CONTROL OF VENEER THICKNESS

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Statistical quality control techniques for the collection and analysis of thickness data have been shown to be feasible and profitable in research or production processes for peeling veneer from tropical woods of Pakistan. Shewhart's X and R charts are well suited for this purpose. Once having indicated the existence of an assignable cause or of having demonstrated the effect of a deliberate manipulation of a veneering operation, the charts can be cited as statistical evidence in drawing inferences about the phenomenon. Examination of veneer peeling lathes revealed that nosebar pressures, knife angles, temperature of logs, properties of the wood embodied in species differences, maintenance of machinery, and care druing operation all affect the control of veneer thicknesses.

These effects can be observed on the charts and adverse manufacturing minimized by making corrective adjustments as noted in the paper.

Veneer of uniform and precise thickness is of the first importance in producing plywood of prescribed bond and dimensional qualities. Regulated peeling of logs can be achieved on rotary lathes through the use of the statistical techniques as formulated by Shewhart;[5] but, usually formalized quality control is ignored.

Although widely practised in advertising, the term, quality, is incorrectly used to imply the superior goodness of a product. In these applications, a qualifying adjective should be attached as shown in Webster's dictionary-Quality: "degree of excellence, as a material of fine quality". The first two preferred definitions are: "1. any peculiar power or property. 2. Essential nature, attribute, characteristic." Radford[4] states, "The term quality as applied to the products turned out by an industry means the characteristics or group or combination of characteristics which distinguished competitors, or one grade of products from a certain factory from another grade turned out by the same factory".

In the latter senses, veneer has the controllable qualities of thickness, condition of surfaces and moisture content. Moreover, controlling quality at a stated level implies that veneer, or plywood, be manufactured to desired standards determined only by end-use requirement. For example, tea-chest plywood need not have the bond quality of marine plywood and thus veneer for the latter must be greatly superior to that of the former.

As in the manufacture of other mass-produced products some variation in veneer thickness is expected and accepted as normal. In this regard, the statistical quality control charts, developed originally by Shewhart and his colleagues at the Bell Telephone Laboratories, U.S.A., can usually be employed readily for defining the natural variation of a process, for revealing assignable causes of unnecessary quality variation, and for aiding in the identification of such causes so that they can be eliminated. The application of these techniques to the lumber industry is well recorded.[1] But this is not so for veneer manufacturing.

It is for the control of veneer thickness in Pakistan that these studies were directed and this paper has been written.

The Problem

Thick and thin or excessively rough veneer makes impossible the intimate contact of wood surfaces so indispensable in securing adequate glue bonds in plywood.[3] With this malefic stock, glue spreads of high-cost imported resins must be materially increased, over an achievable optimum requirement, just to bridge wood gaps. Characteristically, the resultant low-grade plywood is associated with immoderate wastage of glue and wood and, therefore, inordinate costs.

The thickness and surface qualities of veneer reflect simultaneously the effect of the species, condition of the wood, condition of the lathe, and the settings of the knife and nosebar during the peeling process.[2] Usually with control of thickness, other things being properly adjusted, smoothness of surface is also insured. The problem, then, in Pakistan's veneer manufacturing, is to contrive a systematic procedure for obtaining veneer of optimum qualities from logs of almost countless species and conditions.

Collection of Data

In these studies, Shewhart's X and R charts have been employed. The research on knife angle, log temperature, and nosebar pressure ior Koroi (*Albizzia procera*) was conducted on the

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Coe lathe at the Forest Products Laboratory; and the studies of veneer thickness variation in commerical operations were completed on three lathes in two cooperating plywood factories.

From the factory-produced veneer a strip 1-2″ in width was ripped off each 10-20 foot piece of rolled veneer stock. The thickness was taken as illustrated in Fig. 1 and recorded with calculations as shown in Table 1. X and R, the average and the range, of each subgroup were computed; $\bar{\bar{X}}$, (the overall average), UCL and LCL, (upper and lower control limits for $\bar{X}$ and R) were computed and graphed as shown in Figs. 2,3,4,5,6 and 7. These graphs were made immediately upon collection of the data for purposes of interpreting the operating characteristic of the lathes.

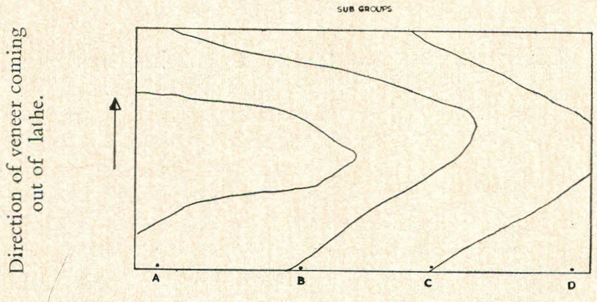

Fig. 1.—Sketch showing the points at A B C and D at which thickness.

