THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

VARIABILITY OF STRIP MATERIAL FOR SPRING PRESSWORK

Report No 416

by

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SUMMARY

An investigation has been conducted to examine the problem of variability of strip material for spring presswork. A survey of the membership established that variability problems were only experienced by less than 40% of members, and problems mainly occurred with materials which are formed in the hard condition ie hardened and tempered carbon steel, stainless steel, copper-beryllium etc. The major causes of strip variability were identified as variations in hardness and thickness and, in some instances, excessive edge camber.

Tests were then conducted to establish the typical levels of variability in hardness, thickness and springback of commercially available strip materials.

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1. INTRODUCTION

In the same way that poor coilability is a problem for coil spring manufacturers, springback variability in strip causes problems for presswork manufacturers, as tool angles need to be reground and adjusted between coils and sometimes during one coil production runs, in order to produce components with the same geometry. The problem is more severe when forming hard or semi-hard materials such as stainless steel and some of the copper alloys.

At present, the specifications covering strip presswork contain no clauses covering the consistency of material with respect to forming. This investigation was undertaken, therefore, with the intention of determining the factors which affect variability in springback in commercially available spring materials and investigating the level of variability which the presswork manufacturers have to accommodate in practice.

2. MEMBERSHIP SURVEY

The first stage of the investigation comprised a survey of those members of the Association who carry out strip press-work

operations, in order to evaluate the extent of the variability problem in the spring industry. To this end, the letter detailed in Appendix A was sent out.

Of the 26 companies that responded to the letter, 16 (61.5%) stated either that they did not experience variability problems as they invariably used soft materials, or that they did not consider strip variability a problem as they only produced a very small amount of strip presswork. The remaining 10 companies (38.5%) indicated an experience of strip variability problems with spring presswork. Their replies to the questionnaire were examined and correlated and the following information extracted:

1. Materials - the majority of strip variability problems occur with those materials which are formed in the hard condition i.e. hardened and tempered carbon steel, stainless steel, copper beryllium etc. However, some problems do occasionally occur with softer materials e.g. annealed carbon steels, mild steel etc.

2. Size Range - it was generally found that the highest proportion of variability problems occur with very thin material i.e. less than 1 mm thick, although some manufacturers cited problems with material upto 5 mm thick.

3. Material Suppliers - opinions regarding the possible relationship between variability problems and material supplier

were mixed; some presswork producers expressing the view that variability problems were more prevalent with certain material suppliers, while other producers were of the opinion that variability problems were independent of material supplier.

4. Presswork Machinery - variability problems can occur on the full range of presswork machinery, but are more prevalent on power presses and multislide machines.

5. Identified Causes of Variability - the most commonly identified causes of the variability problems were:

i) Hardness variations
ii) Thickness variations

cause differing degrees of springback in a formed article

Another identified factor which caused variability problems to some extent was:

iii) Edge camber (edge bow) - particularly problematic in multislide machines where it can cause jamming in the material guides or, if these latter are widened, movement in the die.

6. Solutions to Variability Problems - the most generally practised method of reducing variability problems is to specify very tight tolerances on hardness, thickness and edge camber. These tolerances are generally tighter than those

specified in the British Standards covering strip material, such as BS2870 and BS5770.

The results of the membership survey dictated that the next stage of the investigation should be to examine the hardness and thickness variations in samples exhibiting both good and poor forming performance and, if possible, to relate these factors to springback performance in order to establish suitable tolerance limits for possible inclusion in the British Standards covering strip for presswork. Unfortunately, insufficient suitable samples were forthcoming from the membership to allow a satisfactory investigation to be conducted. The limited number of suitable samples supplied were examined. In addition, an examination was conducted on four typical strip materials in order to determine the typical variability which presswork manufacturers could anticipate.

3. EXPERIMENTAL EXAMINATION OF SAMPLES FROM MEMBERS

Of the strip variability examples supplied by the membership, in only one case were paired samples of good and poor strip supplied for investigation. In all other cases, only samples of poor performance material were supplied which examination found to be to specification. The paired samples consisted of 0.3 mm thick hard rolled copper beryllium strip showing good and poor formability performance; this case was unusual in that the poor formability strip was half hard material, while the strip exhibiting good formability characteristics was fully hard

material. This is contrary to the anticipated performance where the softer material would be expected to have better consistency.

