C. Dynamic Factors Contributing to Buckling and Birdnesting During GMAW Wire Feeding[1]

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Introduction

In gas metal arc welding (GMAW), wire feedability plays an important role towards overall quality. During push wire feeding, the welding wire can buckle and/or birdnest (tangle) as it passes through various bends in the wire liner (Figure 1). The material composition of the welding wire and the wire liner, along with the spatial layout of the two, are believed to contribute to the propensity of the welding wire to buckle and/or birdnest [1,2,3]. In this study, full-scale experiments show the feeding process to be sensitive to a number of factors including the condition of the welding wire, the support conditions of the wire liner, and the liner-to-wire diameter ratio. To gauge the relative sensitivities of each factor, a full-factorial designed experiment was conducted to simulate feeding of ER5356 and ER70S-6 welding wires through various Teflon-impregnated, Nylon-impregnated, and spirally-wound steel wire liners[2].

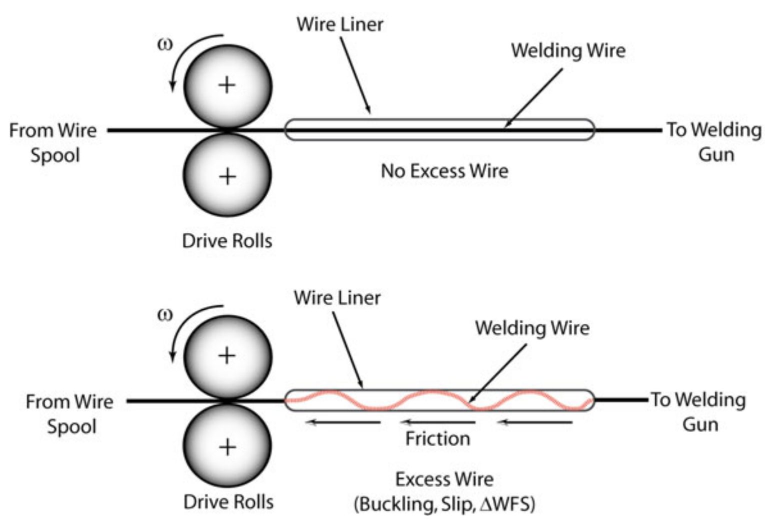

Figure 1. Schematic of the GMAW push wire-feeding operation showing wire buckling.

Technical Approach

Using off-the-shelf components, various welding wires and wire liners were configured to simulate wire feeding during GMAW. ER5356 and ER70S-6 welding wires ranging in diameter from 0.8 mm to 1.6 mm (0.030 to 0.0625 in) were fed through a 3 m (10 ft) length of wire liner. Experiments were conducted using several Teflon-impregnated, Nylon-impregnated, and spirally-wound steel wire liners to provide liner-to-

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wire diameter ratios that ranged from 1.4:1 to 2.2:1. During feeding, the wire feed speed, as well as the wire feeding force, was recorded at both the entrance and exit of the wire liner. The two force measurements were differenced to give an estimate of the friction between the welding wire and the wire liner. To achieve a uniform metric of comparison, the wire feed speed was varied from 5 to 20 m/min (200 to 800 in/min), while also varying the shape of the wire liner from "straight", "looped" and "sigmoidal" configurations (Figure 2). In several experiments, the shape of the wire liner was simultaneously imaged using a video system to determine the factors that contributed to sway in the hose package. The resulting data were analyzed with commercially available software [4] to determine the relative friction effects attributed to changes in the wire feed speed, hose geometry, material combination, and diameter ratio.