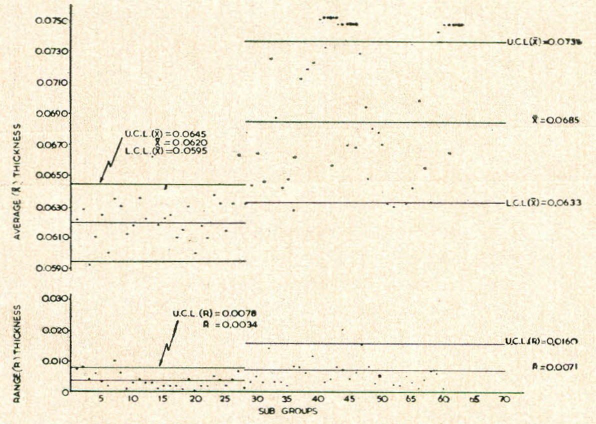

Fig. 2.—$\bar{X}$ and R charts for veneer thickness of lathe A.

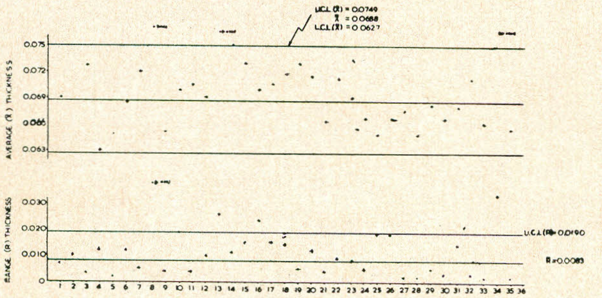

Fig. 3.—$\bar{X}$ and R charts for veneer thickness of lathe B.

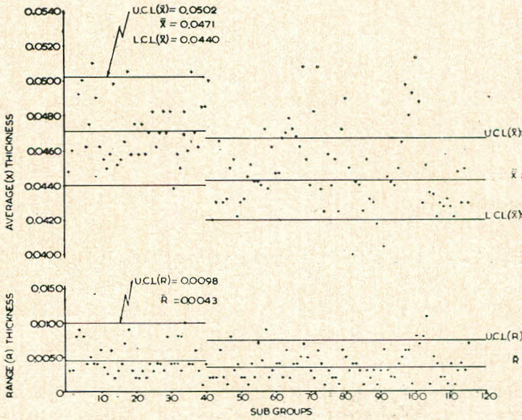

Fig. 4.—$\bar{X}$ and R charts for veneer thickness of lathe C.

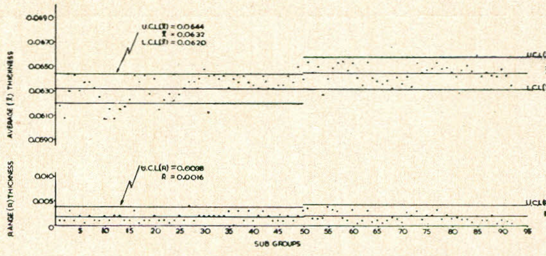

Fig. 5.—X and R charts for veneer thickness of lathe D.

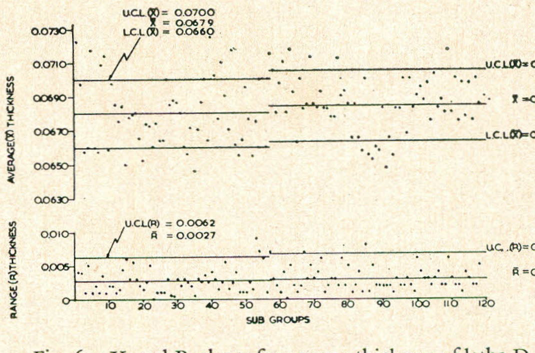

Fig. 6.—X and R charts for veneer thickness of lathe D.

In the laboratory, all veneer produced was, clipped into 12″ pieces, and subgroups were taken at 1′ intervals instead of the 10-20′ intervals used in commercial studies. Shewhart's charts were again the basis for construing the effect of the variables on the veneering process.

