COLOUR TO COLOUR REGISTRATION ON THE DOT

We often believe that when using measuring equipment, especially digital equipment and computers, that the measurement is absolute. However, measuring equipment can display variation — just like the process evaluated by the measuring equipment. The variation exhibited by the measuring equipment used to measure a specific property must be a magnitude less than the variation for that property of the process being evaluated.

In November 2005, I wrote an article titled: "The affect of printing equipment on colour to colour registration". This article was about the affect of measuring equipment on colour to colour registration. I will now use the measuring of register variation as an example of how the measuring system variation must be accounted for in the process evaluation.

The problem

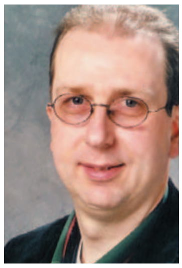
I started this article by explaining that the measuring system has variation and that this can influence the evaluation of the measured process variation. Assuming that the measuring system for collecting colour to colour register data produces a data set and the same applies for the process. In this case we can apply 'normal' statistical analysis.

Using CCD camera

When measuring colour to colour register we mean that we measure the deviation in distance between a reference printed colour and the other individual colours. These are in the print direction and in the cross print direction. Preferably, we do this at a number of positions on the printed image. During testing, I always take six measurements in one printed image — three measurements in the print direction on the operator side and three on the drive side. I then repeat this for at least 10 consecutive images. Therefore, I collect 60 measurement in the print direction and 60 in the cross print direction. All data points are then shown in one graph. This graph will give you an indication of the colour to colour register variation. For the measuring of colour to colour register we can use a CCD camera connected to a computer using "Firewire".

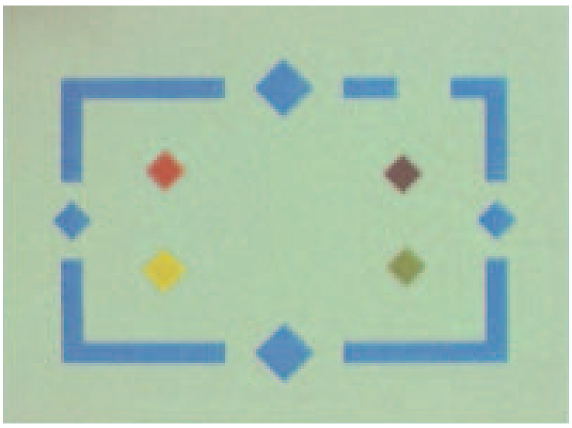
In this example, the colour to colour register element used is presented in Figure 1. The actual size of the image is 44.5 x 33.5 mm. The resolution of the camera used is 640 x 480 pixels. The result is that one pixel is 0.07 mm. Therefore, the resolution of the camera is 0.07 mm per pixel. Remember this might not be totally accurate because of the light source or the gloss interference of the printed surface.

Using clever software allows us to increase the resolution of the measuring system. This is what we used when collecting the data for this report. So what do we do to determine how well the camera is measuring the register? In this case we did four tests using two similar images — one printed on a glossy paper and one on a matt paper. We take



MR STREEFLAND HAS WORKED IN THE CORRUGATED INDUSTRY SINCE 1992. DURING THIS TIME, HE HAS BEEN TECHNOLOGY DEVELOPMENT MANAGER FOR SCA PACKAGING AS WELL AS TECHNICAL MANAGER AT STORK SCREENS. HE STARTED TECHNOLOGY COACHING BVBA IN FEBRUARY 2005.

Figure 1: Register Element



two series of measurements — one holding the camera steady and one series where we move the camera between each measurement. This simulates the moving of the sheet or paper web. However, we are still using the same image so we are looking at a "stable" process. All of this is done for 5 colours.

