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THE COLLEGE OF AERONAUTICS

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FARNHAM ROLLS INVESTIGATION

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S U M M A R Y

The object of this experiment was to investigate the possibility of obtaining pre-setting data for the 'Farnham Rolls'.

The experiment was carried out by applying certain deflections and measuring the resulting radii of curvature. Thus curves of curvature against deflection were produced for different sheet widths, and from these curves attempts to produce a conical frustum with prescribed radii were made.

The results obtained can not be applied to conical parts, but this test served to indicate that it is possible to obtain pre-setting data for various applications.

Introduction

Within the aircraft and certain other industries, considerable use is made of rolling for the forming of metal sheet and strip. Examples of rolled components are skins for aircraft and plates for ships.

However, despite this wide use of sheet rolls, there exists little, if any, information regarding the pre-setting of rolls to produce a particular radius. The usual system is for the operator to keep on working a component until it is about right, or fits a template.

If data existed for pre-setting, the following advantages would result:-

1. The machine could be operated by semi-skilled labour.

2. The component could be rolled to size in a single pass. This is particularly important, as material recently developed for the aircraft industry must be worked once only.

3. Time would be saved as the operator would not need to keep removing the sheet, testing it, rolling again etc.

4. Scrap would be reduced.

The object of this experiment was, therefore, to investigate the possibility of obtaining pre-setting data for the 'Farnham Rolls'.

Description of apparatus

Farnham Forming Rolls; Model 1210.EXX. Serial No. 8/52/13.

Vernier Height Gauge.

Test pieces of 16 SWG steel, 2", 6" and 12" wide.

Description of Tests

The axes of the two lower rolls were set horizontal and parallel with each other, using a precision block level.

The diameters of the rolls were measured and the distance between centres of the bottom rolls set to a particular dimension.

Tests were carried out on the machine to investigate the possibility of using it as a dynamometer by measuring deflection, and hence obtain some indication of the forces involved in rolling. This idea was discarded because machine vibrations would not allow the use of sufficiently sensitive instruments.

The top roll was set parallel to the bottom rolls and positioned for zero deflection (see Figure 2).

Using 2 inch wide strip specimens a series of tests were made for different settings of the upper rolls (Table 1). The final radius of each rolled specimens was measured (see Appendix 1) and recorded.

The above series of operations were repeated using 6″ and 12″ wide strips respectively.

Curves of Radius of Curvature against Interference were plotted for each strip width. (See Figure 3).

Using figure 3 an attempt to produce a cone frustrum was made. The radius of curvature of each end was decided upon and the necessary interferences to produce these radii were obtained from the curves. The top roller was then adjusted accordingly and the specimen rolled. (See Figure 4).

Results

The radii of curvature obtained for each roll setting tabulated in tables 1, 2, and 3, are shown graphically in figure 3. This graph shows how at very low values of interference, say less than 0.070″, very large radii occur, in fact indicating really no bending at all since only elastic deformation had taken place. As the interference increases the radius of curvature decreases, eventually becoming asymptotic near to the radius of the top roll.

Figure 3 shows the effect of increasing the strip width, the larger this becomes, the higher the interference necessary to produce a given radius of curvature.

The third part of the investigation was to attempt an accurate rolling of a tapered component.

The taper required was:

10″ radius to 24″ radius over 12″ length.

From the curves in figure 3:-

Setting for 24″ rad. = 0.108 - point X
Setting for 10″ rad. = 0.132 - point Y.

Figure 4 shows the position of the top roll relative to datum for this part of the experiment.

After rolling a sheet in the position shown, the radii at each end were measured and found to be 6.3" and 6.7"; showing no correlation with the intended radii for the test.

Discussion

Figure 3 shows the relationship between roll interference and radius of curvature of the component. These curves are consistent with each other and with the basic theory of bending.

Vertically the curves are asymptotic to the interference just necessary to cause plastic bending.

Horizontally the curves are asymptotic to a radius of curvature which will be the smallest possible with the machine. This radius, will be slightly larger than the upper roll radius due to spring back.