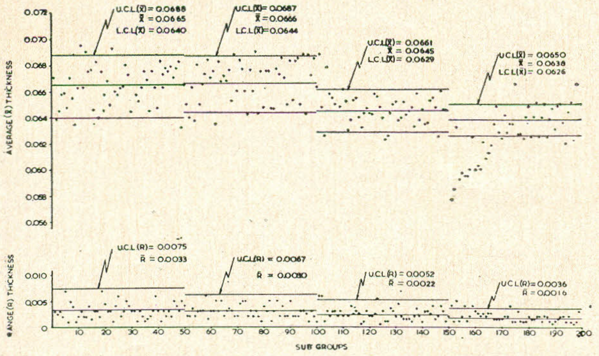

Fig. 7.—$\bar{X}$ and R charts for the veneer thickness of lathe A.

An unknown exotic species was peeled in the initial lathe "de-bugging" studies (Fig. 5 and 6), and afterwards the reported research on Koroi (*Albizzia procera*) was conducted as follows:—

Set Up 1. Bolt cold; No nosebar pressure
- (a) Bolt at room temperature
- (b) Nosebar open
- (c) Knife angle = 90°30′
- (d) Feed rate = 1/16″

Set Up 2. Bolt cold; slight nosebar pressure
- (a) Bolt at room temperature
- (b) Nosebar opening
  - (i) Horizontal opening = 0.060″
  - (ii) Vertical opening = 0.017″
- (c) Knife angle = 90°30′
- (d) Feed rate = 1/16″

Set Up 3. Bolt hot; Slight nosebar pressure
- (a) Bolt temperature = 140°F

TABLE 1.—RECORD SHEET FOR $\bar{X}$ AND R CHART.

Material: Civit
Characteristics measured: Thickness
Units for measurement: 1/1000″

Lathe: C
Date: 21-12-60
Recorder: Barefoot and Salehuddin

Subgroup	A	B	C	D	X	R
1	47	44	44	44	44·75	3
2	48	46	45	45	46.00	3
3	40	38	42	46	41.50	8
4	52	52	50	43	49·25	9
5	50	55	48	47	50.00	8
..	..	..	..	..	..	..
..	..	..	..	..	..	..
40	49	49	46	50	48.50	4
41	49	49	51	51	50.00	2

U.C.L.($\bar{X}$) $= \bar{\bar{X}} + A_2\bar{R}$
$= 47\cdot1 + (\cdot729)(4\cdot3)$
$= 47\cdot1 + 3\cdot1$
$= 50.2$
$= 0.0502$ in (decoded)

L.C.L.($\bar{X}$) $= \bar{\bar{X}} - A_2\bar{R}$
$= 44\cdot0$
$= 0.0440$ in (decoded)

U.C.L.(R) $= (D_4)\ (\bar{R})$
$= (2.282)(4\cdot3)$
$= 9.8$
$= 0.0098$ in (decoded)

Total $\bar{X} = 1929.25$

$\bar{\bar{X}} = 47\cdot1$

Total R $= 177$

$\bar{R} = 4\cdot3$

$\bar{\bar{X}} = 0.0471$ in (decoded)

$\bar{R} = 0.0043$ in (decoded)

(b) Nosebar openings
(i) Horizontal opening = 0.060″
(ii) Vertical opening = 0.017″
(c) Knife angle = 90°30′
(d) Feed rate = 1/16″

Set Up 4. Bolt hot; increased nosebar pressure.
(a) Bolt temperature = 140°F
(b) Nosebar openings
(i) Horizontal opening = 0.050″
(ii) Vertical opening = 0.017″
(c) Knife angle = 90°30′
(d) Feed rate = 1/16″

Assignable causes of variation in veneer thickness were identified when points were out of control on the charts and, when possible, action was taken to eliminate them. Reaction to these measures was recorded.

Variation in Veneer Thickness

The usual practice in developing $\bar{X}$ and R control charts suggests that 20-25 subgroups be taken from an uninterrupted process to establish control limits. In the case of Fig. 2 the first 12 subgroups were collected prior to the Cyclone and subgroups 13-22 immediately following the Cyclone. The lathe was operating as an improved process in the latter case, as shown by the R chart and the $\bar{x}$ chart and the charts must be interpreted with the fewer points. The more careful new set-up of the lathe, made possible by the enforced period of idleness in production, was obviously responsible for this improvement. In trying to further improve the operation the angle of the knife was changed and the subgroups 23-28 show the results of erroneously increasing the angle. The last section of the chart, subgroups 29-61, was based on data collected in several days following the previous group and an increase can be noted in the range of individual subgroups and in the scatter between subgroups. A complete explanation was not possible for this situation since the process was now so badly out of control.

