A Pen Cartridge Assembly Mechanism

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Abstract

This poster mainly introduces the automatic mechanism to inject ink into one kind of pen cartridges. The author designed an automated process and implied finite element method to analyze this mechanism. The deformation of the mechanism is insignificant compared with assembly error.

Introduction

The mechanism of automatic ink injection is to manufacture the following kind of pen cartridges. The complete pen cartridge includes a ballpoint, injected ink and a sliding ball, as shown in Figure 1. The ballpoint in the cartridge is assembled in advance. Two steps are studied to assemble the cartridge: injecting the ink and inserting the sliding ball.

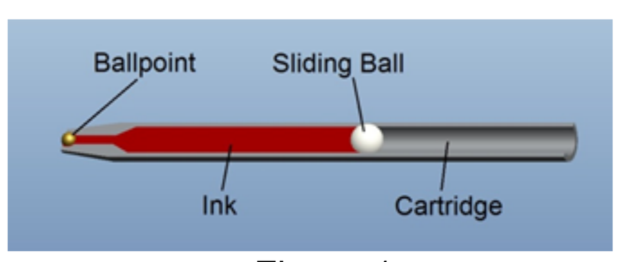

Figure 1

Figure 2 is the overview of the manufacturing process in which the cartridges with fixtures move from right to left. According to the process, the ink is injected when a cartridge is at the first position, then the ball is inserted at the third position.

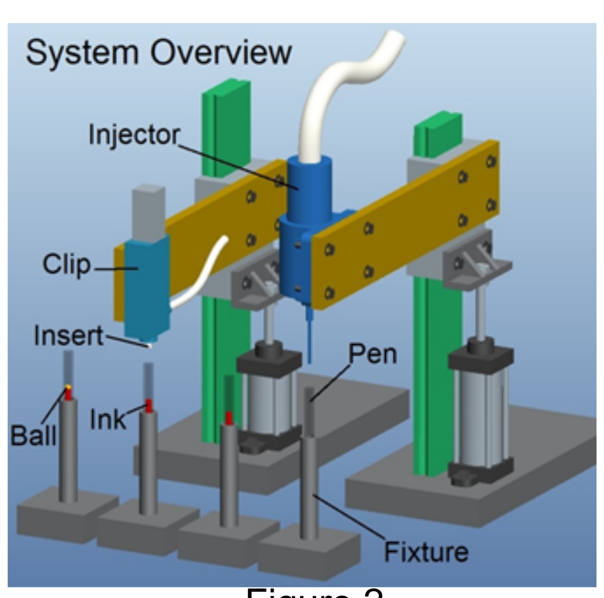

Figure 2

At the first position, there are 4 steps to inject the ink, as shown in Figure 3:
1. The injector falls down until the tip of the injector insert in the cartridge;
2. The valve in the injector opens and the injection starts;
3. The valve closes and the injection stops;
4. The injector retracts back.

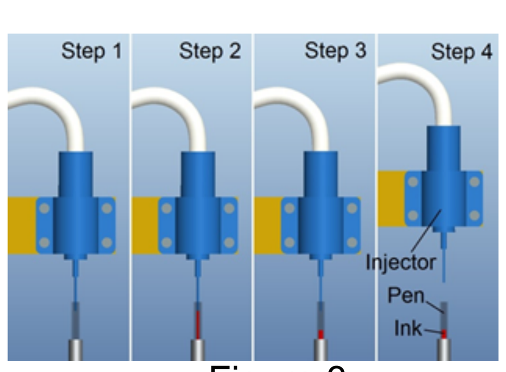

Figure 3

Figure 4 shows 4 steps at the third position to insert the ball:
1. The clip falls down until the end of the cartridge is in the output of the clip;
2. The insert moves up and a ball moves to the unload position;
3. The insert moves down and pushes a ball into the cartridge;
4. The clip retracts back.

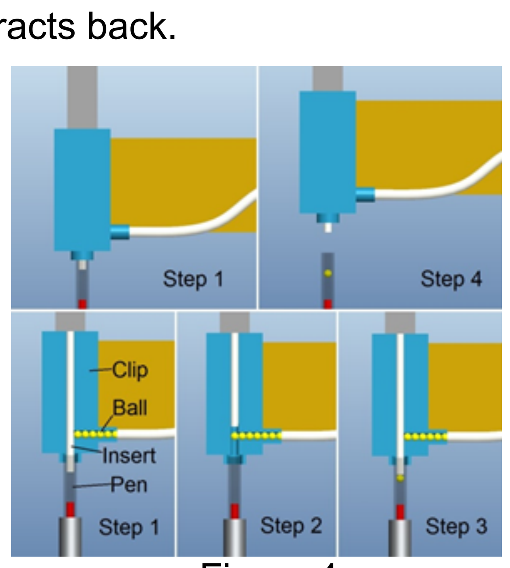

Figure 4

Analysis

Since the ink injection set and the ball inserting set use the same support structure, the analysis only need to be run on the more loading set which is the injection set.

