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TECHNICAL REPORT ARSCD-TR-79010

ESTABLISH FABRICATION METHODS FOR TWO- AND THREE-WIRE MESH SPRINGS

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AUGUST 1979



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
FIRE CONTROL AND SMALL CALIBER
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20. ABSTRACT 20,
and a three-wire mesh spring were designed to equivalent conditions of load, stress, and outside coil diameter, and prototype lots of these designs were fabricated. If the spring pitch equals 12.7mm or less, the mesh springs can be fabricated with good dimensional control. Also, if 1.5 to 2.0 coils are closed on each spring end, spring separation can be prevented.

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PREFACE

This project was accomplished as part of the U.S. Army Manufacturing Technology Program. The primary objective of this program was to develop on a timely basis manufacturing processes, techniques, and equipment for use in production of Army materiel.

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OBJECTIVE

The objective of this project was to develop manufacturing techniques and procedures for the fabrication of two- and three-wire mesh springs on production coilers.

INTRODUCTION

Comparison of Mesh Springs with Stranded Wire Springs

Presently, the stranded wire spring is the only helical spring configuration used in impact-loading applications. The use of stranded wire springs is recommended for those applications in which the compression velocity is comparatively high, of the order of 6.1 meters per second (20 feet per sec) or higher. Velocities of this magnitude are common to the drive, extractor, ejector, and firing pin springs in automatic weapons. Stranded wire springs have the functional capacity to minimize the surge vibrations by the frictional interaction between the individual wires within the strand. This available dampening is effective in decreasing the dynamic coil displacement and in proportionately reducing the stress levels that result in longer spring life. Similar surge dampening and extended spring life can be attained with the use of mesh springs. However, mesh springs are relatively new, and proper techniques have not been established for their fabrication.

A mesh spring assembly consists of two or three wires of equal diameters that are coiled together around the same axis into springs with equal coil diameters and equal number of coils. The springs are close together and, because of this, cause a rubbing action between the individual wires that helps to diminish the surge forces. The appearance of a mesh spring differs from a stranded wire spring in that the individual wires are not stranded into a cable construction, but are separate and in contact with each other. The individual springs in a mesh design are substantially parallel throughout their length. This distinction is made clear in figure 1 in which a stranded wire spring is compared with a two-wire mesh spring. A two-wire mesh spring with a three-wire mesh spring is compared in figure 2.

For computational purposes, the mesh spring is treated similarly as the stranded wire spring. For the calculation of the load-deflection rate, the mesh spring is resolved into as many partial springs acting in



Figure 1. Comparison of a stranded wire spring with two-wire mesh spring.

