THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

A FEASIBILITY STUDY OF JIG SET TOOLING FOR AUTOMATIC SPRING COILING MACHINES

by

M.R. Southward, B.Sc.

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SUMMARY

A problem is encountered by spring manufacturers with repeat orders when the quantity and time interval between orders is unknown. Since the coiling machine must be reset every time the order is received, setting up time may take up a significant proportion of the overall running time of the machine, depending upon batch size, and any method of reducing it would be beneficial.

Some coiling machine manufacturers have partially solved this problem by numbering interchangeable items such as profile cams or providing scales on all adjustable links to enable the position of these items to be noted and reset at a later date. No recording facility is available, however, for the position of coiling points. Since each coiling point can be moved in three directions and rotated, any method of reducing this variability would be of benefit and this area will be examined in future work.

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1. INTRODUCTION

The setting up of an automatic spring coiling machine to produce a specific spring may be very time consuming, depending upon the type of coiling machine and the spring design. For relatively small batches of springs the amount of time involved in setting the machine may be large in comparision with the production time (and hence the setting up cost may be a large proportion of the total production cost). The set up time is thus a critical factor in terms of overall machine usage and production costs. A second factor affecting costs is the necessity for skilled labour which is becoming increasingly scarce. Any method of reducing the pressure upon this labour force would be of benefit.

Frequently a coiling machine is used to produce a batch of springs and is then altered to produce various other springs, but at a later date, when a repeat order is received, needs resetting to the earlier spring design. Thus, in the long term, the coiling machine may be set up many times for one particular spring design.

The purpose of this investigation is to consider the design of a simple device which will enable the settings on a coiling machine to be recorded once it is producing the required design. This will enable the coiling machine to be reset quickly at a later date for any repeat orders.

To aquire a broader understanding of the difficulties and time consuming operations involved ~~in~~ the setting up of an autocoiling machine for repeat orders, a number of spring man-

ufacturers were visited to discuss their experience of such problems.

2. PROBLEMS ENCOUNTERED IN SETTING UP AN AUTOCOILING MACHINE

The manufacturers visited varied in the size of their operations, yet shared similar opinions as regards the setting of coiling machines for repeat orders. The easiest method of presenting the problems encountered is to consider the various stages involved:

1) selection and positioning of drive rolls;

2) selection and alignment of wire guides;

3) selection of coiling points;

4) selection and positioning of cut off tool;

5) selection of mandrel* and coiling to correct coil diameter with necessary amount of initial tension;

6) adjustment of gearing for correct wire length;

7) selection of correct pitching tool; and

8) adjustment to produce spring to the required free length and correct end coil formation.

* In the case of two point coiling machines, mandrel diameter does not affect the coil diameter.

Let us now consider these operations, the first four of which are of a purely mechanical nature and require no great skill. A reduction in the time required would only be possible by incorporating a new design of drive roll or a wire guide independent of wire diameter.

The time spent on operation 5 is determined by whether the machine is of the single point (Fig. 1) or the double point (Fig. 2) type. In a single point machine the mandrel is used both as a wire support during the 'cut off' operation and as an aid to spring formation, so it must, therefore, be of the required size, which is fractionally less than the internal diameter of the spring. In the case of a double

point machine, the mandrel is used merely as support for the wire during the 'cut off' operation and does not influence the spring formation. Hence the mandrel dimension is not critical, except that it must be much less than the internal diameter of the spring. The function of the mandrel is one of the major differences between single and double point coiling machines.

Operation 5 also includes the positioning of the coiling points. A coiling point can be moved in three dimensions and rotated (Fig. 3). Therefore, the setting of a double point coiling machine presents a double problem. The coiling points must be positioned to enable the machine to coil a spring to the correct diameter, with sufficient initial tension and without marking the wire. The operation requires skilled labour in the case of both single and for double point coiling machines.

The sixth operation depends on the make and model of each machine, as some incorporate a sliding scale for the full range of wire lengths, whilst others require a change of gears and the positioning of an indexed cam. Consequently, if the reading is recorded for each spring design, then, when a design needs to be repeated at a later date, the wire length can be achieved quickly.