Twenty test samples of approximately 2 in. length were cut consecutively from each of the good and poor performance materials and were individually identified. The thickness of each individual sample was measured at numerous random points on the surface using calibrated micrometers, and its average thickness determined therefrom.

Each strip was then formed through an angle of 90^{o} around a punch of radius 1 mm (ie approximately 3 times the strip thickness) by means of "Avothane" block forming. All the tests were carried out at 90^{o} to the rolling direction of the strip on a Worcester 6 ton power press. The method of forming (illustrated in Figure 1) was to lay the strip under test on an Avothane block constrained in a steel bolster which was fixed to the bed of the press. The profiled punch was then forced onto the strip, pressing it into the block. As Avothane is a flexible polyurethane material which is virtually incompressible, the block was made to deform to accommodate the punch and strip. The bolster restrains the deformation of the Avothane on the base and four sides, thus forcing it to flow upwards around the punch and forming the strip to the profile of the punch. (The detailed procedure for setting up the punch and adjusting the stroke of the press has been described in a previous report [1]). After forming, the springback angle of each sample was measured by means of a Nikon Shadowgraph.

Finally, the hardness of each individual sample was measured at numerous points away from the deformed region using a Vickers Hardness Testing Machine, and the average hardness for each sample was determined.

The results for the thickness, springback and hardness tests are presented in Tables I and II for the good and poor performance material respectively, and the sequential variation in these parameters is shown in graphical form in Figures 2, 3 and 4 respectively.

Examination of the results shows that, although the "good" performance material had a slightly lower springback variability than the "poor" performance material, it had greater variability of thickness and hardness. It is not possible from this limited amount of testing to determine why the good performance material had better springback characteristics, but clearly hardness and thickness variations do not provide the full explanation.

4. EXPERIMENTAL EXAMINATION OF STOCK MATERIALS

In order to examine the typical level of variability in hardness, thickness and springback of commercially available strip materials used by springmakers in the hard condition, tests as detailed in section 3 above were carried out on random samples of mill hard copper beryllium (BS2870 CB101 W(H)M), pre-hardened and

tempered CSHT 80 carbon steel (BS 5770 Pt:3), 302S25 stainless steel, and 17/7 PH stainless steel strip materials. The results of this testing are presented in Tables III - VI.

5. CONCLUSIONS

1. Over 60% of replies from the membership indicated that strip variability was not a problem.

2. The main causes of strip variability as identified by the membership survey were hardness and thickness variations, and excessive edge camber.

3. The typical variability in these parameters for copper beryllium, prehardened and tempered carbon steel, 302 stainless steel and 17/7PH stainless steel have been illustrated.

4. From samples of good and poor performance strip supplied by the members, it was not possible to identify accurately the cause of the higher springback variability of the poor performance material.

6. RECOMMENDATIONS

In order to pinpoint the major causes of springback variability in strip material, a more comprehensive series of testing needs to be conducted on a large number of suitable paired samples of

various strip materials showing good and poor performance. From the results of this testing, it should be possible to establish variation limits on hardness and thickness such that springback variations will be minimised and which the presswork manufacturer can utilise when specifying material. The co-operation of members, who would need to supply a large number of samples, is essential for such a programme of work to be carried out.