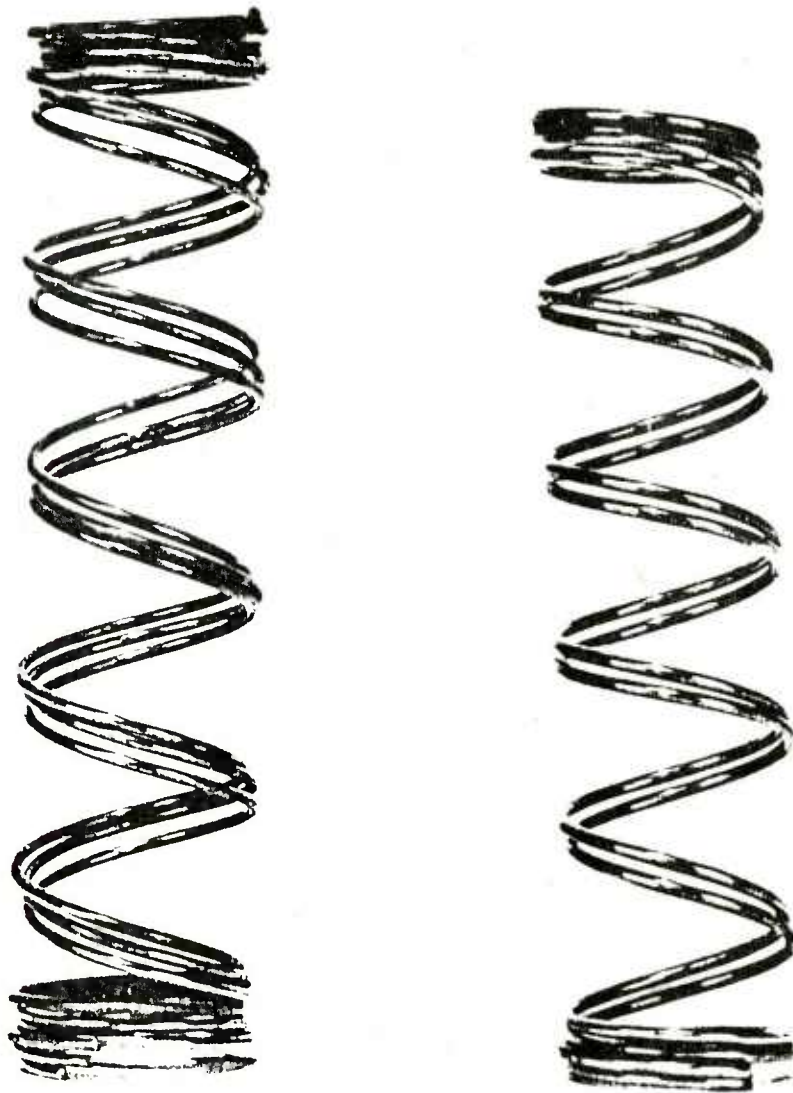


Figure 2. Comparison of a two-wire mesh spring with a three-wire mesh spring.

parallel as the number of wires present in the assembly.

$$\text{Load-deflection rate, } R = \frac{P}{F} = \frac{KGd^4}{8D^3n}$$

where

P - spring load, N

F - deflection of spring from free height, m

K - number of wires in the assembly

G - modulus of torsion for spring material, N/m²

d - wire deameter, m

D - mean coil diameter of spring, m

n - number of active coils

S - spring stress N/m²

To determine the stress-deflection rate in an individual spring, the conventional stress formula is used.

$$\text{Stress-deflection rate, } U = \frac{S}{F} = \frac{GD}{\pi D^2n}$$

History of Multiwire Springs

Stranded wire springs were originally used by the Russian Army in their weapon systems. Western nations first observed these springs in Russian weapons captured during the Spanish Civil War (N. Chironis, Spring Design and Application, McGraw-Hill, 1961). The principle of stranded wire springs was then adopted by the German and French military in the late 1930s and incorporated into their weapon development. This type of spring construction was a comparatively late addition to U.S. ordnance since it was introduced to U.S. weapons shortly after the end of World War II.

Mesh springs are a recent U.S. Army development. Even though they provide the same type of dampening action as stranded wire springs, mesh springs offer the advantage of shorter leadtime in obtaining basic materials since

wire is more readily available than cable. They also provide a cost reduction since the stranding operation is eliminated.

Current Method for the Manufacture of Mesh Springs

The major problems in the present manufacturing of mesh springs are those involving high production cost and excessive fabrication time. The reason for this is that mesh springs are coiled on a lathe type machine equipped with a rotating arbor. In this operation, the individual wires are hand-fed simultaneously onto the arbor, and much attention is required to properly control the spring dimensions. The purpose of this program is to determine the modifications and special tooling that are necessary to adapt production coilers to the fabrication of mesh spring assemblies.

DISCUSSION

Mesh Spring Designs

Two designs of mesh spring assemblies were prepared for this project. A two-spring mesh with a wire size of 11.43×10^{-4} meters (0.045 in.) is shown in table 1. and a three-spring mesh with a wire size of 9.91×10^{-4} meters (0.039 in.) is shown in table 2. The mesh spring assemblies were designed so that the following equivalent conditions would be maintained between the two designs:

1. The working stresses of all the individual springs will be equal.
2. The combined functional loads of the individual springs in the two-spring mesh will be equal to the combined loads of the individual springs in the three-spring mesh.
3. Each assembly will have the same outside coil diameter.

This similarity between the two designs was considered desirable so as to provide a meaningful basis on which to compare results if endurance cycling tests were conducted. Detailed specifications of the two designs are given on the Specification Sheets.

Table 1. Specification sheet
for design 1, two-spring mesh

Wire Size (m)	11.43×10^{-4}
Outside Diameter (m)	17.53×10^{-3}
Number of Coils	7
Type of Ends	Closed
Free Height, Approx. (m)	80.5×10^{-3}
Mean Assembled Height (m)	53.2×10^{-3}
Total Load at Mean Assembled Height (N)	41.4
Minimum Operating Height (m)	25.9×10^{-3}
Total Load at Minimum Operating Height (N)	82.3
Total Load-deflection Rate (N/m)	1540
Maximum Solid Height (m)	20.3×10^{-3}
Spring Helix	Optional
Stress at Mean Assembled Height (N/m^2)	586 MP _a
Stress at Minimum Operating Height (N/m^2)	1172 MP _a
Stress at Solid Height (N/m^2)	1344 MP _a