The time factor for operation 7 is small but does vary from machine to machine. There are two basic types of pitching tool: the wedge type and the pusher type. Some machines possess one type only, whilst others possess both types. With repeat orders in mind, all pitching tools should be numbered so that they can be recorded for each spring design, together with the method of pitching.

The final operation, 8, may be very time consuming, as it involves attempting to produce the required spring length with correct end coil formations. The critical stage in this operation is the pitching mechanism, which can be divided into three sections, each section being variable:

a) cam segments;

b) cam follower; and

c) starting position of pitching tool.

Some machines number each cam and index the cam shaft as well as the cam follower, thus enabling positions to be recorded for each spring design. In such instances cams can be quickly reset at a later date for a repeat order. The only variable that remains constant is the initial starting position of the pitching tool. The use of the pitching tool sometimes, depending upon the spring design, affects the spring diameter, necessitating adjustments to the coiling points. To be performed efficiently, this operation demands the use of skilled labour.

Also to be considered in the setting up of a coiling machine are the following external factors which influence the spring produced:

i) wear of the coiling points;

ii) variation between batches of wire; and

iii) tension in roller straighteners.

3. DISCUSSION

As mentioned previously, there are many separate operations involved in setting up a coiling machine. Some of these can be made less time consuming for those machines that possess scales on all moving parts, because the machine settings for the various spring designs can be recorded. This is the best available method, other than redesigning the coiling machine, and machines not having such scales would be more efficient if they were fitted. The application of information recorded in this way to a repeat order gives at best an identical set up but what is normally achieved is a close approximation, which can easily be adjusted to the required machine setting by an experienced operator. Even if we assume that the ideal situation is achieved, in that the setting is identical to the original, the problem is still not solved. It has been

found that two different batches of wire coiled on one machine setting will produce a slightly different spring. Even if this ideal situation can be achieved, therefore, an experienced operator is always required to perform the final adjustments.

As already stated, some machines have scales on the adjustable parts, the only adjustable parts not indexed being the actual coiling point arrangement. Thus, in order to reduce the setting up time for a repeat order, some method of recording the tooling arrangement on the original set up would be beneficial.

Of the two basic forms of coiling point arrangement, the double point is more time consuming to set up than the single point type. The double point system is to be considered here, as this is where maximum benefit will occur. Two types of device can be used:

i) Single design

In this case, the device would be set to record the original tooling arrangement and then stored until a repeat order was received. Prior knowledge of repeat orders would be required. Such a device would need to be simple and cheap, since most of the time it would be kept in storage and also because many such devices would be necessary to cover a range of spring designs.

ii) Multi-design

This device would require calibration of each moving part to enable each tooling arrangement to be recorded quickly and accurately. The machine settings could thus be recorded for every spring design and advance warning of a repeat order would be unnecessary. The device would also be in continual use.

Whichever device were used, some problems would be common to both, i.e. their adaptation to individual coiling machines and allowances to be made for wearing parts. Over the years there have been a large number of manufacturers who have sold many different types of machine. A further complication is that

parts from apparently identical models are not always interchangeable. Moreover, the coiling points wear during coiling and a secondary groove is sometimes formed; thus, when the tooling arrangement is recorded, consideration must be given as to whether new points will be used for a repeat order.

The fact was mentioned earlier that adjustable parts on some machines were calibrated. A development introduced by one manufacturer is a coiling machine which permits removal of the cam shaft assembly, thus enabling the shaft to be stored until a repeat order is received, which is an ideal arrangement. Unfortunately it is still affected by variations in batches of wire and the initial cost of cam shafts.

Information has also been received about a new foreign machine that enables the tooling and cams to be removed in one piece from the front of the machine. Skilled labour can thus be employed to adjust the tooling on the simulator, produce the required spring, and then have this spring subjected to subsequent treatments and inspection. When one coiling machine has finished its production cycle, the old tooling can be replaced by the new tooling, so that the coiling machine remains idle for the minimum time. With this method, only one experienced setter is required, together with an assistant to keep several machines running.

Any device designed to save time on setting up of the coiling machine must be considered in relation to the complete operation, including all subsequent treatments of the springs through to inspection. Only after final inspection of the spring can coiling proceed. The subsequent operations are usually as follows:

a) stress relieving after coiling;

b) grinding;

c) peening;

d) stress relieving;

e) prestressing; and

f) inspection.