7. REFERENCES

1. Saynor D, "Minimum Bend Ratios of Stainless and Carbon Spring Steel Strip" SRAMA Report No. 305, 1978.

TABLE I TEST RESULTS FOR GOOD PERFORMANCE MATERIAL

Sample number	Thickness (mm)	Springback angle (°)	Hardness (HV10)
1	0.303	81.167	259.5
2	0.304	80.733	257.5
3	0.305	80.267	262.5
4	0.304	81.733	259.5
5	0.305	81.100	262.0
6	0.306	82.767	261.0
7	0.303	80.833	262.0
8	0.310	80.967	263.5
9	0.312	78.800	247.0
10	0.303	81.333	265.0
11	0.304	82.250	264.0
12	0.308	80.967	260.0
13	0.307	80.583	263.5
14	0.301	81.333	266.5
15	0.304	81.200	261.0
16	0.306	81.917	262.0
17	0.306	82.967	262.0
18	0.304	80.750	258.0
19	0.306	80.267	261.0
20	0.303	82.450	260.0
Mean value	0.3052	81.219	260.875
Variance	6.36×10^{-6}	0.881	14.872
Maximum value	0.312	82.967	266.5
Minimum value	0.301	78.800	247.0
difference between maximum and minimum values	0.011	4.167	19.5

TABLE II TEST RESULTS FOR POOR PERFORMANCE MATERIAL

Sample number	Thickness (mm)	Springback ( )	Hardness (HV10)
1	0.304	84.733	219.5
2	0.306	79.850	218.0
3	0.304	84.317	220.5
4	0.306	83.067	218.5
5	0.307	83.000	219.5
6	0.305	84.133	225.0
7	0.306	83.900	219.5
8	0.306	81.250	224.0
9	0.306	84.500	219.5
10	0.310	82.733	219.5
11	0.309	84.217	221.0
12	0.308	84.083	223.0
13	0.306	84.733	223.0
14	0.307	84.567	224.0
15	0.308	83.867	225.0
16	0.308	84.467	223.0
17	0.309	84.183	217.0
18	0.308	84.667	215.0
19	0.305	84.167	219.5
20	0.304	83.050	218.0
Mean value	0.3066	83.674	220.6
Variance	2.94×10^{-6}	1.481	7.44
Maximum value	0.310	84.733	225.0
Minimum value	0.304	79.850	215.0
Difference between maximum and minimum values.	0.006	4.883	10.0

TABLE III TEST RESULTS FOR MILL HARD COPPER BERYLLIUM STRIP

Sample number	Thickness (mm)	Springback angle (°)	Hardness (HV10)
1	0.258	82.583	306.0
2	0.258	82.467	322.0
3	0.256	83.467	319.5
4	0.263	82.500	327.5
5	0.258	80.733	311.5
6	0.262	85.900	330.0
7	0.259	84.233	330.0
8	0.262	83.767	333.0
9	0.262	81.333	336.0
10	0.260	85.333	333.0
11	0.262	83.250	324.5
12	0.262	83.600	336.0
13	0.258	82.800	342.0
14	0.264	84.700	336.0
15	0.260	84.167	336.0
16	0.258	83.117	322.0
17	0.257	84.300	327.0
18	0.264	83.750	330.0
19	0.261	81.633	336.0
20	0.259	81.167	306.0
Mean value	0.2602	83.238	327.2
Variance	5.56x10	1.797	98.16
Maximum value	0.264	85.900	342.0
Minimum value	0.257	80.733	306.0
Difference between maximum and minimum values	0.007	5.167	36.0

