THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

EFFECT OF DRIVE ROLL PRESSURE ON FREE LENGTH WIRE LENGTH AND FATIGUE LIFE VARIABILITY

Report No. 342

by

M. S. Bayliss, B. Eng.

MAY 1982

THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

EFFECT OF DRIVE ROLL PRESSURE ON FREE LENGTH WIRE LENGTH AND FATIGUE LIFE VARIABILITY

Report No. 342

by

M. S. Bayliss, B.Eng.

SUMMARY

The drive rolls on an automatic spring coiling machine are capable of exerting a wide range of loads on the spring wire. If the pressure is too light then slipping will occur thus giving large variations in wire feed and therefore free length. In the other extreme excessive pressure will cause plastic deformation and damage to the wire which may well reduce the fatigue life of the spring. It was decided, therefore, to investigate the effect of the drive roll pressure on free length variability, wire length variation and the variation of fatigue life of springs.

The results indicated that the drive roll pressure does effect all three parameters and that the optimum pressure to use is the minimum which will guarantee freedom from slipping.

MAY 1982

CONTENTS

EFFECT OF DRIVE ROLL PRESSURE ON FREE LENGTH, WIRE LENGTH AND FATIGUE LIFE VARIABILITY

1. INTRODUCTION

The drive rolls fitted to auto-coilers are interchangable and adjustable so that the size of wire and the load they exert on that wire can be changed. Thus it is in order to assume that for a given wire size the drive roll pressure will vary considerably depending on the machine used, the spring design and, most importantly on the machine setter.

If drive roll pressure does have an effect on spring variability then it is important that it is kept within its optimum range.

It was decided to look at this effect by investigating the following three parameters:

1. Free length variation of coiled springs;
2. Variation in wire lengths in the springs by measuring spring weight;
3. The variation in fatigue life of the springs

2. SPRING DESIGN

One spring design has been used throughout this work. The design was chosen so that it would highlight the variations in free length and wire weight (i.e. large number of turns and wire length) but would also be capable of being stressed to high levels so that fatigue life would be measurable.

The following design was chosen:-

Wire diameter	= 1.60 mm
Outside Coil diameter	= 9.85 mm
Total number of turns	= 12
Nominal wire length	= 311 mm
Free length before grinding	= 38.5 mm
Free length after grinding & scragging	= 32 mm
Fatigue Stress range	= 100 - 880 N/mm^2
BS 1726 Free length tolerance	= $\pm$ 0.74 mm
Material BS 5216 Grade 2	

3. EXPERIMENTAL PROCEDURE

A Torrington 115A automatic spring coiling machine was used for this work and fitted with electronic load cells to measure the drive roll load.

The coiling machine was set to produce the required spring design with the drive rolls set to a nominal load. The load was then reduced until a point at which noticeable slipping occurred. A load just above this point was then taken as the lower practical limit. The roll pressure was then increased up to a point where it was considered that undue strain was being put on the the coiling machine. The maximum load was then taken as being just below this point. Two other levels were then selected between these points. The test loads used were 0.375, 0.75, 1.5 and 3 tons. The machine was set to produce the required design at the first of these loads and then run to produce a batch of 1000 springs. The last 10 in every 100 springs were collected for analysis. The machine was then set and run at each of the higher loads, in turn with fine adjustment being made to the tooling where necessary to obtain the same spring dimensions.

The free length and weight of the collected springs were then measured.

Ten springs from each of the collected samples were end ground and scragged stable for fatigue testing. The fatigue testing consisted of cycling the springs between an initial stress of 100 N/mm^2 and a maximum stress of 880 N/mm^2 until failure, these stress values being found by individually load testing each spring before fatigue testing.

4. RESULTS

The individual free lengths and weights of the spring have been used to calculate the standard deviation and short term drifts of the free lengths and wire weights. The deviation of the wire weight was then converted into wire length by using the following formulae:

$$1 = \frac{W \times 4 \text{ mm}}{7.8 \times 10^{-6} \times \pi d^2}$$

Where 7.8×10^{-6} = density of steel
d = wire diameter
w = weight of spring

By taking 3 times this deviation we obtain the tolerance for 99.9% of all the springs coiled. The results for the effect of the drive roll pressure on short term drift and wire length are given in Tables 1, 2 and figures 1, 2 respectively.

The results for the fatigue testing were subjected to both 'f' and 't' statistical tests to determine whether the drive roll pressure had any significant effect on fatigue life and scatter. The 'f' test showed over 99.9% significance proving that the scatter of fatigue life became worse with increasing drive roll pressure. However, the 't' test showed that there was no significant difference between the mean lives of the springs coiled at different drive roll pressures. The results of the fatigue test have also been plotted on figure 3.

