Stator Motor Winding Machine

Manufacturing Systems Project Operations Manual

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Table of Contents

I. Introduction

The purpose of this project is to design, fabricate, and automate a machine that winds copper wire onto brushless motor stators. The machine was required to automatically load and place stators, wind the wire onto each stator pole, then dismount the stator and reload the next one. To meet this goal the team first had to brainstorm and draw out ideas with Pro|E, draw out state diagrams, and then spend countless hours fabricating, assembling, and troubleshooting.

This paper goes over simple instructions for the operation of the machine, then describes the specifications and details of operation, and finishes with diagrams such as PLC ladder logic and state machine to complete the documentation.

Enjoy.

II. Instructions for Operation

To start the machine first power it on, which moves it into the idle state, then flip switch 1 on and off to move the machine into the initial grabbing position. When in position, carefully move the wire between the cutter and pincher, and flip switch 2 on and off. The wire should then be grabbed, and the machine will go back into the idle position. Flip switch 3 to begin the loading/winding.

Loading the machine with more stators can be done by simply sliding in more stators down the stator slide.

III. Descriptions

a. Machine Specifications

This machine winds 26 AWG copper magnet wire from a ¼ lb spool. The stator has the

following specifications:

9 Poles

22.7 mm OD

8.0 mm ID

4.5 mm thickness

Figure 1: Stator

b. Machine Operation

The major parts of the machine are the Stator Spindle Platform, the Loading Mechanism, the Stator Positioning System, the Wire Winding System, the Cutter/Gripper System, and the Unloading System.

Stator Spindle Platform

The stator is moved around in the mechanism by means of this pneumatically actuated platform. The platform itself slides on 4 dry linear bearings, and has two main positions – the loading/unloading position, and the wire winding position.

Loading Stators

Stators slide down an angled ramp until they hit flexible guards. The stator spindle, which slides on the pneumatically actuated platform, then slides through a slot in the slide. The spindle tip slides into the center hole of a stator, pulling it through the flexible guards.

Stator Positioning System

When the sliding platform reaches the full extent of the air cylinder, it is in the winding position. A shaft is lowered and coupled with the stator spindle, pinning the stator in place. A stepper motor is connected to the top shaft, and rotates the spindle into the correct position by means of an inductive sensor positioned close to the stator.

Wire Winding System

The wire winding system includes the side guards (shown above), the front guards, and the rotating arm assembly. A smart motor is connected to the outer shaft, rotating the arm and wire spool. The wire is guided into place on each pole by means of the guards. After wiring each phase, the Cutter/Gripper System is activated.

Cutter/Gripper System

After the winding has been done, the cutter/gripper system that is attached to a pneumatic cylinder slides in, grabs and cuts the wire. The cutter is powered by a pneumatic cylinder, and the Gripper is a pneumatic pincher with rubber pads for improved gripping.

c. Future Improvements

1. Get the machine winding! To do this, we need to write a program for the Linear Actuator, write a program for the stepper motor, complete the program for the smart motor, and redesign the front guards on the winding assembly (The gap between them is too large).

2. In this machine, there is no unloading system equipped. By adding an unloading system, the removal of the stator can be automated.