The graph also shows that increase in strip width decreases the radius of curvature obtained for a particular roll interference. The curves are consistently of the same asymptotic nature.

Using points 'X' and 'Y' on figure 3, an attempt was made to accurately produce a conical frustrum, as previously described.

The radii of curvature of the two ends of the frustrum were not as predicted. They were almost equal and smaller than either of the intended radii.

The reason considered most contributory to these effects is that, since the test piece was narrow and the actual deflections small, the material would tend to deflect to the small radii over the whole width - especially if friction prevented the material at the large radius end from sliding between the rolls.

It is therefore considered that further investigations into the rolling of conical shapes be carried out with reference to the above discussion. In this way the effect of friction, width of strip and roll interference may be evaluated separately and their effects made known on graphs. Settings could then be fully tabulated for machine-tools of this type.

Appendix 1

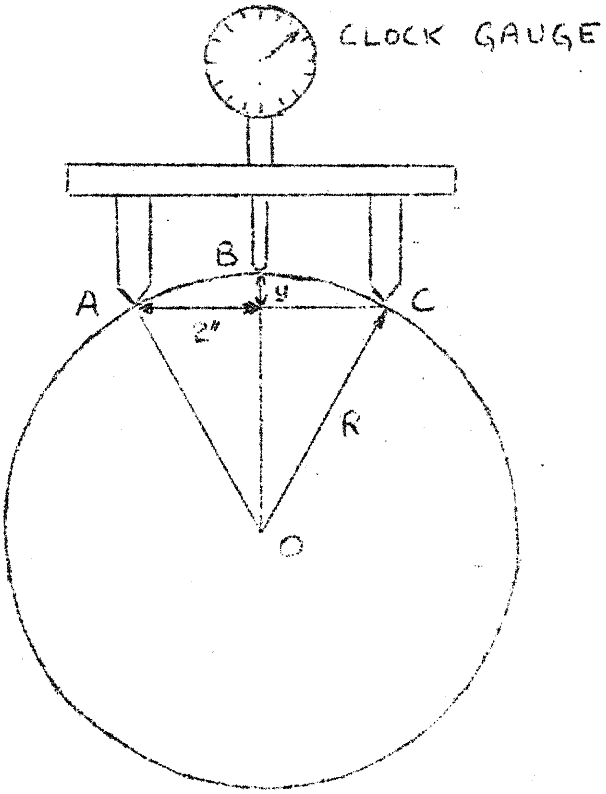

Figure 5

ABC represents the rolled component.
It is assumed that the curvature is a circle with centre 'O' of radius R.

y = deflection due to curvature measured on clock.
Distance between legs A → C = 4"

Thus, by intersecting chords

$$(2R-y)\,y = 2^2$$

$$\therefore \quad R = \frac{2}{y} + \frac{y}{2}$$

As deflections are very small $\frac{y}{2}$ can be neglected.

$\therefore$ Radius of curvature = $\frac{2}{y}$

Farnham Rolls

Radii of Curvature obtained for various roll interferences, with different strip widths

Gauge Setting	Interference of rolls	Rad. of curvature	
"	"	"	
6.430	0	∞	
6.350	0.080	37.8	
6.325	0.105	16.65	
6.300	0.130	9.21	
6.275	0.155	6.46	
6.282	0.148	7.00	TABLE 1
6.291	0.139	7.28	2" wide strip
6.309	0.121	9.86	
6.317	0.113	11.51	
6.332	0.098	16.65	
6.341	0.089	26.8	
6.360	0.070	83.0	
6.340	0.090	36.0	
6.320	0.110	16.0	TABLE 2
6.305	0.125	10.4	6" wide strip
6.290	0.140	8.32	
6.320	0.110	21.0	TABLE 3
6.305	0.125	11.1	12" wide strip