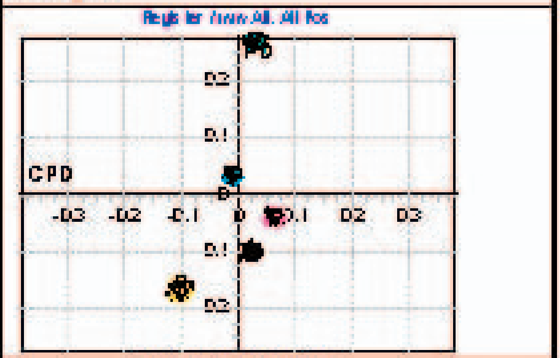
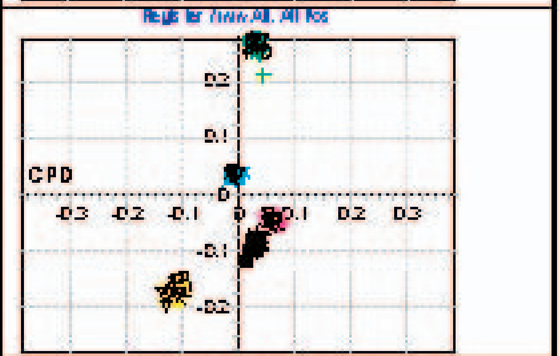
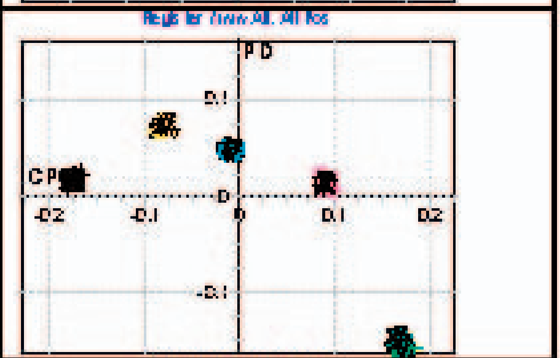
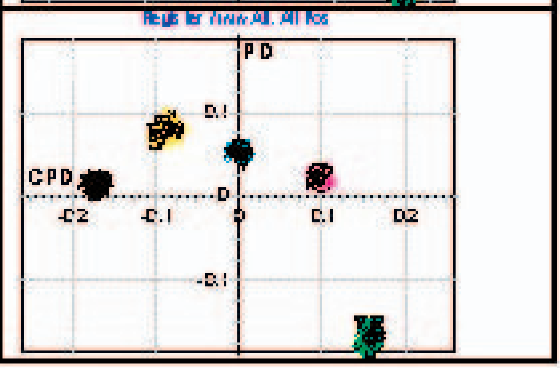
To analyse the data we will calculate the standard deviation of the data collected per colour in the print direction and in the cross print direction. You can calculate the total standard deviation using the following equation:

$$s_{tot} = \sqrt{s_{PD}^2 + s_{CPD}^2}$$

stot = Total Standard deviation
spd = Standard deviation in print direction
scpd = Standard deviation in cross print direction

Test results

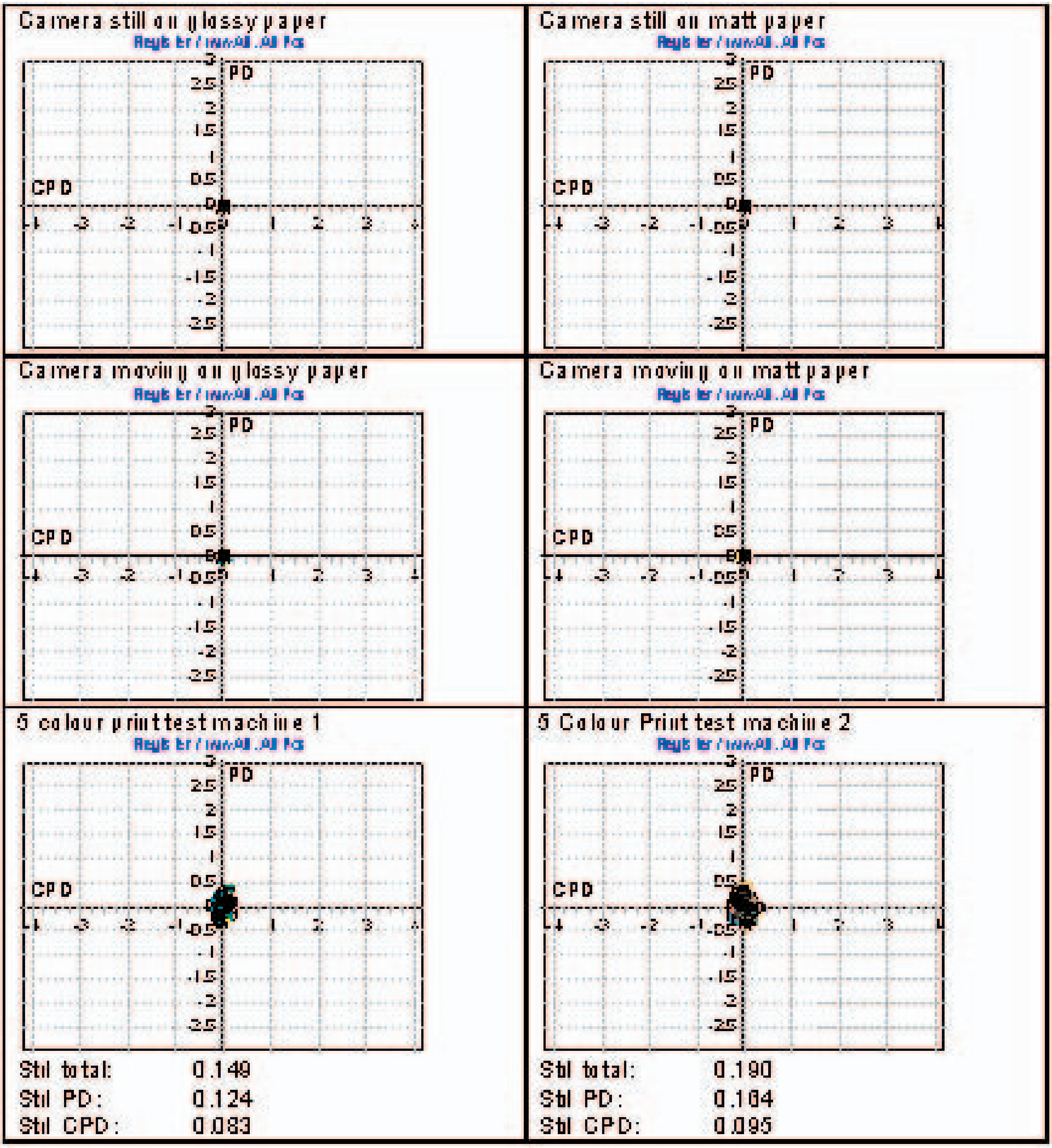
The following table shows the results for the 4 tests done (all values in mm):