The dimensions of the injection set are as follows (Figure 5):
1. The distance between the centerline of the column and the centerline of the injector is 180 ± 0.3 mm.
2. The height from the top surface of the base to the bottom surface of the slider of the column is 140 ± 0.1 mm.
3. The height from the top surface of the base to the centerline of the arm is 195 ± 0.2 mm.
4. The height from the tip end of the injector to the centerline of the arm is 75 ± 0.1 mm.
5. The width of the column is 40 ± 0.05 mm.
6. The width of the arm is 50 ± 0.05 mm.

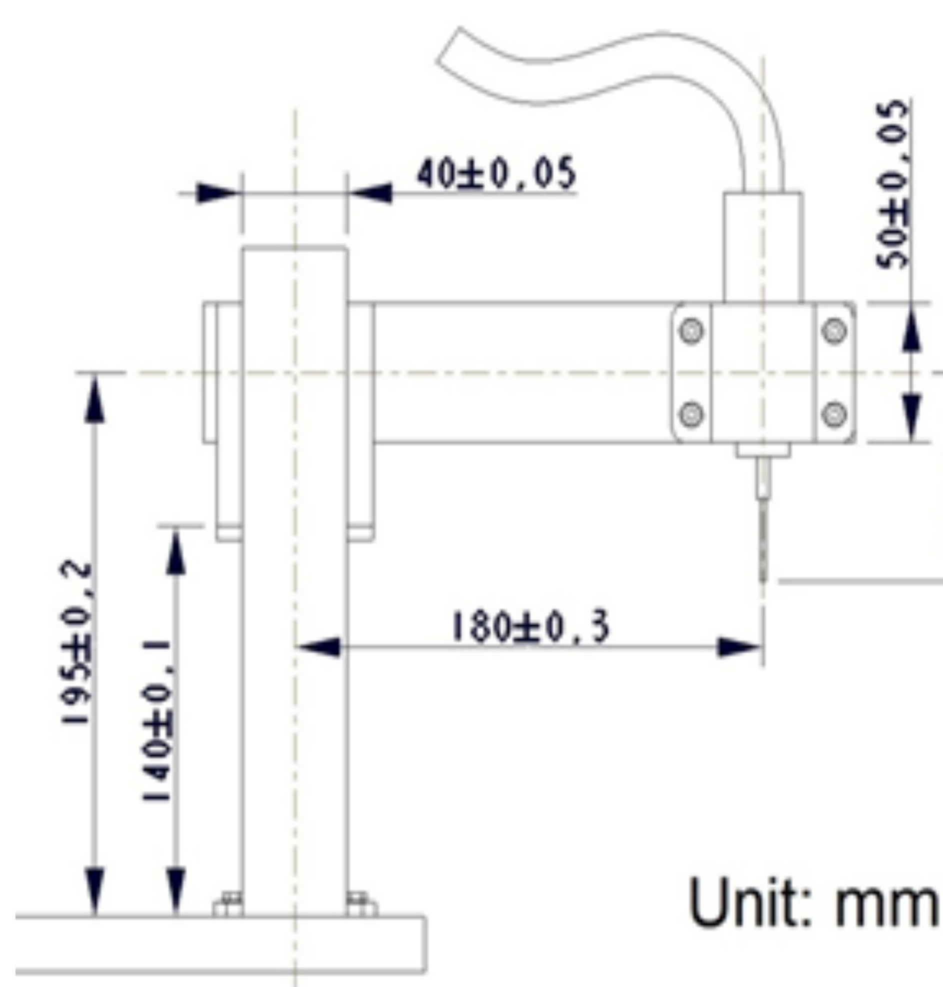

Figure 5

The injector added a load of 50 N on the arm which is made of aluminum alloy. In Figure 6, A represents the positions of 4 bolts; B represents the position of the load. Figure 7 shows the deformation of the arm.