5. DISCUSSION

The measurement of the free lengths of the sample springs showed that the free length variations were reduced to a minimum by using a drive roll pressure of just over 1 ton. However, it can be seen that in the range of 0.375 to 2 tons the actual variation only changes by 0.02 mm. Thus it can be said that if the drive roll pressure is not excessive then its value will not measurably effect the free length variation.

The wire length variation indicated that the variation was reduced by using ~~e~~ither the highest or lowest pressures. The 'f' test analysis of the fatigue results showed that the scatter significantly increased with increase in drive roll pressure. However, the 't' test showed that there was no difference in the mean lives of the springs coiled at the different drive roll pressures.

Hence a low drive roll load should be used so that a more consistent fatigue life is obtained.

Overall then it can be seen that the best combination of low free length and wire length variations with consistent fatigue life is obtained by using a drive roll pressure of a little above the point of obvious slipping.

It must be remembered, however, that the actual values of these results can only be applied to the same combination of machinery, spring design and wire, but it would seem reasonable to assume that the general trends found should apply for all similar equipment.

6. CONCLUSIONS

1. Drive roll pressure affects free length variation and wire length variation of springs by only a small amount across the whole range of drive roll pressures investigated.

2. High drive roll pressures adversely affect the scatter in fatigue life but not the mean lives of the springs.

3. The optimum value for drive roll pressures is a little above threshold value at which obvious slipping occurs.

TABLE I EFFECT OF DRIVE ROLL PRESSURE ON FREE LENGTH VARIATION

VARIATION	DRIVE ROLL PRESSURE (TONS)			
	0.375	0.75	1.5	3
FREE LENGTH (mm)	± 0.351	± 0.342	± 0.330	± 0.417

TABLE II EFFECT OF DRIVE ROLL PRESSURE ON WIRE LENGTH VARIATION

VARIATION	DRIVE ROLL PRESSURE (TONS)			
	0.375	0.75	1.5	3
WIRE LENGTH (mm)	± 3.6	± 3.99	± 4.37	± 3.30

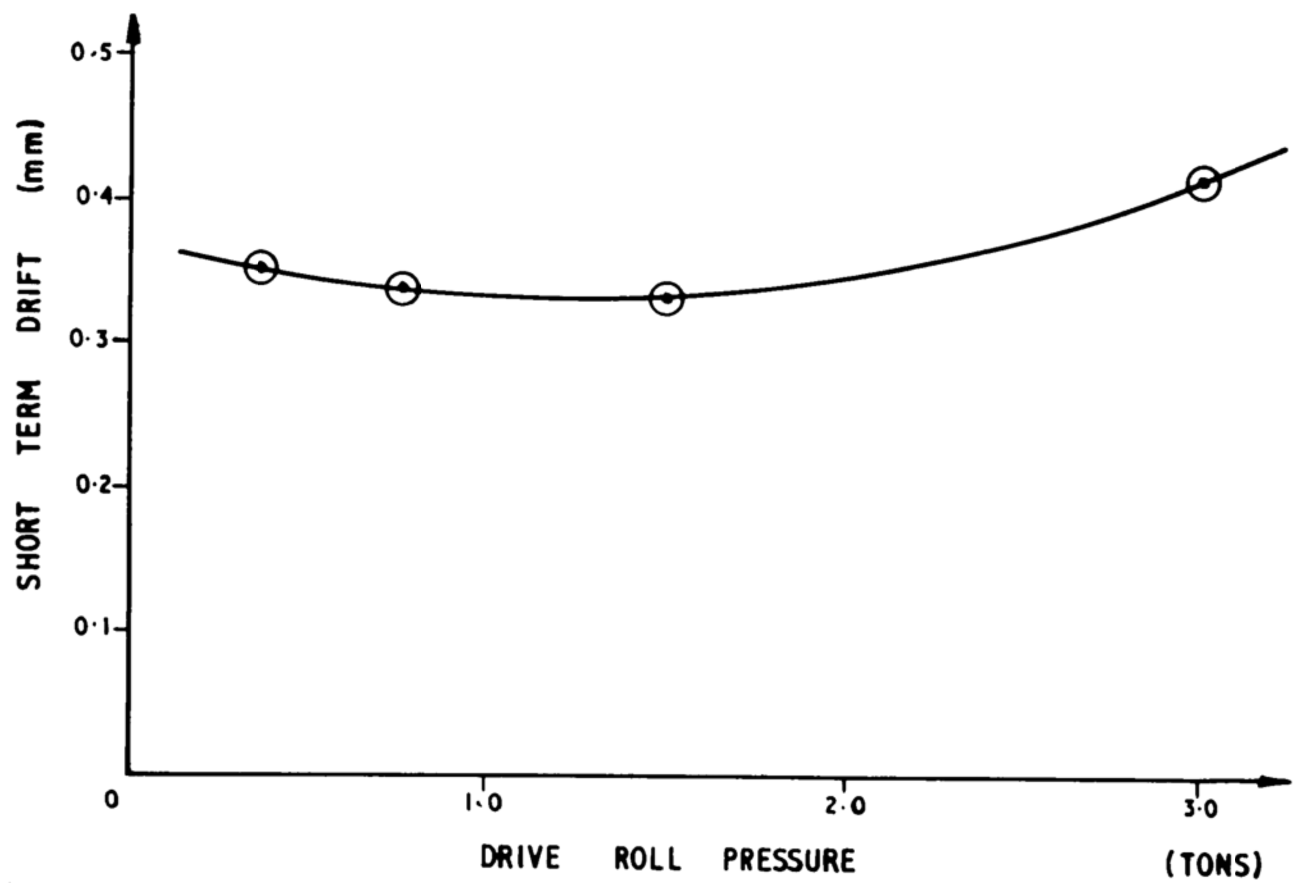

FIG. I. FREE LENGTH VARIATION v DRIVE ROLL PRESSURE.

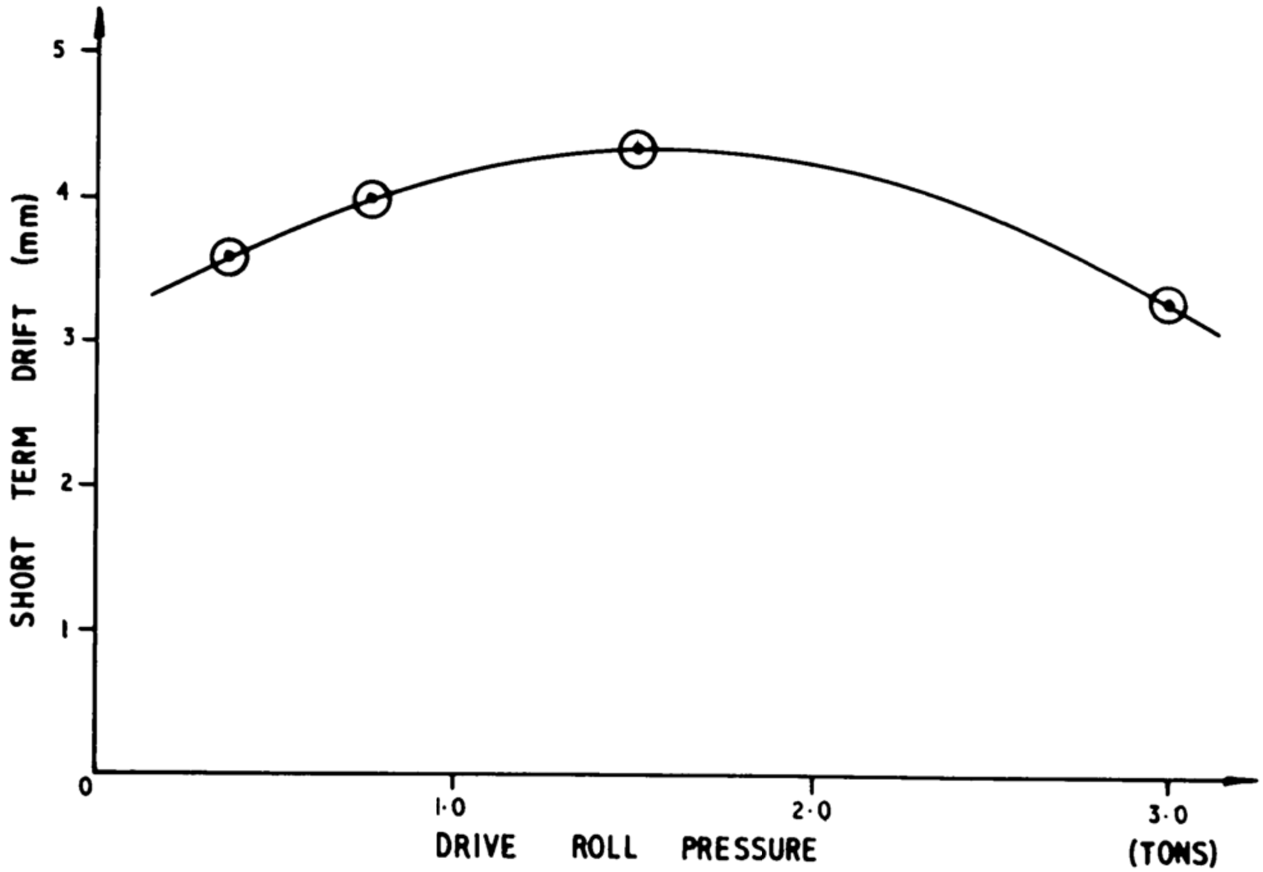

FIG. II WIRE LENGTH VARIATION v DRIVE ROLL PRESSURE.