TABLE IV TEST RESULTS FOR CSHT80 CARBON STEEL STRIP

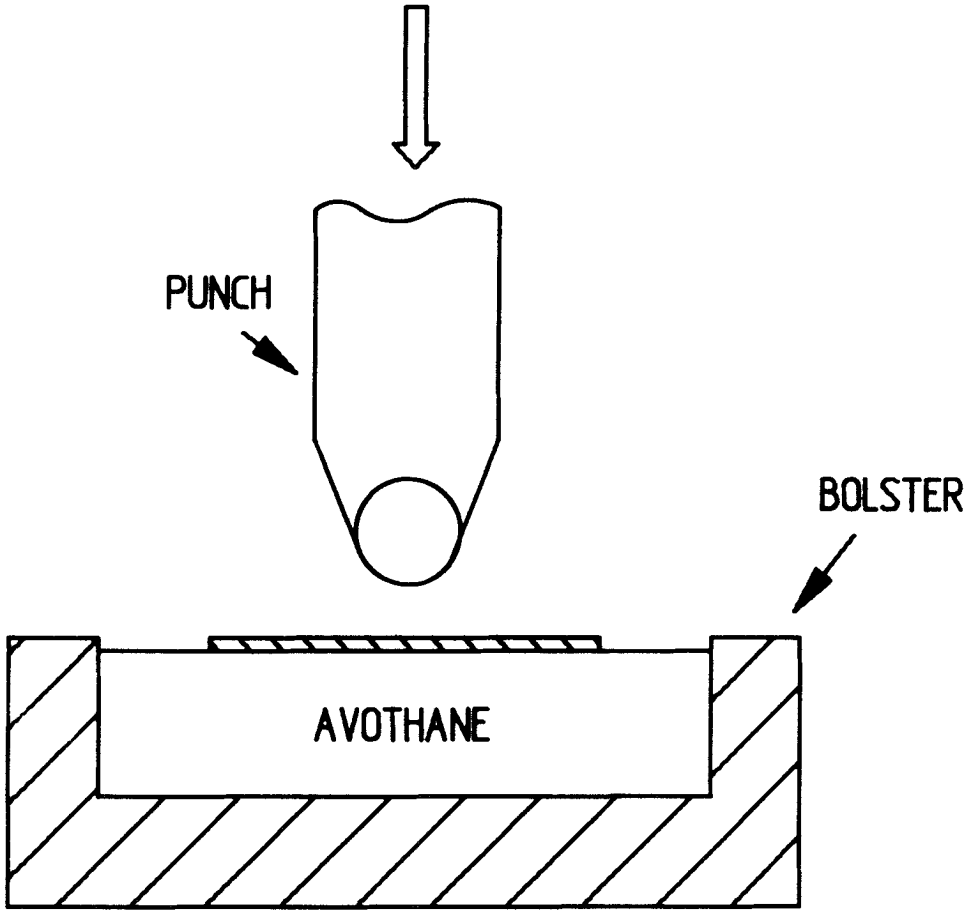
Sample number	Thickness (mm)	Springback angle (°)	Hardness (HV10)
1	0.262	88.300	454
2	0.259	89.583	459
3	0.262	85.500	459
4	0.264	89.917	454
5	0.264	89.733	464
6	0.262	90.400	468
7	0.262	90.500	468
8	0.267	90.500	473
9	0.264	90.683	464
10	0.262	90.750	464
11	0.267	90.700	468
12	0.264	90.833	459
13	0.267	90.750	464
14	0.267	90.800	468
15	0.264	90.800	473
16	0.264	90.833	454
17	0.262	91.000	464
18	0.262	91.133	468
19	0.262	91.000	468
20	0.262	91.083	473
Mean value	0.2635	90.240	464.3
Variance	4.550×10^{-6}	1.605	35.61
Maximum value	0.267	91.133	473
Minimum value	0.259	85.500	454
Difference between maximum and minimum values	0.008	5.633	19

TABLE V TEST RESULTS FOR 302S25 STAINLESS STEEL STRIP

Sample number	Thickness (mm)	Springback angle (°)	Hardness (HV10)
1	0.259	90.333	401
2	0.262	90.583	390
3	0.259	91.000	390
4	0.264	91.017	394
5	0.269	90.367	394
6	0.262	90.600	390
7	0.264	90.633	394
8	0.262	89.167	390
9	0.259	89.200	394
10	0.262	89.003	383
11	0.262	88.917	390
12	0.259	88.833	385
13	0.264	89.100	397
14	0.262	89.267	390
15	0.259	90.600	387
16	0.262	90.500	383
17	0.269	90.600	390
18	0.267	90.733	383
19	0.262	91.183	387
20	0.262	91.083	387
Mean Value	0.2625	90.138	389.95
Variance	8.75×10^{-6}	0.662	21.65
Maximum value	0.269	91.183	401
Minimum value	0.259	88.833	383
Difference between maximum and minimum values	0.010	2.350	18