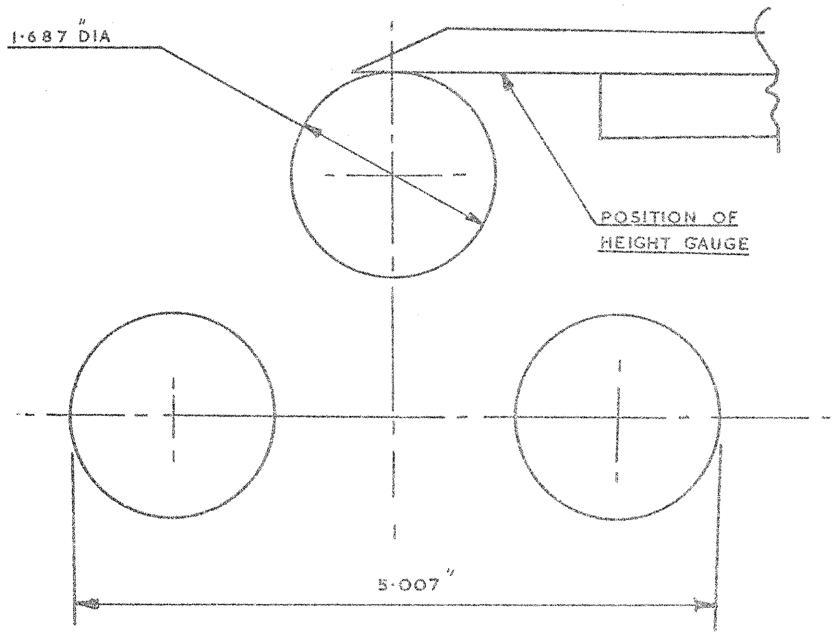

FIG.1. SETTING OF ROLLS.

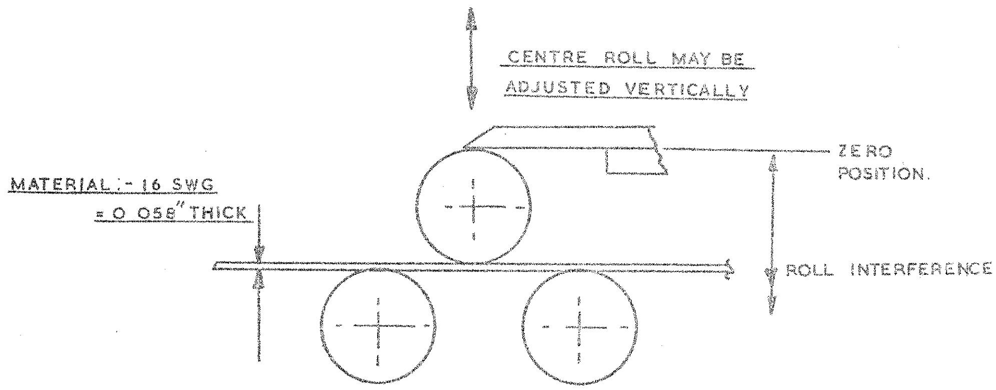

FIG.2. SHOWING POSITION OF ZERO DEVIATION.