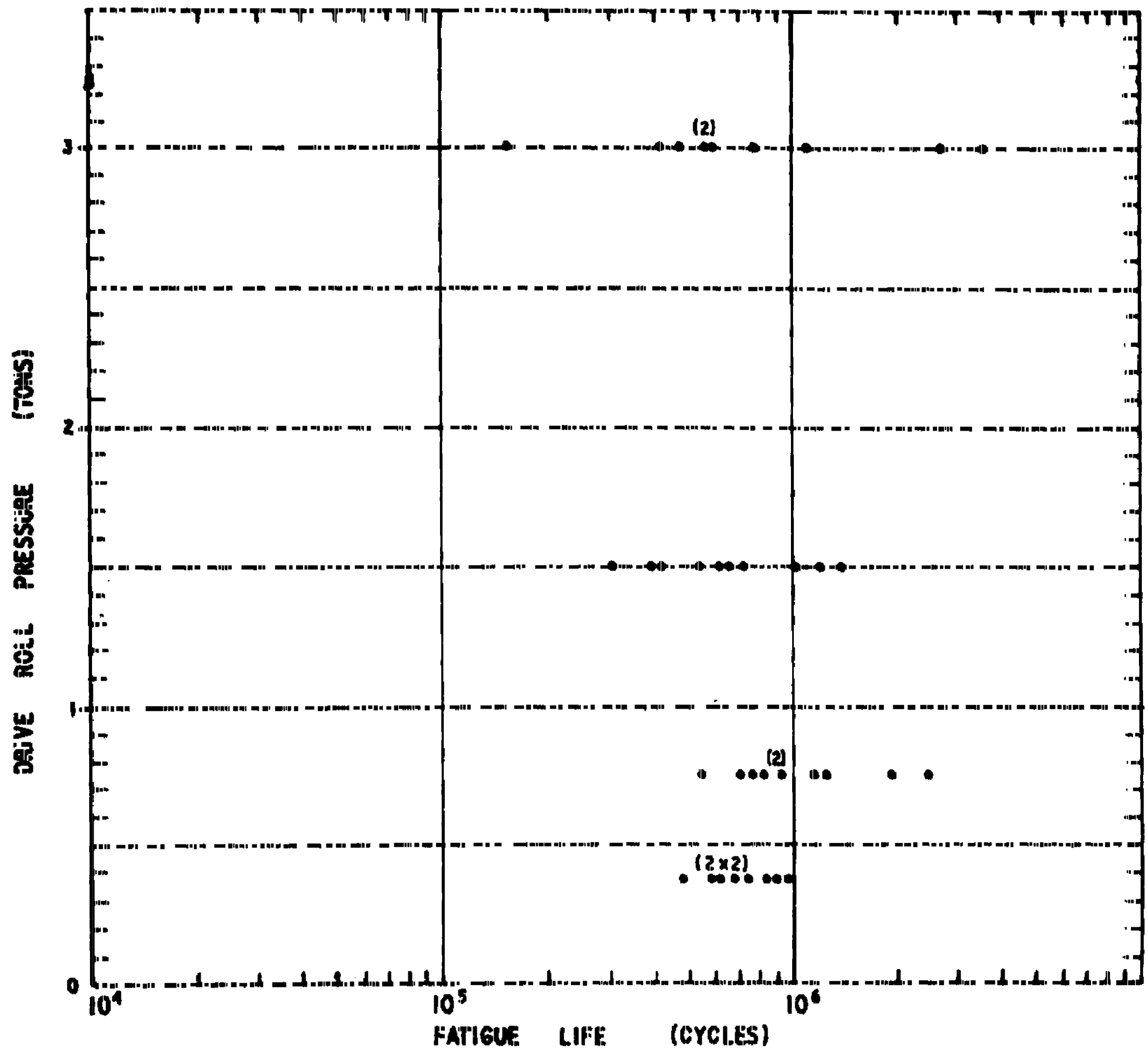

FIG. III. THE EFFECT OF DRIVE ROLL PRESSURE ON FATIGUE LIFE.