IV. Diagrams

I/O Wiring Table

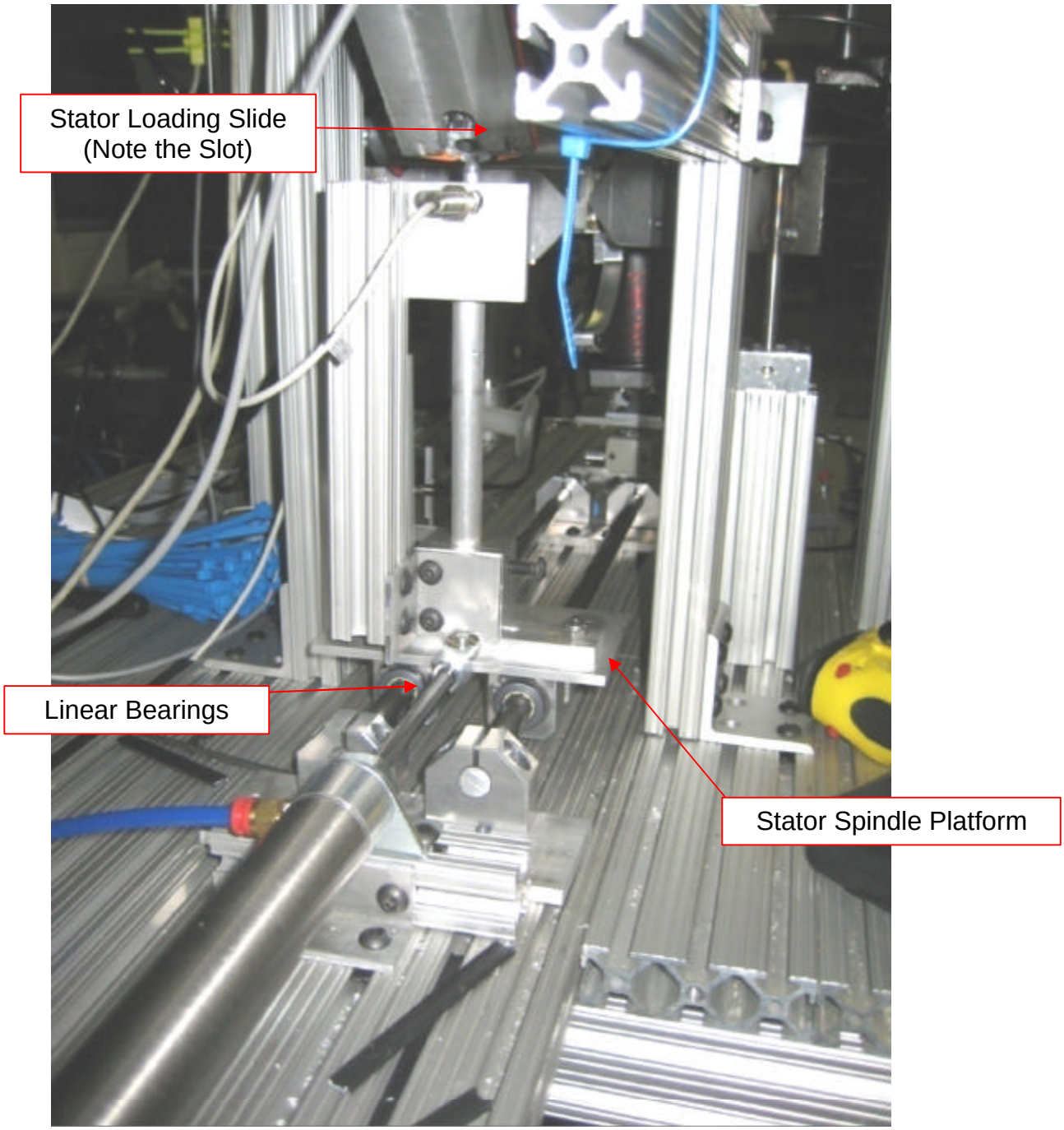
INPUTS		OUTPUTS	
X0	IAI Slide	***Pneumatics***	
X1	Bcyl Extend Sensor	Y0	Motor Lift
X4	Load Cyl Sensor	Y1	
X5	Smart Motor Home Sensor	Y2	Stator Platform Cylinder
X6	Stator Positioning Sensor	Y3	Stator Feed Lift Cylinder
X7	Stepper Motor DOWN Sensor	Y4	Stator Unload
X10	Smart Motor Output	Y5	
X14	Stepper Motor UP Sensor	Y6	Wire Layer Offsets
C0	.+24V	Y7	
C1	.+24V	Y11	IAI SLIDE
C2	.+24V	Y12	
C3	.+24V	Y13	
		Y14	
		Y100	Smart Motor Inputs
		Y101	
		Y102	
		Y103	
		Y104	
		Y105	
		C0	Ground
		C1	Ground
		C2	Ground
		C3	Ground
		C100	Ground