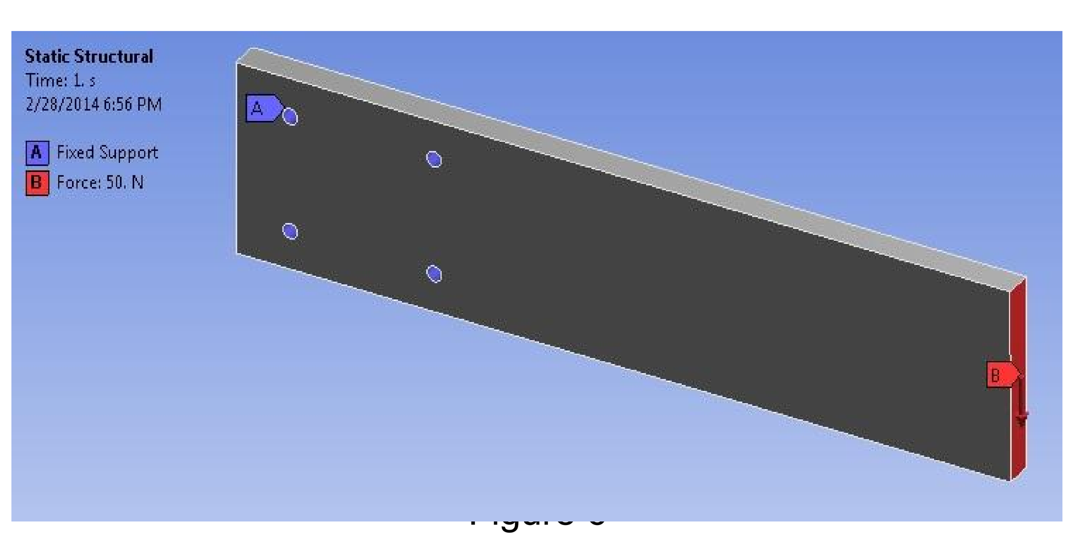

Figure 6

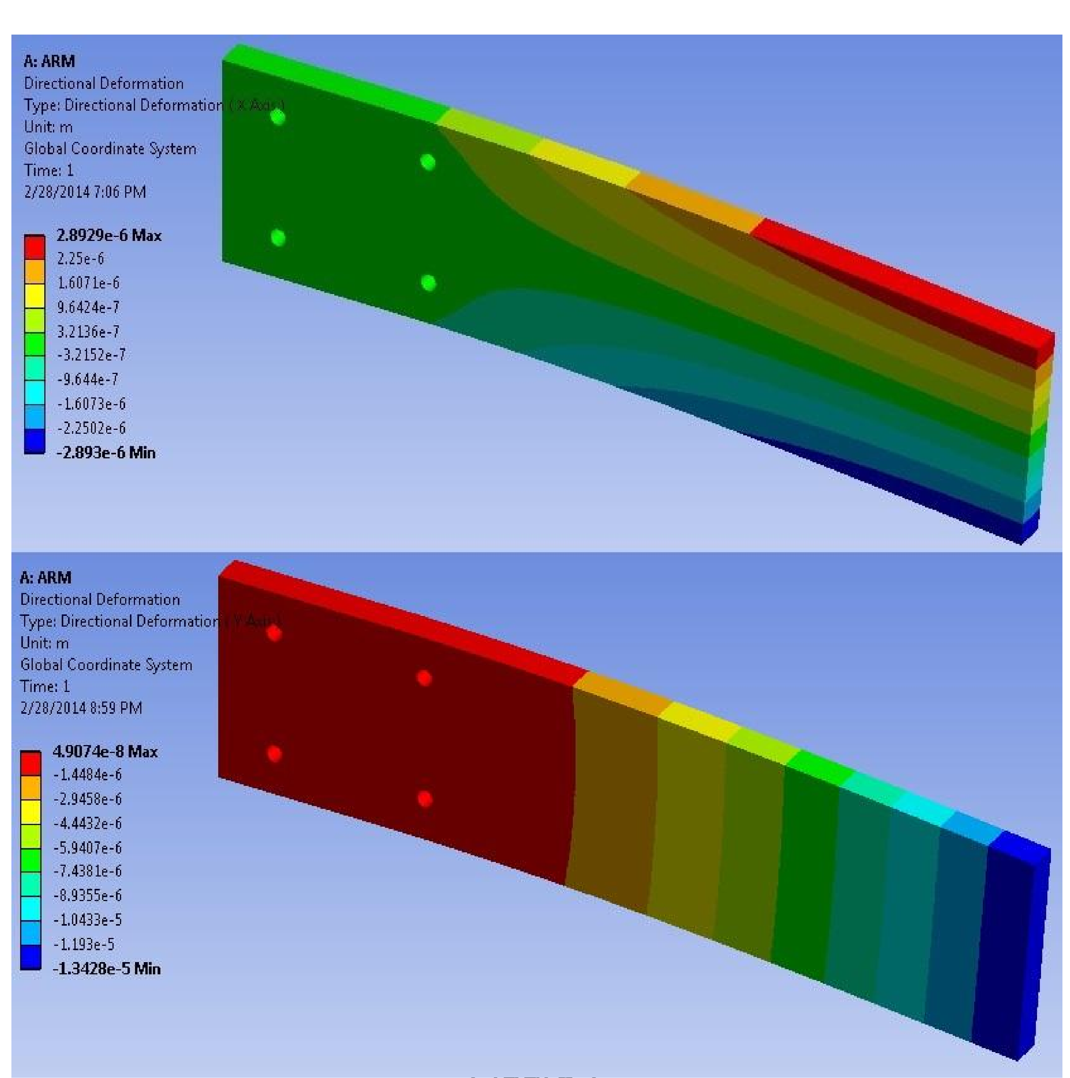

Figure 7

Then, the x-axis displacement of the tip end of the injector based on the deformation of the arm is

$$X_1 = \frac{x_{arm} \cdot l}{\frac{d_{arm}}{2}}$$
$$= -2.893 \times 10^{-6} \times \frac{75}{\frac{50}{2}}$$
$$= -8.679 \times 10^{-6} m = -0.008679 mm,$$

where x_{arm} is the deformation of the bottom edge of the arm on x-axis, d_{arm} is the width of the arm, l is the height from the tip end of the injector to the centerline of the arm. The y-axis displacement is

$$Y_1 = y_{arm} = 1.343 \times 10^{-5} m = -0.01343 mm$$

Since the load of injector is 50 N and the effective length of the arm is 180 mm, the torque of 9 N·m is applied on the column. The material is aluminum alloy as well.

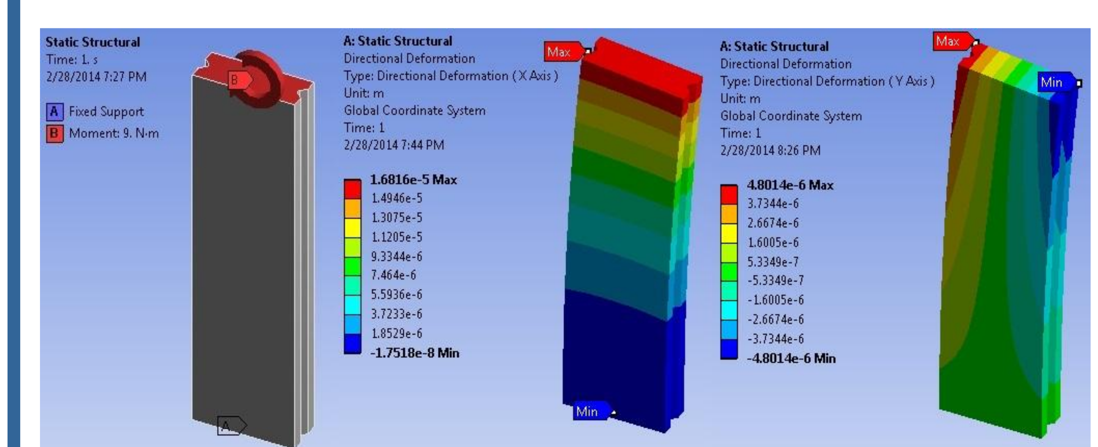

Figure 8

Applying the similar procedure (Figure 8) to the column, the x-axis displacement of the tip end of the injector based on the deformation of the column can be obtained as

$$X_2 = \frac{x_{col}(h_{arm} - l)}{h_{col}}$$
$$= 1.68 \times 10^{-5} \times \frac{195 - 75}{140}$$
$$= 1.44 \times 10^{-5} m = 0.0144 mm,$$

where x_{col} is the deformation of column on x-axis, h_{arm} is the height from the top surface of the base to the centerline of the arm, h_{col} is the height from the top surface of the base to the bottom surface of the slider of the column.

The y-axis displacement of the tip end of the injector based on the deformation of the column is

$$Y_2 = \frac{y_{col} \cdot L}{\frac{d_{col}}{2}}$$
$$= -4.801 \times 10^{-6} \times \frac{180}{\frac{40}{2}}$$
$$= -4.321 \times 10^{-5} m = -0.04321 mm$$

Then, the total displacements on x-axis and y-axis can be obtained as

$$X = X_1 + X_2 = -0.008679 + 0.0144 = 0.00572 mm$$

$$Y = Y_1 + Y_2 = -0.01343 - 0.04321 = -0.05664 mm$$

Conclusion

The result of analysis shows that the deformation of the mechanism is insignificant. How to reduce assembly error is the main problem to improve this mechanism.

Moreover, this method contains the risk of hurting the ball point when loading cartridges into fixtures. Fixing the cartridge in a horizontal way can eliminate the risk. However, the horizontal way will significantly increase the cost of fixture and control system.

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