TABLE VI TEST RESULTS FOR HARD ROLLED 17/7 PH STRIP

Sample number	Thickness (mm)	Springback angle (°)	Hardness (HV10)
1	0.267	88.833	446
2	0.259	88.367	441
3	0.264	88.233	441
4	0.262	88.300	433
5	0.259	88.500	441
6	0.264	90.217	437
7	0.262	90.383	433
8	0.262	90.283	446
9	0.259	90.200	437
10	0.262	90.300	439
11	0.259	88.583	437
12	0.264	88.400	441
13	0.259	88.917	446
14	0.262	88.533	435
15	0.259	88.633	454
16	0.259	88.850	441
17	0.267	88.517	433
18	0.257	88.417	441
19	0.264	88.617	441
20	0.259	89.017	450
Mean Value	0.2615	88.005	440.65
Variance	7.85×10^{-6}	0.578	30.13
Maximum Value	0.267	90.383	454
Minimum Value	0.257	88.233	433
Difference Between Maximum and Minimum Values	0.010	2.15	21



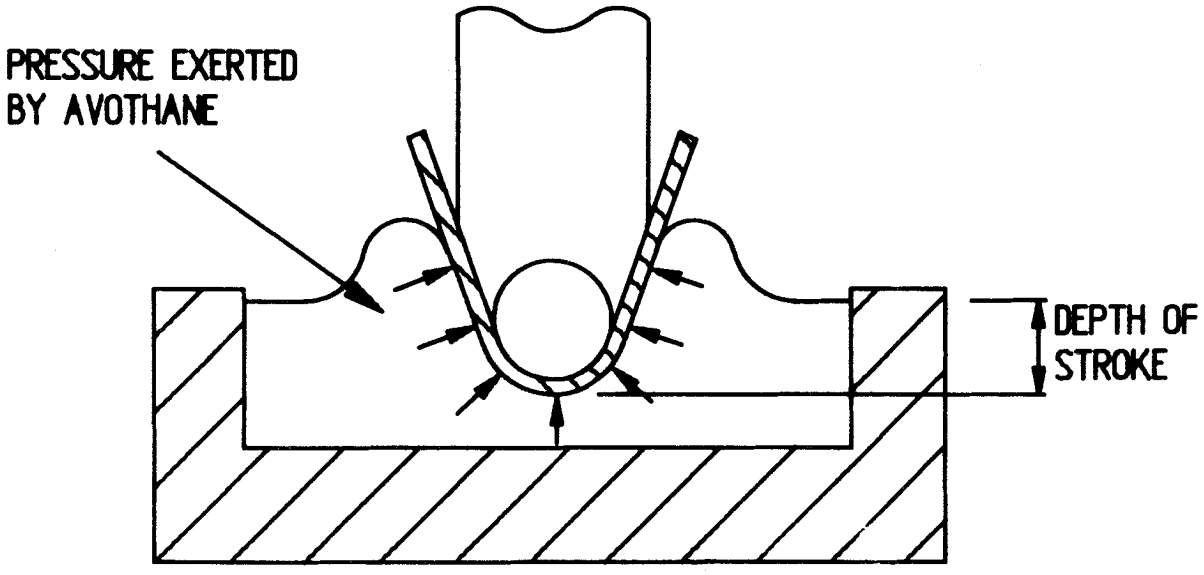


FIG 1 DIAGRAM ILLUSTRATING AVOTHANE FORMING

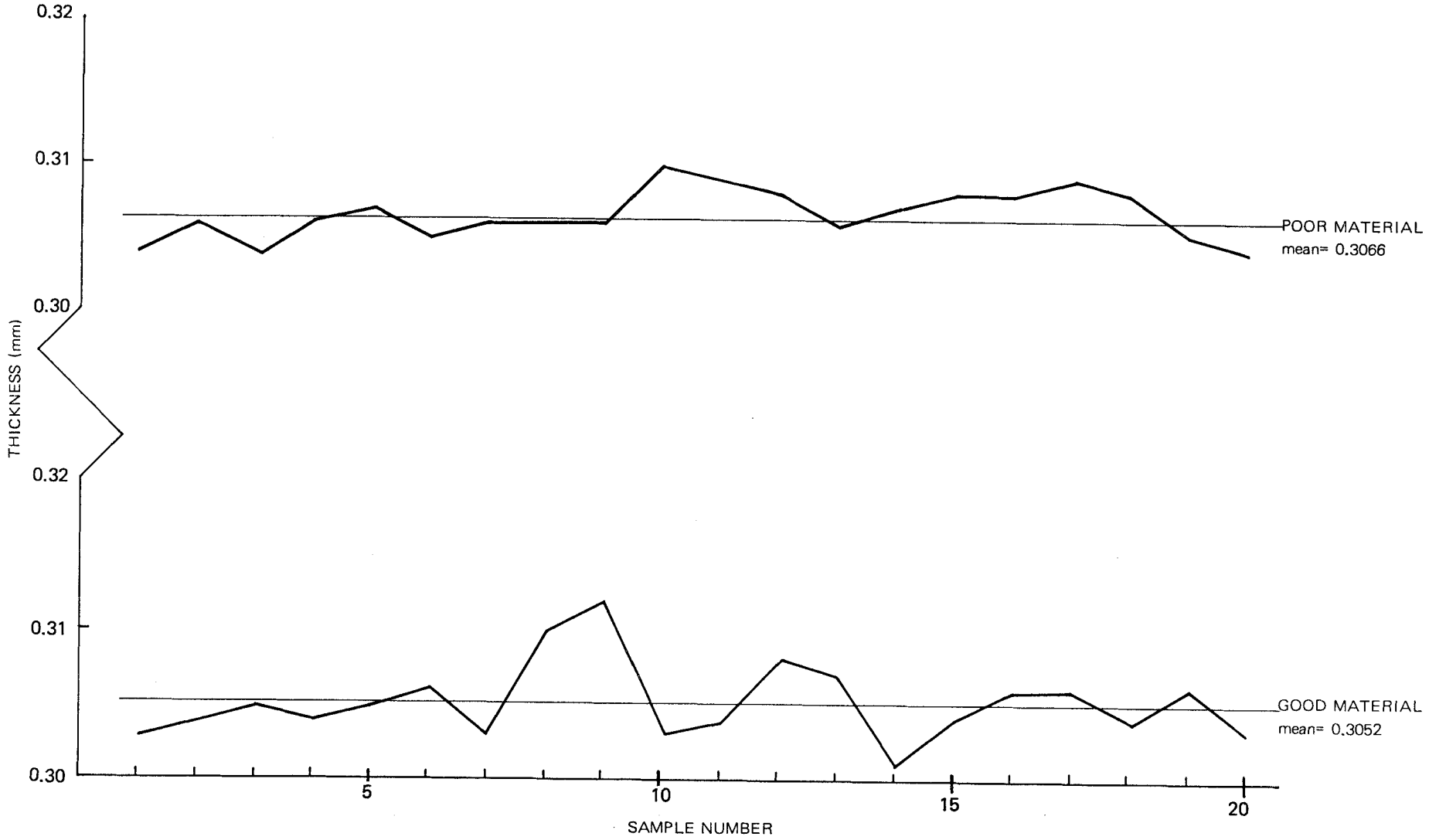


Fig 2: THICKNESS VARIATION FOR GOOD AND POOR PERFORMANCE COPPER- BERYLLIUM STRIP.