Smart-Motor Program

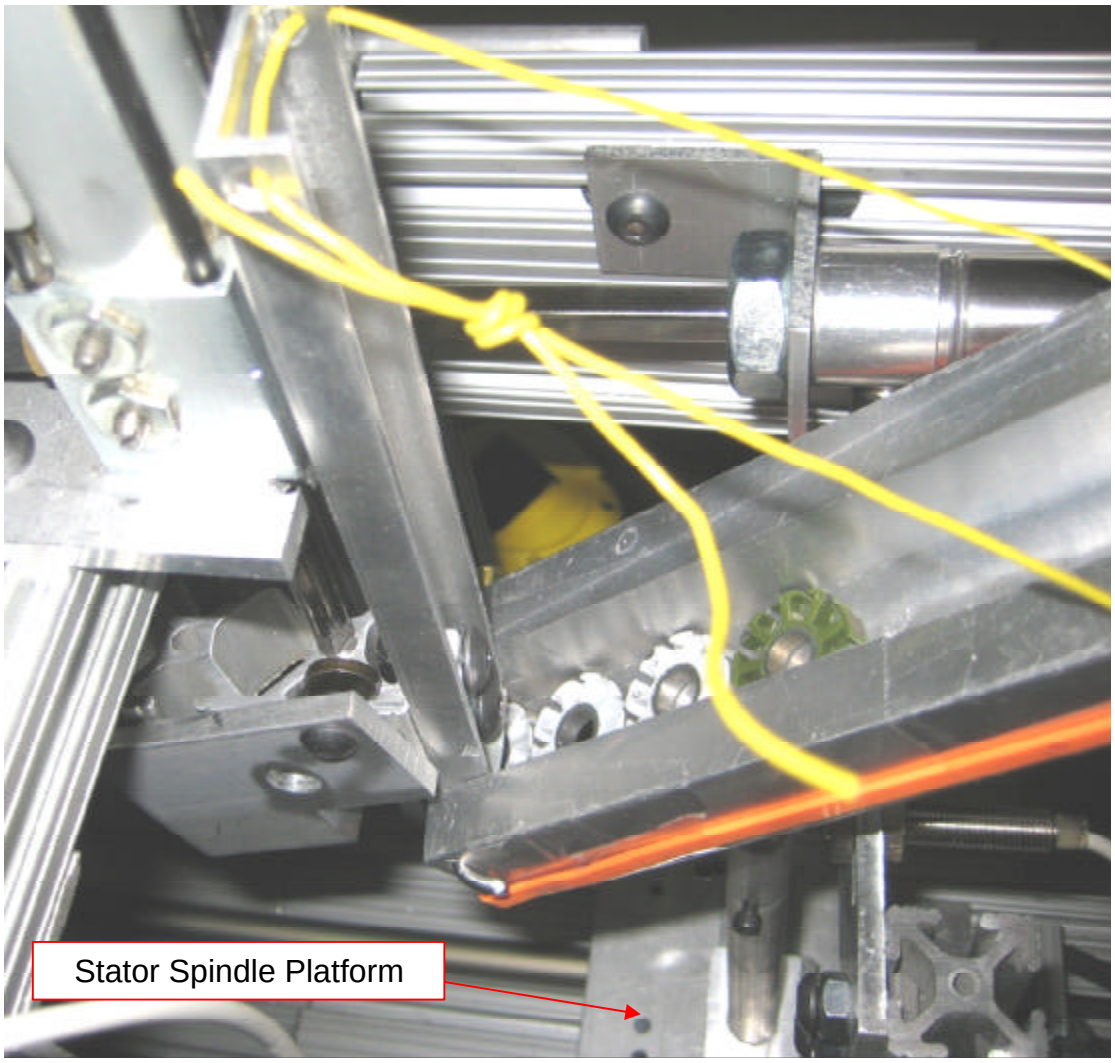
```
                                                Untitled
' Smart Motor Program
A=300
V=100000
UAO
' Setting Tuning Parameters
KP=250
KI=28
KD=50
KL=20
KS=1
KV=0
KA=0
KG=0
F
UA=0
C5
WHILE 1
        UA=0
        IF UGI==1                       'Homing routine
                GOTO 10
        ENDIF
        IF UCI==1                       'Winding, 7 rotations
                GOTO 20
        ENDIF
        IF UDI==1                       'Goto gripping and cutting routine
                GOTO 30
        ENDIF
        IF UEI==1                       'Initial position
                GOTO 40
        ENDIF
        IF UFI==1                       'Winding, 6 rotations
                GOTO 50
        ENDIF
LOOP

'HOMING
C10
        IF UBI==1                       'Make sure not already at home
                O=0
                P=0
                G
                TWAIT
                GOTO 5
        ENDIF
        V=10000
        D=7000
        G
        WHILE Bt
                IF UBI==1
                        O=0
                ENDIF
        LOOP
        P=0
        G
        TWAIT
UA=1
WHILE UGI==1 LOOP
GOTO 5

'7 ROTATIONS
C20
        V=100000
        D=49000
        G
                                        Page 1
```

```
        TWAIT
        UA=1
        WHILE UCI==1 LOOP
GOTO 5

'GRIPPING POSITIONS
C30
        V=10000
        P=2625
        G
        TWAIT
        UA=1
        WHILE UDI==1 LOOP
GOTO 5

'INITIAL POSITION
C40
        V=10000
        P=5250
        G
        TWAIT
        UA=1
        WHILE UEI==1 LOOP
GOTO 5

'6 ROTATIONS
C50
        V=100000
        D=42000
        G
        TWAIT
        UA=1
        WHILE UFI==1 LOOP
GOTO 5
END
```