Material - Music Wire, QQ-W-470

Stress Relieve - Heat at $232^{\circ}\text{C} \pm 14$ for 30 minutes

Table 2. Specification sheet
for design 2, three-spring mesh

Wire Size (m)	9.91×10^{-4}
Outside Diameter (m)	17.53×10^{-3}
Number of Coils	6
Type of Ends	Closed
Free Height, Approx. (m)	79.8×10^{-3}
Mean Assembled Height (m)	54.1×10^{-3}
Total Load at Mean Assembled Height (N)	41.4
Minimum Operating Height (m)	28.4×10^{-3}
Total Load at Minimum Operating Height (N)	82.3
Total Load-deflection Rate (N/m)	1576
Maximum Solid Height (m)	21.6×10^{-3}
Spring Helix	Optional
Stress at Mean Assembled Height (N/m^2)	586 MP _a
Stress at Minimum Operating Height (N/m^2)	1172 MP _a
Stress at Solid Height (N/m^2)	1344 MP _a

Material - Music Wire, QQ-W-470

Stress Relieve - Heat at $232^{\circ}\text{C} \pm 14$ for 30 minutes

Coiler Modifications and Operation

A segment type production coiler, rather than the arbor type, was used in this project because of the ease that is provided in the setting up and adjusting of components such as feed rollers, wire guides, and pitch cams. The following necessary modifications of the components were made to facilitate the coiling of mesh springs:

1. Three grooves each 0.38mm (0.015 in.) in depth and 0.64mm (0.025 in.) in radius were machined on the periphery of the feed rollers. The grooves were separated 1.12mm (0.040 in.) apart. Each individual wire of the mesh spring passed through a groove while being driven into the coiler. This size groove was adequate to satisfactorily accommodate the wire diameter 1.14mm (0.045 in.) of the two-wire mesh or the wire diameter 0.99mm (0.039 in.) of the three-wire mesh. In the event that a two-spring mesh is being coiled, just two grooves would be used.

2. Corresponding grooves were machined on the surface of the wire guides (with the exception of the final wire guide). The feed rollers and wire guides are assembled onto the coiler so that the corresponding grooves are mated properly to ensure that the wires can be driven and guided simultaneously.

3. A V-shaped cut was made in the final wire guide. This component is such that the separated individual wires are received and then funneled through the V-shaped groove so that they converge and are in contact together just prior to coiling.

4. A groove was machined at the tip of the coiling point into which the adjacent wires are received just before they are wound around the arbor. The width of the groove was approximately 10 percent larger than the sum of the diameters of the wires in the mesh design.

5. A similar groove that was also 10 percent larger than the sum of the wire diameters was machined onto the cutoff tool.

6. The arbor (around which the spring is coiled) was made about 7.62mm (0.30 in.) longer than that used to wind the conventional single springs. This extra length was necessary so that a full coil remains on the arbor after the finished spring has been removed from the arbor. The use of the remaining coil facilitates the initial coiling of the succeeding mesh spring in that

the proper clearance is ensured between the spring wires and the pitch tool.

7. The pitch cam was designed to have approximately a 10 percent higher rise than that required for winding single springs with the same wire size and coil diameter. With this cam, the longitudinal motion of the pitch tool is controlled and, therefore, the amount of coil pitch as well as the closing of end coils. The modified cam also provided a slower speed of the wire feed that helped to keep the wires together.

In the wire-feeding operation, the individual reels of wire are mounted on a common spindle. Therefore, to maintain uniform feeding rates among the reels, they must be of equal diameter.

CONCLUSIONS

1. If the spring pitch equals 12.7mm or less, the mesh springs can be fabricated with good dimensional control. Practical manufacturing tolerances on the coil diameter, number of coils, and free height approximated those tolerances used in the winding of single-wire springs.

2. As the pitch value approaches 15.2mm, workable tolerances tend to increase, and the closing of end coils is less perpendicular to the spring axis.

3. Extension type mesh springs wound with all coils in contact and with some initial tension coil easily and remain well intact.

4. Mesh springs were also fabricated from stainless steel material, QQ-W-423, and found to coil as easily as the music wire material.

RECOMMENDATIONS

The end coils should be closed so that the individual springs in the mesh assembly remain intact as a unit. Normally for single-wire springs only one coil is closed at each end of the spring. However, for mesh springs, 1.5 to 2.0 coils should be closed at each end to prevent spring separation.

Fatigue cycling tests should be conducted on mesh

springs to determine their endurance properties.

Stranded wire and single wire springs should be designed to the equivalent stress, load, and space conditions of the mesh springs, and should be endurance-tested to obtain comparative test data.

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