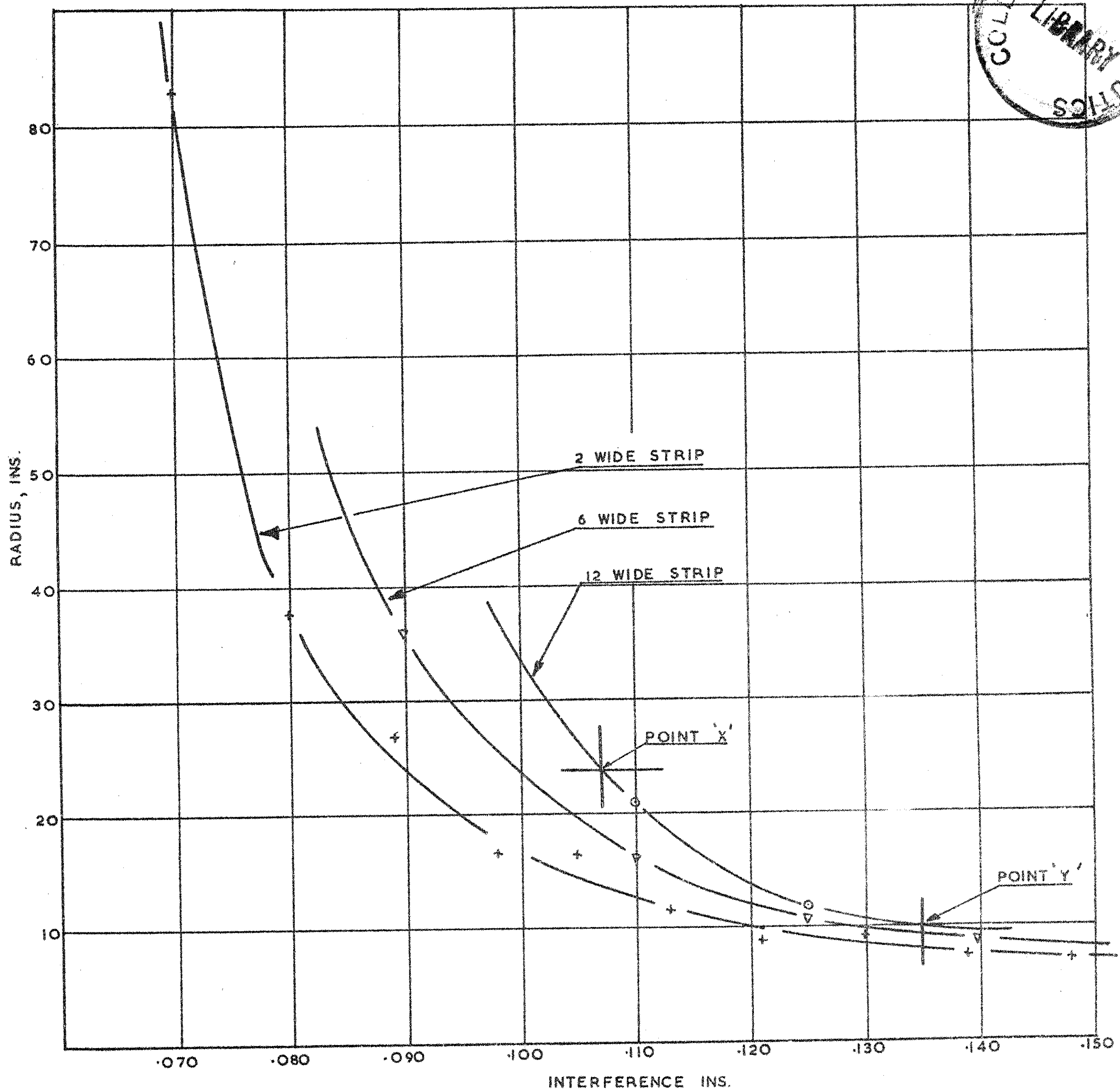

FIG. 3. GRAPH OF COMPONENT FINAL RADIUS - ROLL INTERFERENCE.

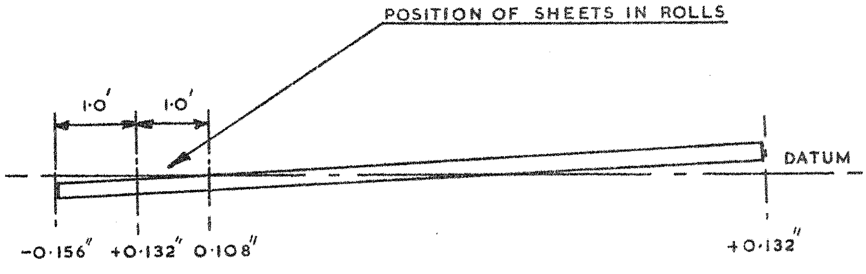

FIG. 4. SET-UP FOR ROLLING TAPERED COMPONENT.