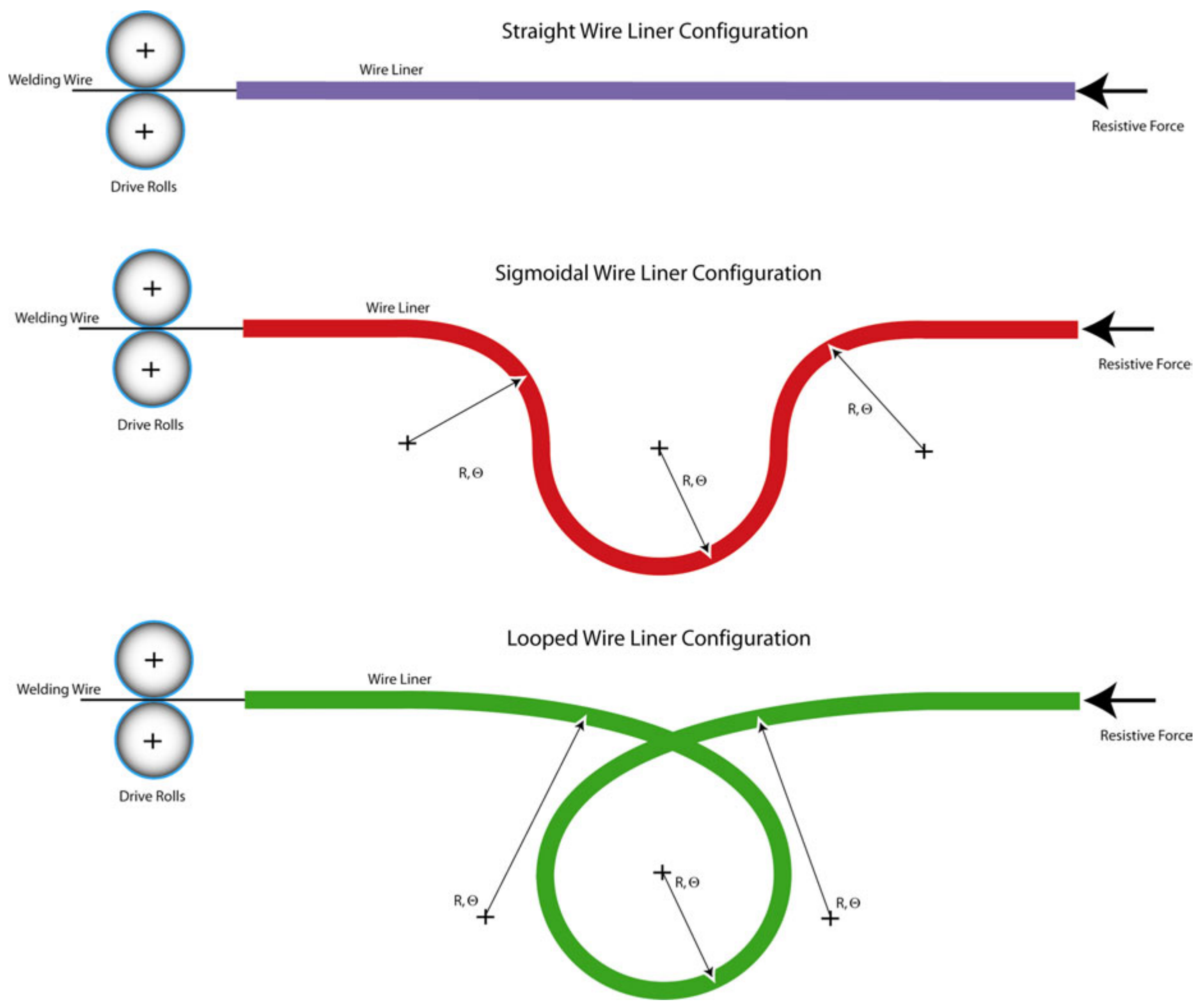

Figure 2. Sketch of the three wire liner shapes used for feeding ER5356 and ER70S-6 welding wires.

Results and Discussion

Results indicate that friction between the welding wire and the wire liner is closely tied to all dynamics factors involved in GMAW wire feeding (Figure 3). Under normal feeding conditions, such as when the wire liner is straight and when the liner length is limited to 3.0 m (10 ft), the friction force between the wire and liner under good (clean) conditions is approximately 2.5 N (0.5 lb_f) for systems having a diameter ratio of

1.4:1. However, given identical conditions, looping the wire liner can increase the friction force four-fold (Figure 4). Additional experiments conducted with short lengths of wire liner (L ~ 0.75 m or 2.5 ft) confirm that variations in the friction force can be reduced nearly two-fold by physically constraining the wire liner during feeding. Video analyses of the wire feeding process show that the spatial vibration and sway of the hose package is caused by repetitive kinks (r ~ 0.2 m or 6.5 ft) in the welding wire. Here, the bends are attributed to unraveling of the wire from the spool and to passage of the wire through the wire straightener and drive mechanism (Figure 5). The resulting perturbations are transmitted and observed as variations in the exit wire feed speed and feeding force. Digital images recorded during feeding also confirm that the welding wire glides along the walls of the wire liner and buckles only when adequate clearance (i.e., when using oversized liners) exists between the welding wire and the wire liner. Buckling of the welding wire was also observed upon initial feeding of the wire through the liner, and typically occurred when the total wire feeding force was approximately 44.5 N (10 lb_f) and when the liner was tightly looped (r ~ 30 cm or 12 in).