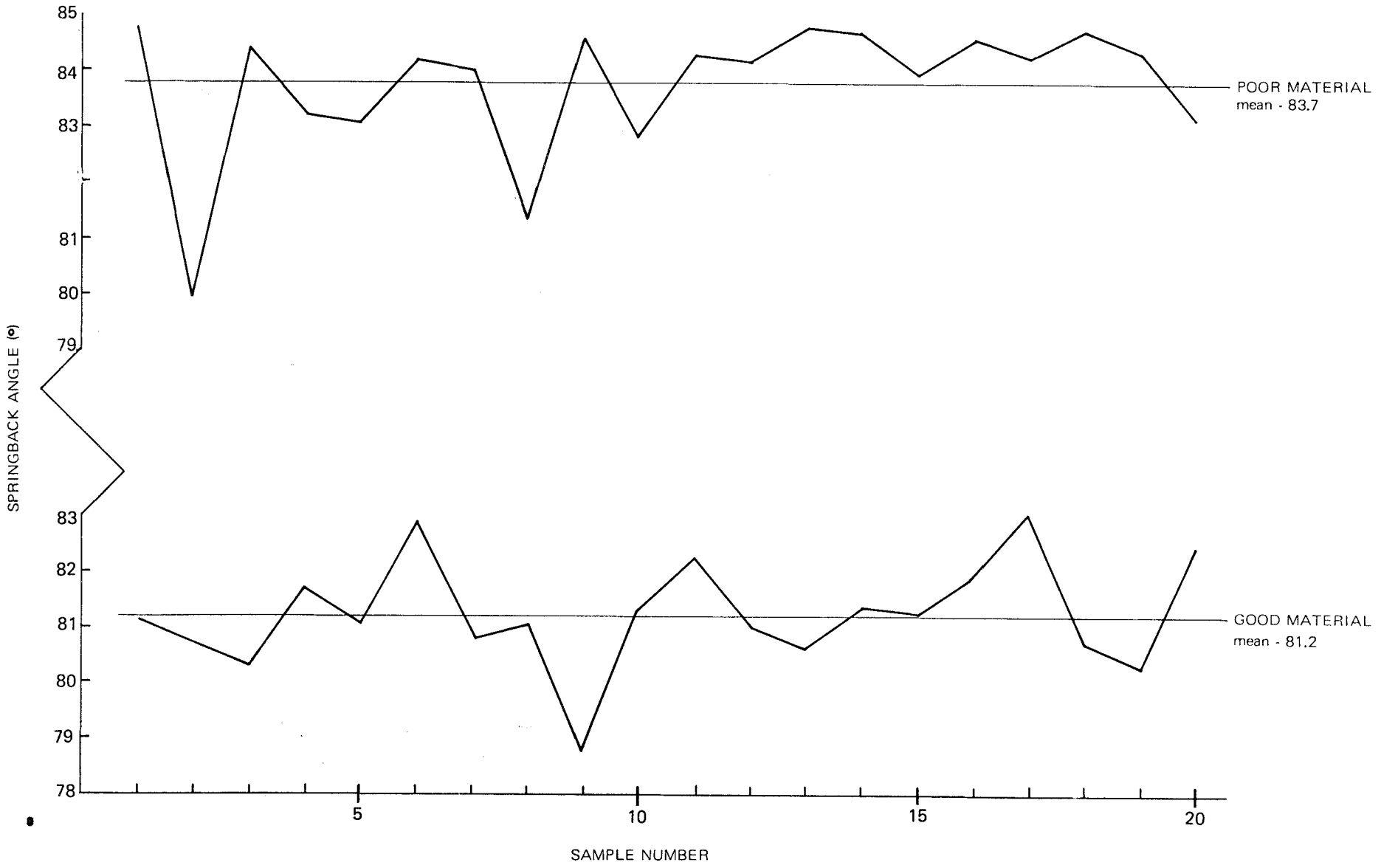


Fig 3: SPRINGBACK VARIATION FOR GOOD AND POOR PERFORMANCE COPPER- BERYLLIUM STRIP

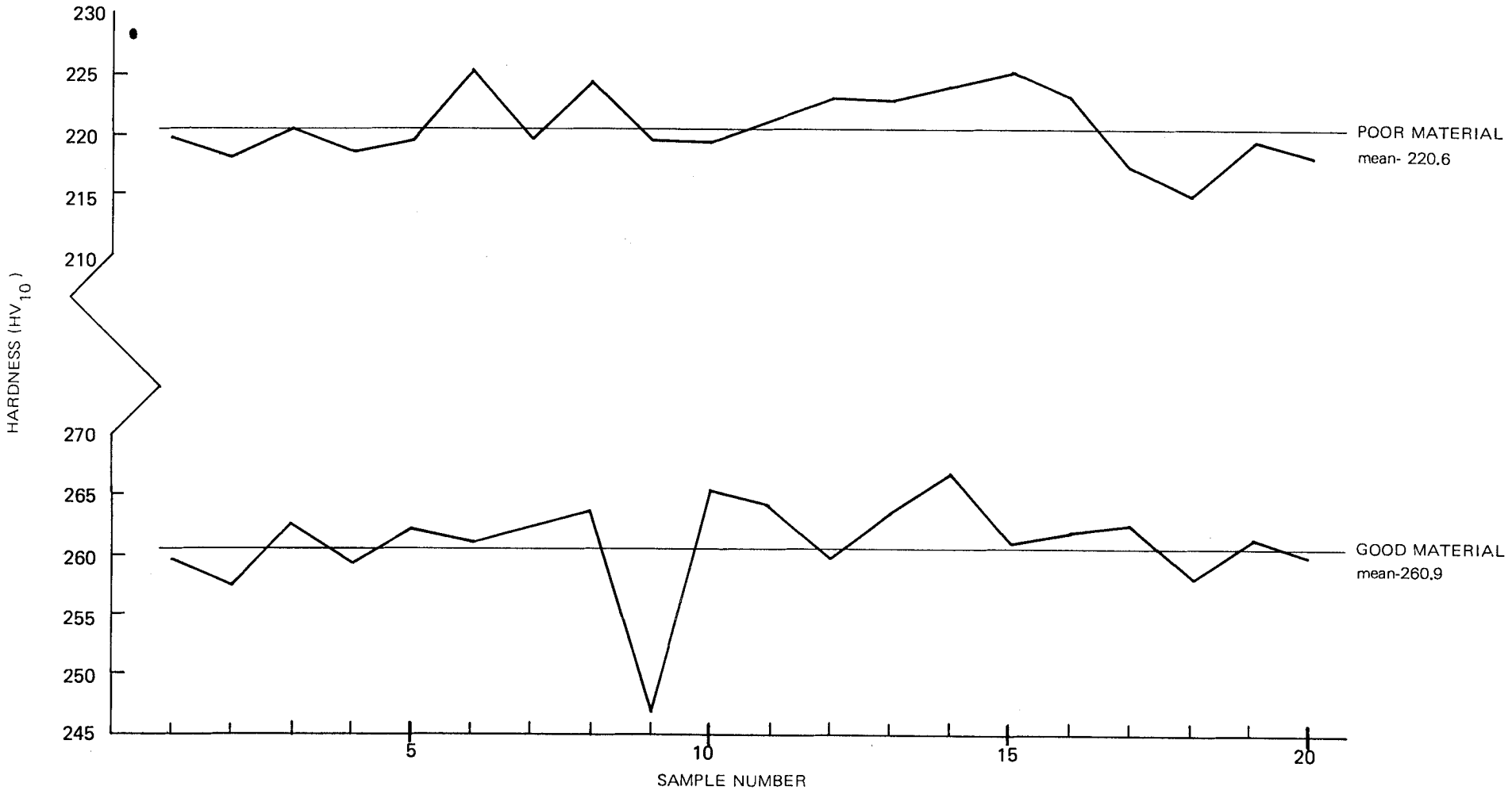


Fig 4: HARDNESS VARIATION FOR GOOD AND POOR PERFORMANCE COPPER - BERYLLIUM STRIP

APPENDIX A

"Dear Sir

Variability of Strip Material for Spring Presswork

As part of the 1986/87 research programme, SRAMA will be examining the variability of strip material for spring presswork. Some members have experienced problems regarding the variability of strip material from one coil to another, with the result that tool angles have to be ground and adjusted in order to produce components with the same geometry.

In order to assess the background and extent of the problem, and to establish possible means of identifying poor performance material, we would like your assistance in providing information and test samples. Your answers to the following questions would be appreciated:-

1) On what type of material do variability problems most frequently occur?

2) Is the problem more pronounced with any particular size range or material supplier?

3) With what type of presswork machinery do the problems most frequently occur?

4) Have you found a cause or solution (other than regrinding tool angles) for any variability problems?

In addition, could you please retain one to two kilogramme samples of strip material with poor variability together with sample components which illustrate the problem. These samples (ideally accompanied by samples of good material) should be sent to SRAMA, who will investigate the variability problem free of charge.

If you feel you would like to discuss this topic in your own factory, then please contact me and I will arrange to visit you."