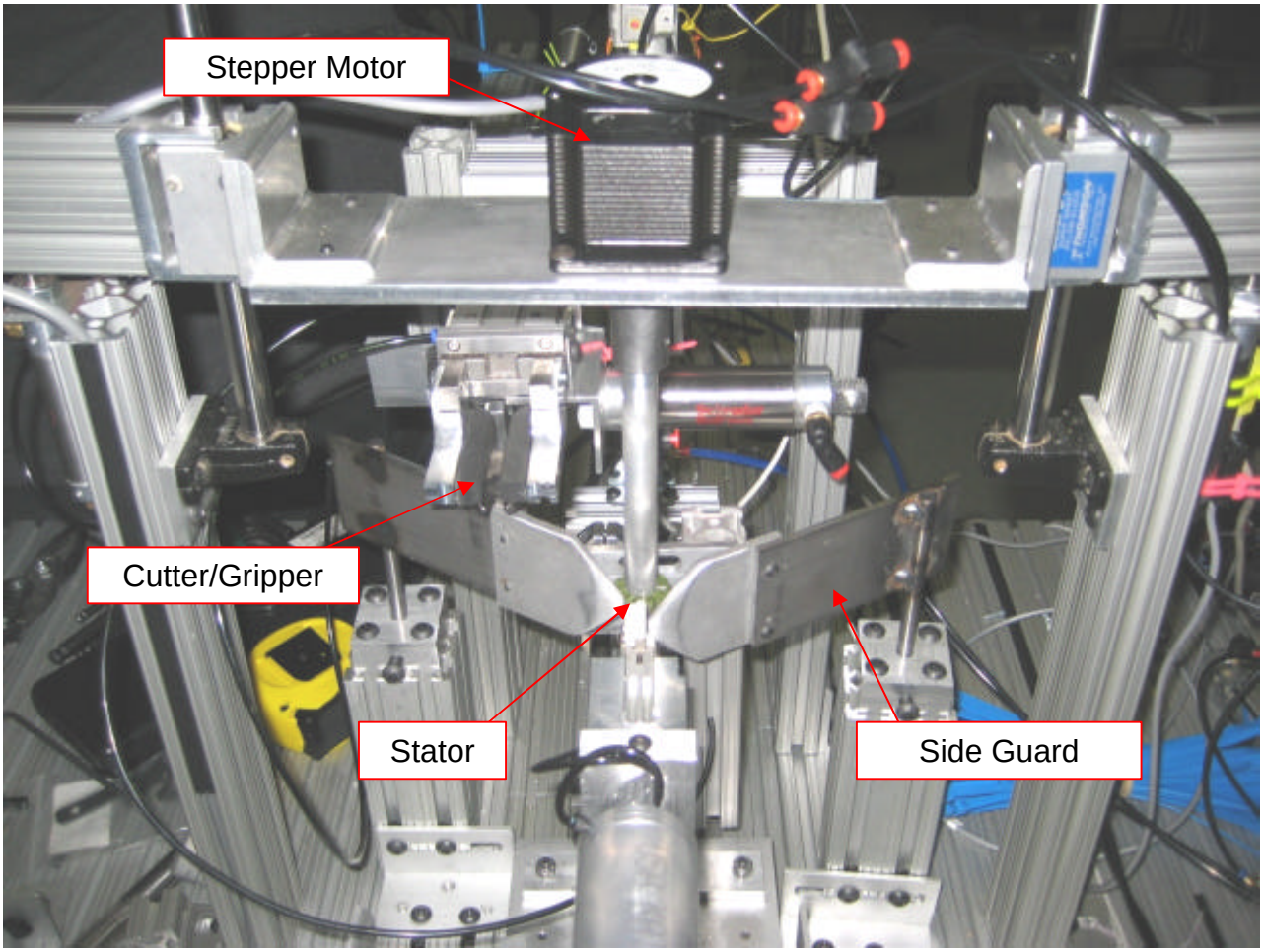
Project Pictures and Descriptions



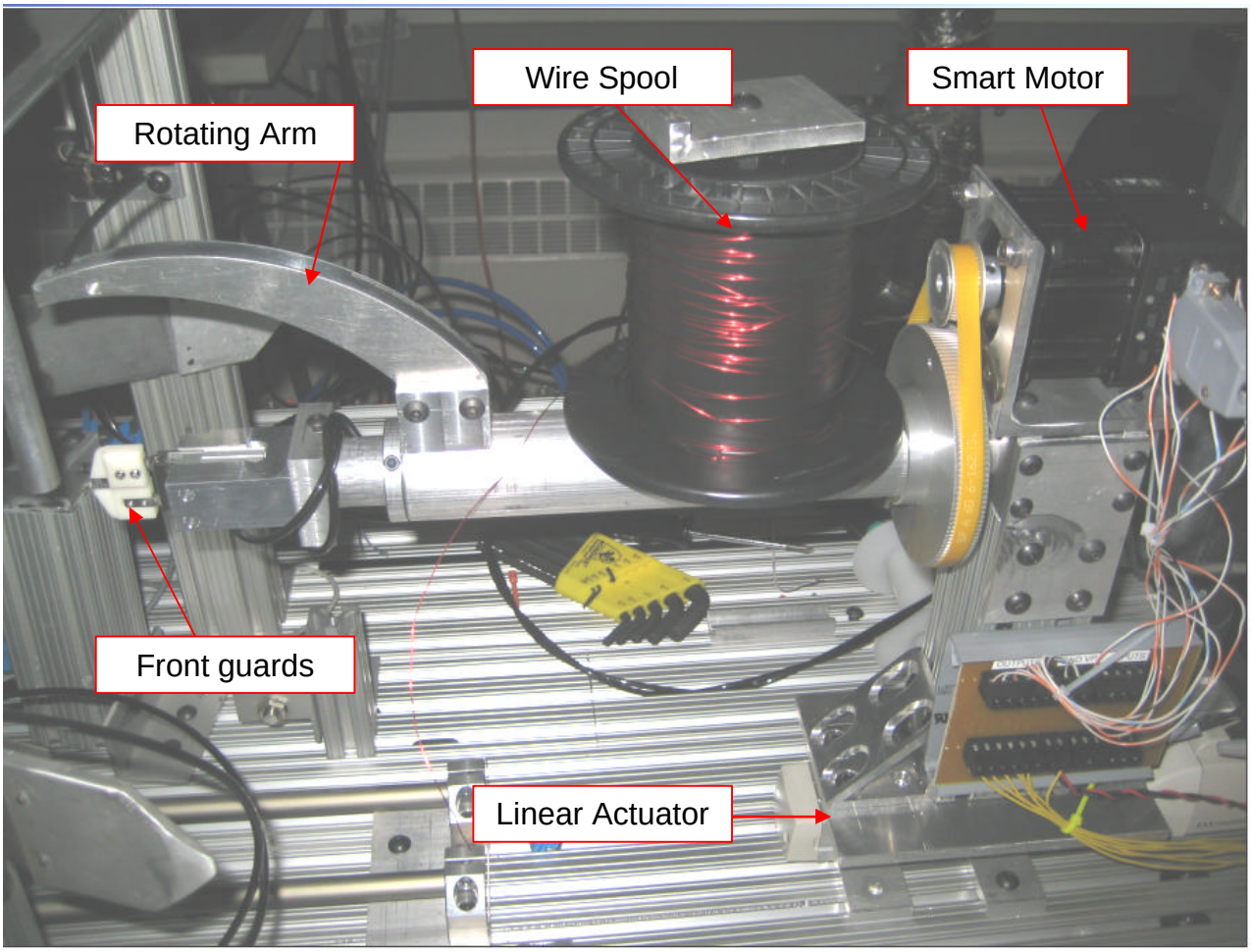
Stator Spindle Platform, showing pneumatic cylinder that pushes the stator spindle from the loading position into the winding position. Note the dry linear bearings and the loading system.



