

# Formulatrix Inspection Test

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### Problem statement

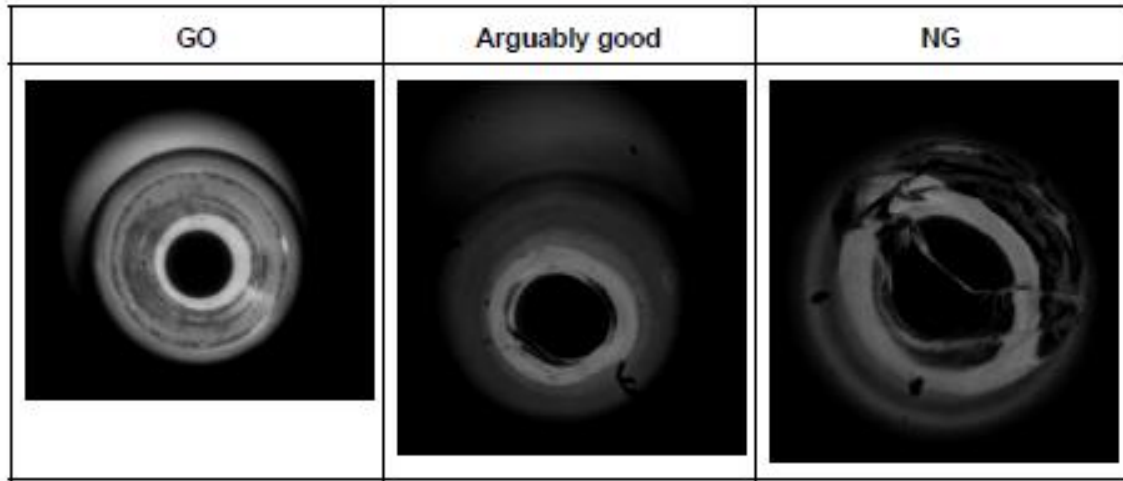
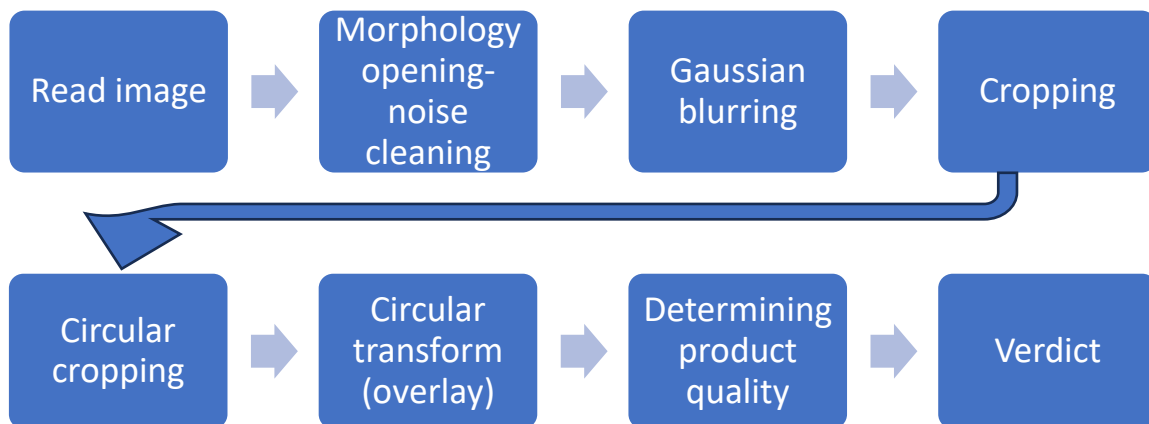


Figure 1 Image sample

From the sample image, I inferred that the problem was asymmetrical end of tip. This may be due to bad shaping (not circular) or some material leak (such as in NG), resulting in (perhaps) bad product. The requirement is to design a program able to check for the shape of the tip (and its end) and judge (with reason) if the tip is good or NG.

### Proposed solution



Looking at the problem, I propose a system mainly to check for circular shape. To do this, I apply Hough Circle Transform on the image, one for the outer circle and one on the inner circle, as well as embossing the image with a circular overlay.

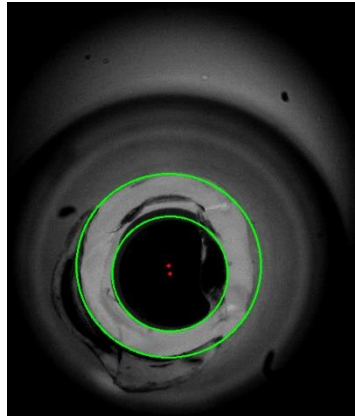


Figure 2 Sample Overlay

However, to augment the image and transformation, I also add some preprocessing to the image, such as morphology opening, blurring, and cropping. This is because most of the images are mostly filled with black (background). Certainly, brightness filtering can also be implemented. However, I refrain from doing so, so that darker images can also be processed. (A more meticulous tuning such as DoG can also be applied).

After the preprocessing, I further check for ratio between the image width and height (circular object means the image can be as close to a square) by applying a lighter hough circle transform (on the outer circle if the image is found to be rectangular. This also serves as the first checking of the tip shape (tip with terrible outer shape is considered NG).

Then, the transformation is applied on the inner and outer circle, based on the size of the cropped image. Then, I calculate for the nearest centroid between detected outer circles and inner circles from the transformation (to check for concentricity). Normally, if the distance between the centroid is higher than 30% of the *estimated* outer circle (cropped image size), the tip is asymmetrical.

Also, in the case of inner circle, I calculate the ratio between pitch black pixels and colored pixels (colored pixels mean obstruction in the injection). As a rule of thumb, if the amount of *estimated* obstruction is higher than 30% of the *estimated* tip end, the tip is defect.

To implement dynamic rigidity, I added a *difficulty* parameter, which defines the transform's sensitivity as well as some other things (closing kernel size and standard for NG and arguably good).

Sample input	Sample output (arguably good/good)