The subgroups 29-50 were collected on civit veneer which was peeled with too large a knife angle. Subgroups 50-61 were from a mango log which yielded better veneer as reflected by the range chart and the reduction in average thickness. The two points outside the control limits were caused by a change in the grain direction of the mango bolt being peeled. Thus the lathe set-up appeared to be better suited to peeling mango than civit. The same general improvement in lathe B is shown in Fig. 3 at subgroup 24 where a mango bolt was peeled, also after several civit bolts had been cut in a poor state of control.

As noted, lathe B was operating very erratically and thus producing poorly manufactured veneer. Such veneer could not have been used in making a plywood capable of meeting high quality standards.

Lathe C in Fig. 4 was initially producing veneer substantially thicker than the target value of 0.0394″. The charts, observation will reveal, indicate that the process was also not operating in a state of control. To avoid thin veneer the operator was setting the lathe to produce excessively thicker veneer. The sudden decrease in the process level exhibited at subgroup 42 onwards followed the replacement of same parts in the feed mechanism of the lathe. The R chart does not reflect any improvement within subgroups, thereby indicating that at any given moment of cutting the lathe was still operating essentially as before except for the change in thickness level.

Insufficient nosebar pressure was thought to be one cause for the widespread dispersion of $\bar{x}$'s on the chart just discussed. During the peeling from which subgroups 102-115 came, the nosebar pressure was first set at a machine gauge reading of 10 as usual, then 7, and again 10 (all within one log). Upon setting to 7, a substantial improvement in the R chart and $\bar{x}$ chart was noted as shown on the figure. Reverting to a gauge reading of 10 caused the process to assume its former scatter as indicated by the two remaining subgroups.

Assignable causes for out of control points on these graphs, Fig. 3 and 4 were identified as:—

1. Knife angle too great at small bolt diameter.
2. Big knots in the bolts.
3. Civit log of abnormal wood (subgroups 97-101). (Wood very brittle, soft, and stringy).
4. Dry wood.
5. Insuffieient nosebar pressure.
6. Uneven pressures during round-up.

The studies at the Forest Research Laboratory, shown in Fig. 5 and 6, were done while peeling the unknown exotic species. As depicted in Figure 5, thick and thin veneers were being produced cyclically in the initial set-up due to the knife angle being too small. At about subgroup 30 the cycling ceased as the diameter of the bolt decreased, indicating that the knife angle was approximately correct at that stage of peeling. From subgroup 50 onward a new log was peeled at a greater knife angle which resulted in (1) the average thickness being higher and (2) the cycling being not evident, indicating the correctness of the change. The range chart remained essentially the same indicating no general change of variation within subgroups. During these studies generally low points (subgroups 64-72) and then generally high points (subgroups 73-85) were recorded.

Figure 6 illustrates the variable thickness of veneer produced while searching for the assignable cause noted by Fig. 5. Subgroups 94-119 of Fig. 6 were plotted after adjusting the feed mechanism and reveal the correctness of the action; thus, the assignable cause was a loose feed screw.

Statistical presentations of a process by pictorial means is an objective of the $\bar{x}$ and R chart, and Fig. 7 describes completely the effect of deliberate manipulation of the variable factors chosen for study. The four sections of the figure depict respectively data from the four set-ups outlined for peeling Koroi. The several points below the control limits in subgroups 151-165 were assigned to loose chucking of the log. The other scattered points which are out of control could be due to the properties of Koroi, which is dense, hard, and wild-grained. In this type of wood the peeling forces would be constantly fluctuating and could cause a "low grade" out of controlness.

Heating of the log had the greatest affect on peeling especially when adequate nosebar pressure was employed as was done in peeling veneer of the last section. The veneer produced in this run had a much better appearance than the veneer of sections 1 and 2. Further tests however on the complete quality of the veneer of each run are being made.

Figure 7 also gives cause for examining the statistical aspects of the subgrouping employed. The "low grade" out of control may result from a slight error in estimating the true between subgroups variance and thus calculation of incorrect $\bar{x}$ control limits. For absolute accuracy, a rational subgroup must be chosen; but as is more likely in this case, the machine may need a still unidentified adjustment. This situation will be further studied. In any event a minor theoretical failure of this nature has little effect on interpretation of the results and thus can be ignored for practical purposes.

For process control in veneer manufacturing these statistical techniques are valuable, simple and rapid. Since only from data which is in a "state of control" can accurate inferences be drawn about either a research study or a commercial operation, these charts are almost indispensable in veneer peeling studies.

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