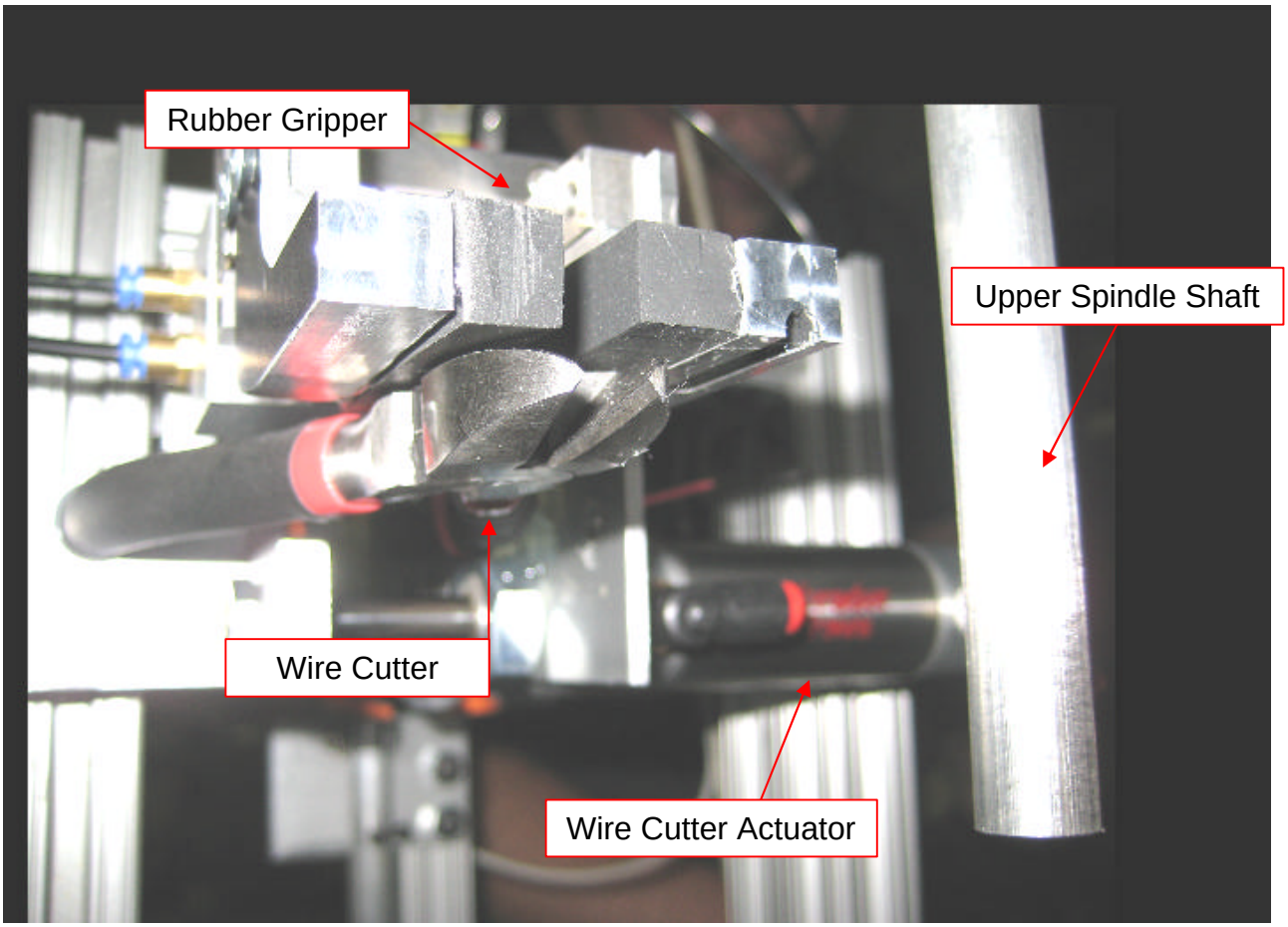
Stator loading slide - Top View. The orange zip-ties shown in the pictures keep the stators from falling slide off the tube until the stator spindle tip sweeps in and grabs one of them.



Wire winding position – The view of the machine from the Smart-motor side. The stepper motor moves up and down to clamp down on the stator and spin it into position. The side guards work to keep



Side View of wire winding assembly – Linear Actuator moves wire winding assembly back and forth, the smart motor spins the outer shaft, which has the arm and wire spool mounted on it.



Wire Gripping/Cutting Assembly – This component is crammed between the upper stator spindle shaft and the aluminum frame of the machine. A non-rotating pneumatic cylinder is activated to move the gripper onto the wire.