Not all of these operations, however, apply to every spring design. Neglecting the time between operations, the time for a), c), d) and f) cannot be varied if they are to be carried out correctly. The time taken for operation e) is dependent upon whether it is a hand or machine operation. If done by machine the following comments on grinding also apply to that operation. The grinding operation involves setting up the grinding machine in accordance with the required spring design. This involves two problems: firstly, if the machine is already in use, the coiling machine has to stand idle longer than necessary; and secondly, the grinding machine, once set, must stand idle, like the coiling machine, until the initial springs have passed inspection and coiling can proceed. Al alternative is to grind the springs by hand but the use of the different process may give rise to errors. The suggestion has been made that a simple and inexpensive device operated by hand and reproducing the effects of an automatic grinding machine would be a useful way of reducing the waiting time.

CONCLUSIONS

1. Many operations are involved in setting up a coiling machine. On some machines the adjustable links used in these operations have been calibrated. Records kept of each reading for a spring design will save time when a repeat order is received.

2. The only adjustable parts of coiling machines which are not calibrated are the actual coiling tools. Since each tool can move in many directions, a device to record the position of each tool would be beneficial for resetting the machine when repeat orders are received.

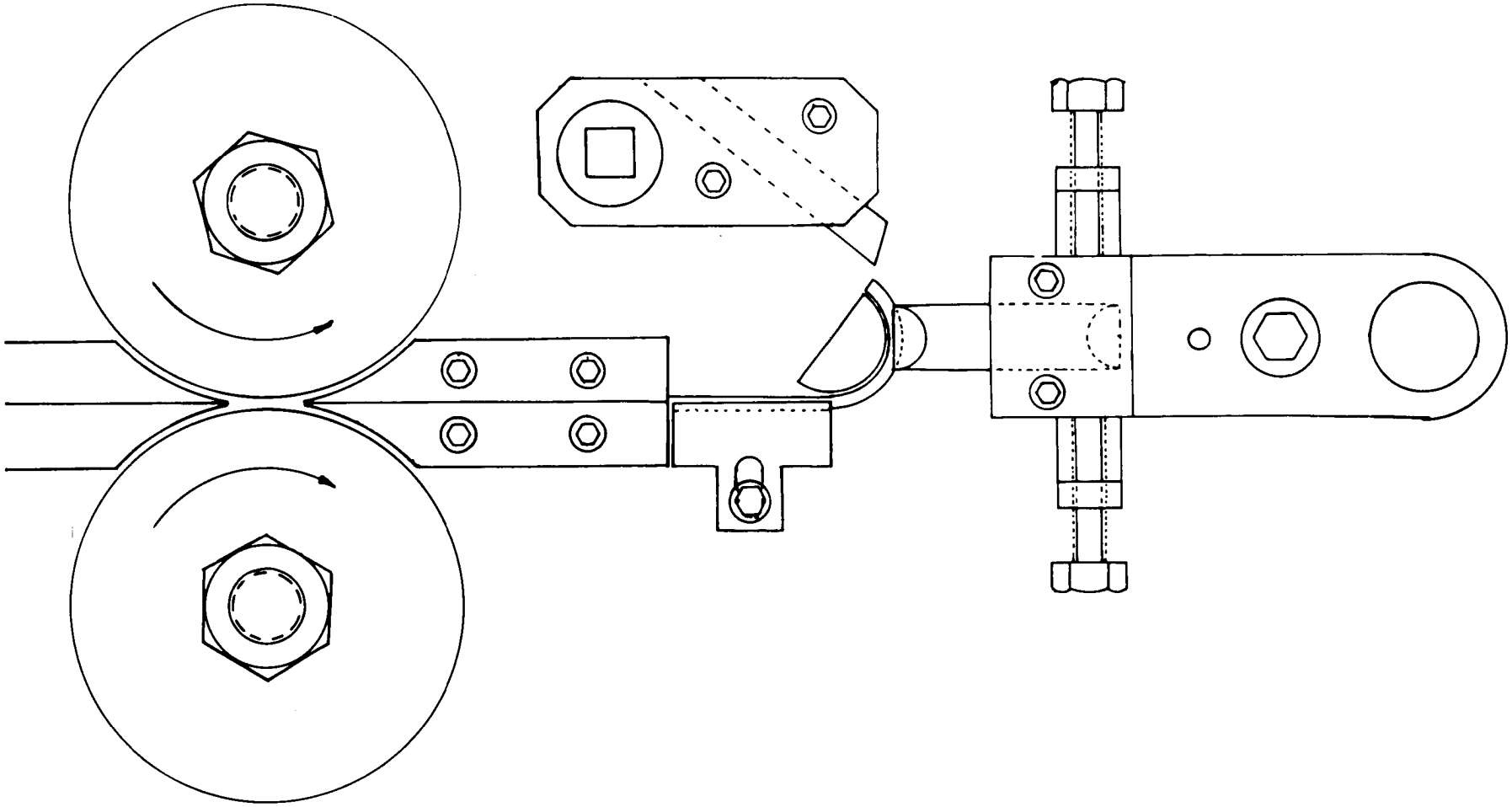

FIG.I SINGLE POINT COILING SYSTEM

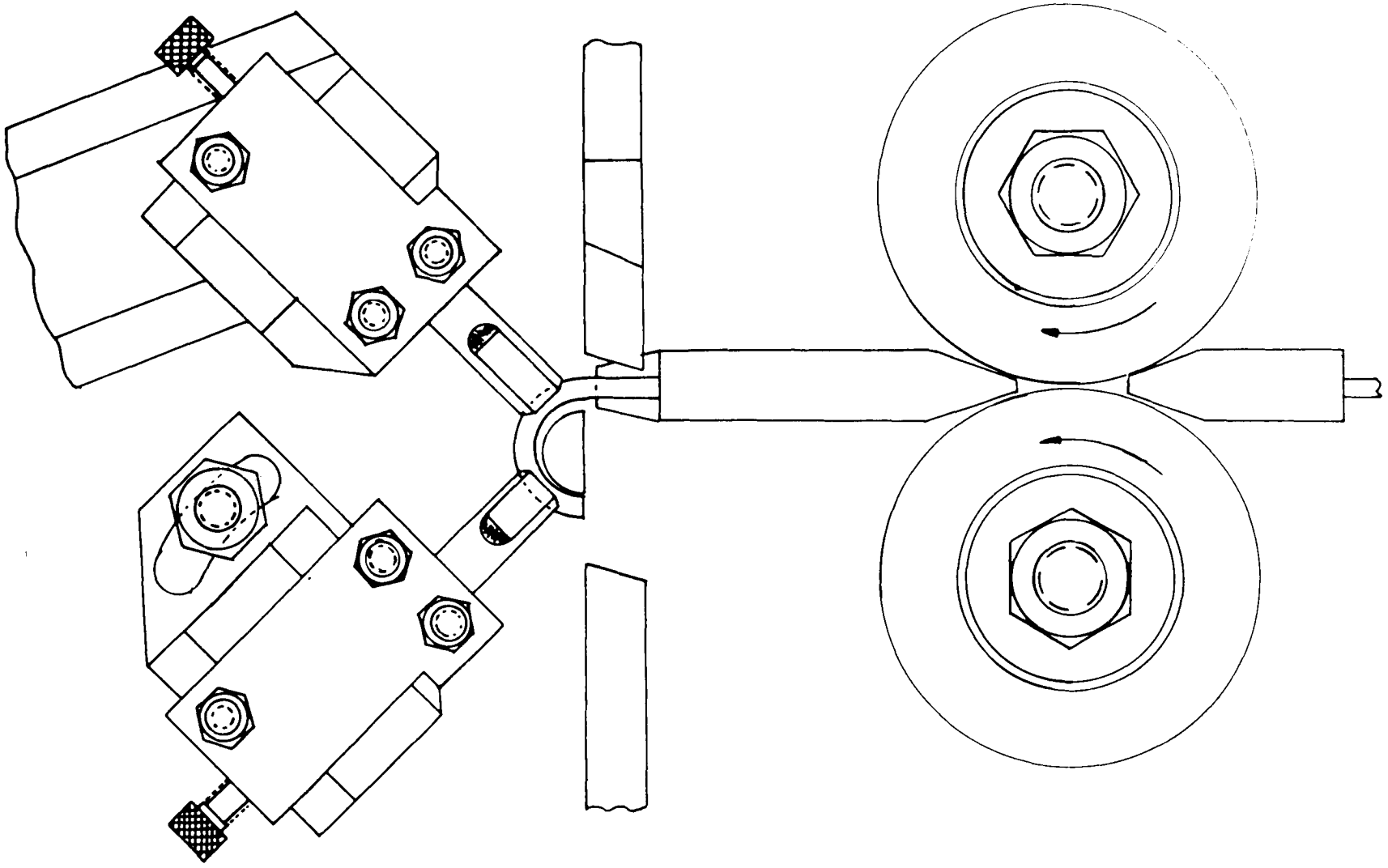

FIG. 2 DOUBLE POINT COILING SYSTEM

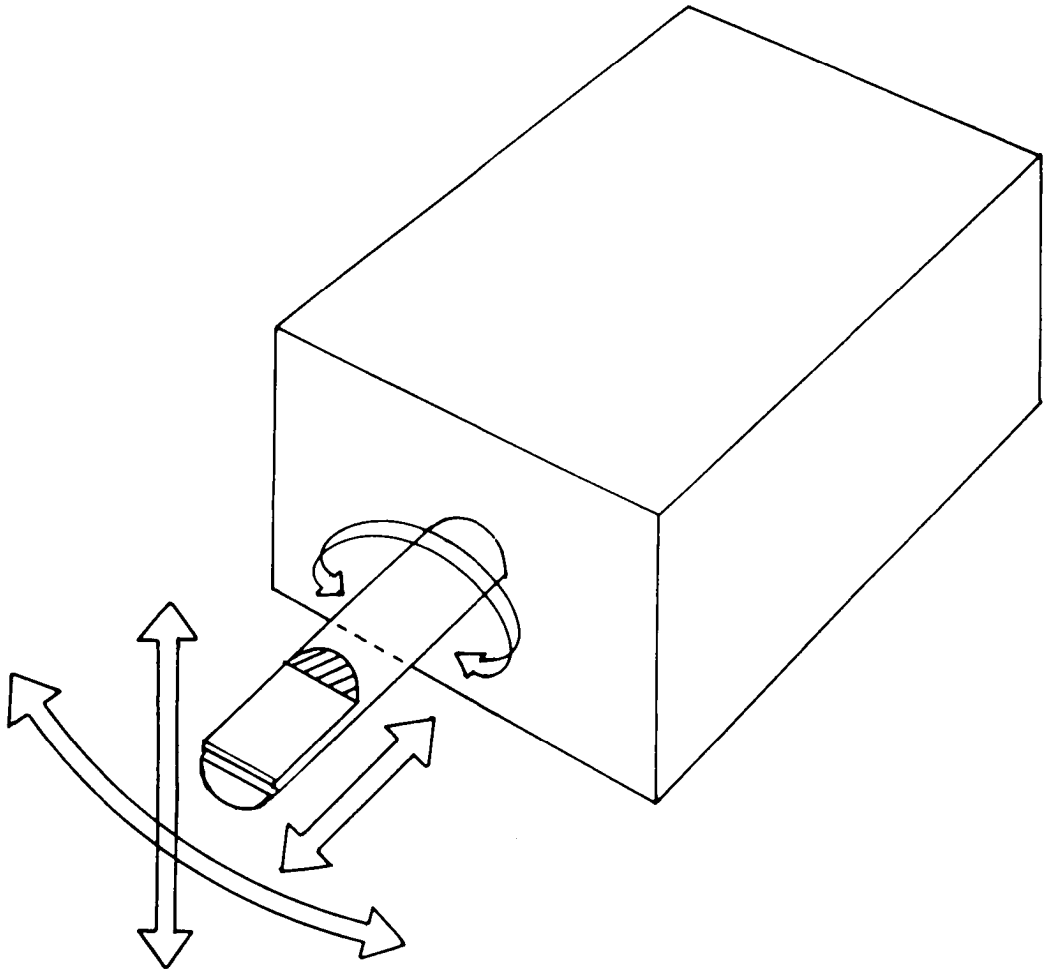

FIG. 3 MOVEMENT OF COILING POINT