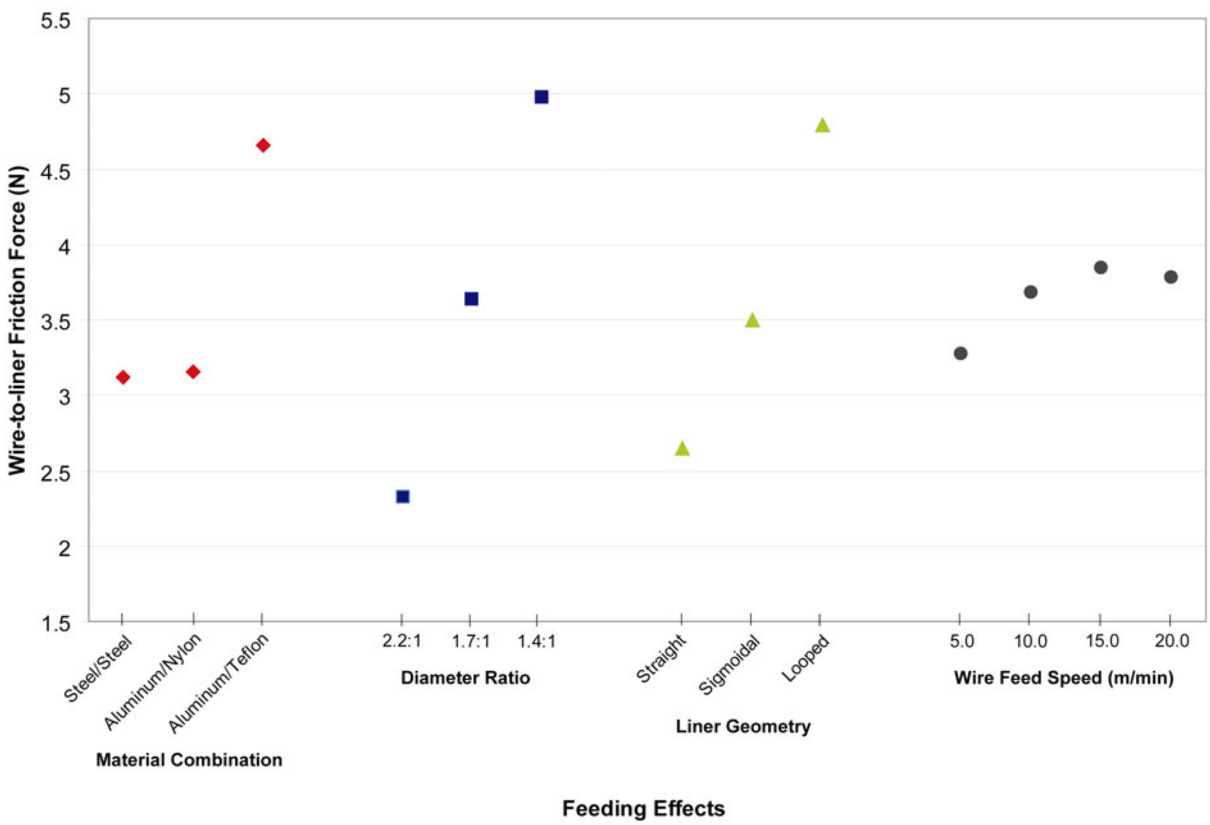

Figure 3. Marginal means plot showing the relative effect of changing materials, diameter ratio, hose geometry, and wire feed speed towards the wire-to-liner friction during simulated feeding.

