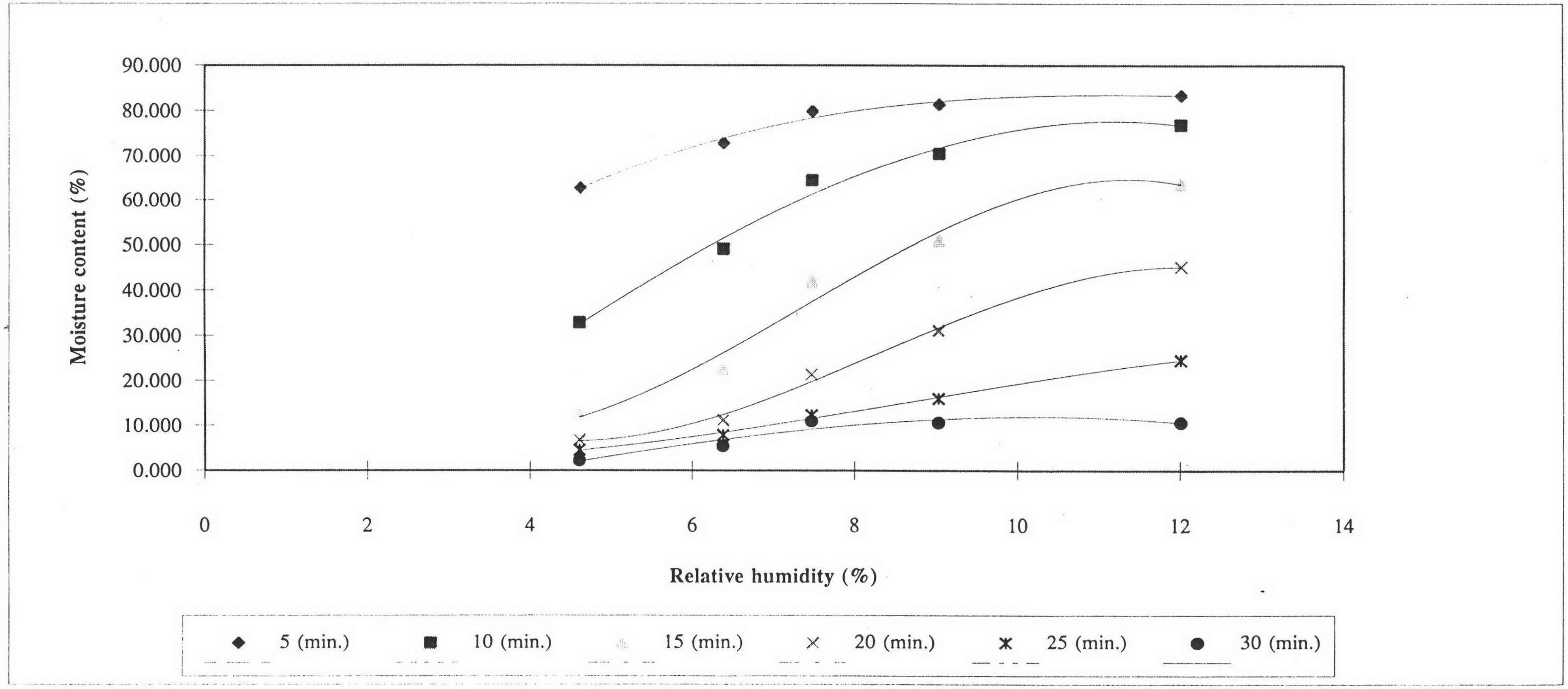

Figure 6.24

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 2.0 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.

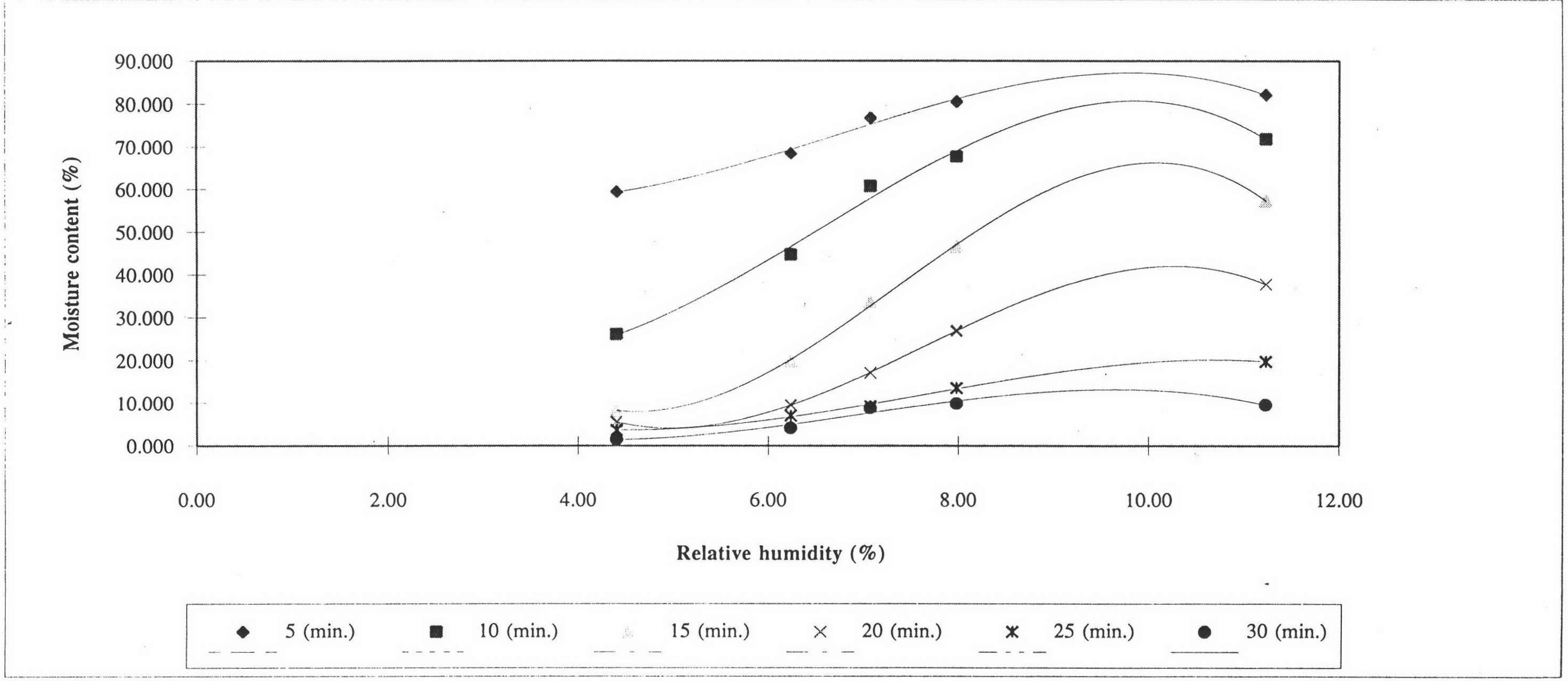

Figure 6.25

Comparison of moisture content of veneer during drying at different relative humidity

Thickness of veneer ; t = 2.0 mm.

Hot air velocity = 2.5 m/s.

Drying time ; td = 5, 10, 15, 20, 25 and 30 min.