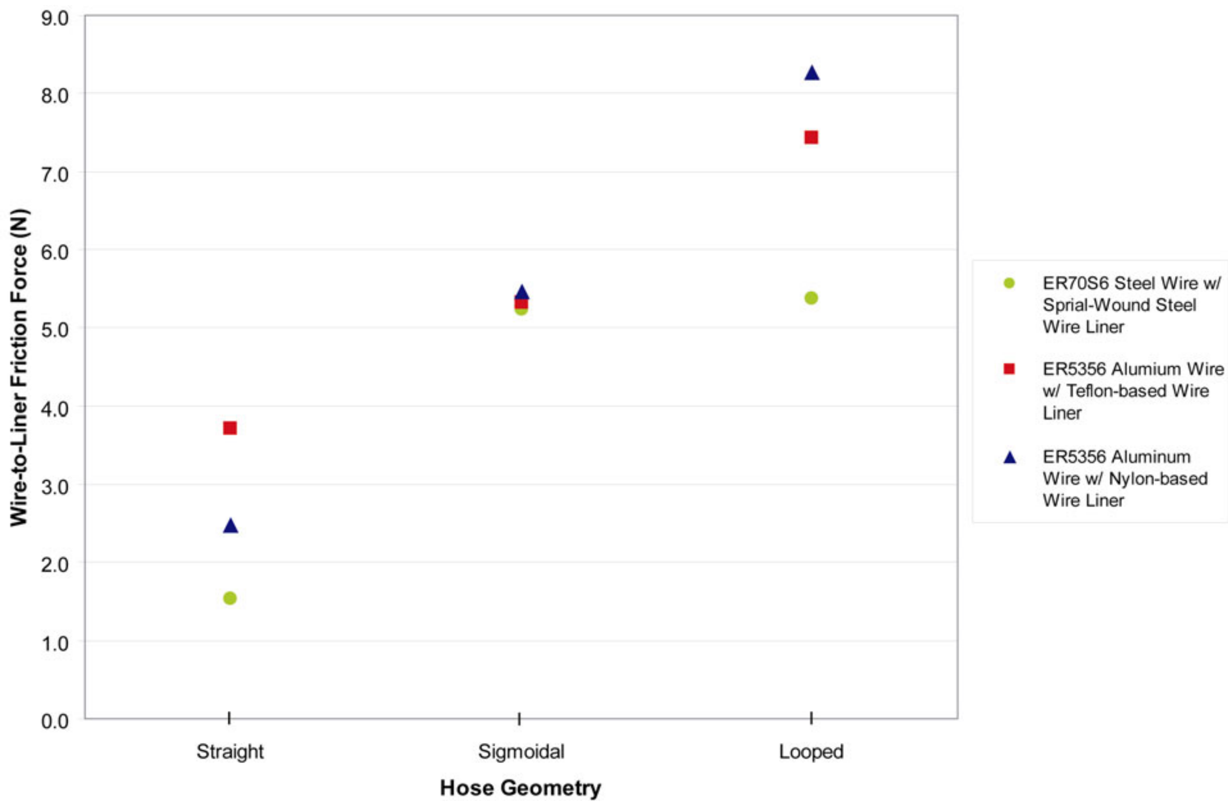

Figure 4. Effects plot indicating an increase in friction as the liner shape is changed from the straight to a looped configuration. The data shown is for a diameter ratio of 1.4:1 and is averaged for wire feed speeds ranging from 5 to 20 m/min (200 to 800 in/min).

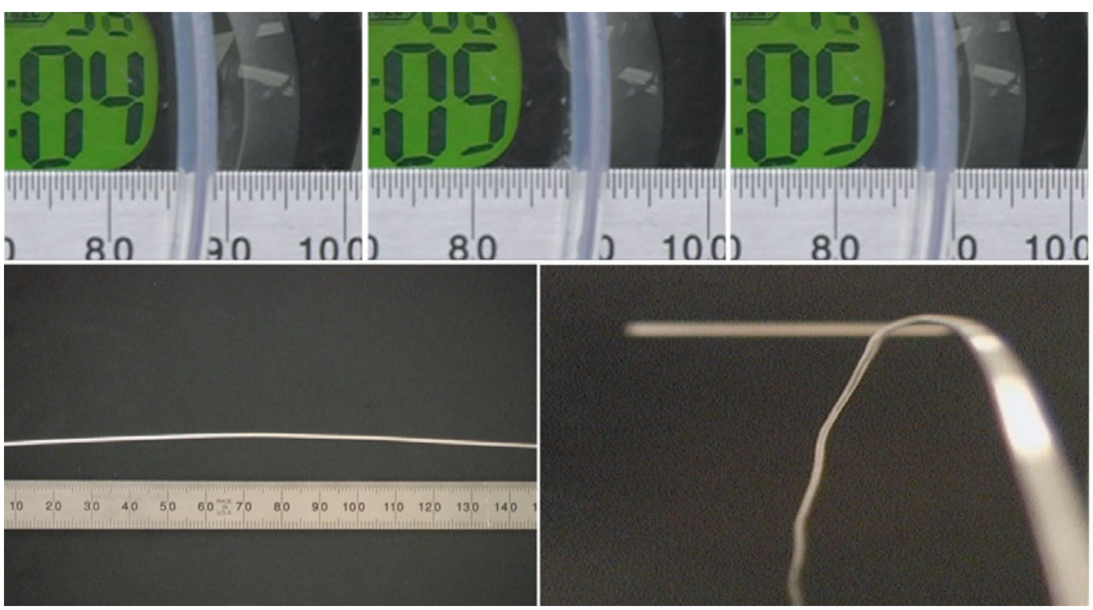

Figure 5. (Top) Frame-to-frame images (Δt ~ 10 ms) showing spatial movement of the wire liner. (Bottom) Deformities in the welding wire produced by the wire straightener and drive mechanism when viewing the wire head-on (left) and axially (right). All scales in millimeter units.

Conclusion

This study provides experimental data for determining the factors affecting GMAW wire feeding performance. Full-scale experiments show that feeding performance, in terms of wire feed speed and feeding force, varies with the material system and with the spatial layout of the wire liner. Video analyses of the feeding process also show that sway of the hose package propagates through the wire liner to influence the exit wire feed speed and overall wire feeding force. When the hose package is looped, overall feeding forces can increase by a factor of 4 to 5, thereby contributing to buckling and/or birdnesting of the welding wire.

References Cited

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