Test	Colour	s_{tot}	s_{pd}	s_{cpd}	Image
Camera still on glossy paper	ALL	0.006	0.004	0.005	
	Yellow	0.009	0.005	0.007	
	Magenta	0.006	0.004	0.005	
	Green	0.007	0.004	0.005	
	Cyan	0.005	0.003	0.004	
	Black	0.006	0.004	0.004	
Camera moving on glossy paper	ALL	0.011	0.008	0.007	
	Yellow	0.014	0.010	0.010	
	Magenta	0.009	0.005	0.008	
	Green	0.011	0.009	0.006	
	Cyan	0.007	0.004	0.006	
	Black	0.012	0.009	0.007	
Camera still on matt paper	ALL	0.006	0.004	0.004	
	Yellow	0.006	0.004	0.004	
	Magenta	0.006	0.004	0.004	
	Green	0.007	0.005	0.005	
	Cyan	0.005	0.003	0.004	
	Black	0.006	0.004	0.004	
Camera moving on matt paper	ALL	0.009	0.006	0.007	
	Yellow	0.011	0.007	0.008	
	Magenta	0.008	0.005	0.006	
	Green	0.011	0.009	0.006	
	Cyan	0.008	0.004	0.006	
	Black	0.008	0.006	0.006	

You can see from the results that two different images for the glossy and the matt paper are used. We have not offset the data to the centre so you can see the variation of the individual colours. If you look at the variation data, then you see that there is not a large difference for print and cross print direction. This was expected because we are looking at the capability of the camera and not the printing equipment.

Also notice the scaling difference in the images for the coated and matt paper. This is due to the difference in offset between the colours in the measured images for the glossy and matt paper. The increase in variation when starting to move the camera is also visible.

Let us now compare the images using the same scale (3 x 4mm) with data collected from two print test and the camera data:



The data of the two machines shown was for a corrugated post printer with vacuum transfer and direct drive and an older pre-print machine. This data shows a greater register variation in the print direction than in the cross print direction.

Discussion

The question we need to ask is: Does the measuring variation of the camera have a significant influence on the result of the print tests? Let us first take a closer look at the camera variation. It shows a total variation of 0.011 for the moving camera on a coated surface. If we apply normal statistics, then this means that 99.97 per cent of all measurements are within a radius of 3 x 0.011 = 0.033 mm. Careful! It is 6 sigma, but we only look at half the normal distribution when talking about a radius. The diameter of the circle would be 0.066 mm. This value is very close to the size of one pixel (0.070 mm). We can conclude that the resolution and the error are identical in this case.

The difference in variation found for the two machines compared with the camera variation is 0.149/0.011 = 13.5 for machine 1 and 0.190/0.011 = 17.3 for machine 2. This is large enough to allow us to judge the machines using the camera. The results show that the machines can hold register within a circle with a radius of 0.447 mm and 0.570. But this is not including the mounting of the plates and the adjustments made by the operators. Therefore, what is supplied to the customer will be significantly larger. If the end result is within 1 mm then the completed job is still excellent.

Conclusions and Recommendations

- If you intend to buy equipment for register control on your machine then it is wise to test it independently from the machine it will control. The variation of the controlling equipment might affect the quality of the print if the resolution is inadequate for what you want to achieve in print register.
- Printing equipment is not more stable when installing register controlling equipment. It might result in hunting a moving target. It is not correct to assume that the next image can be corrected in register using the data derived from the previous image printed. You can only correct systematic errors.
- If tests show that your machine is stable in terms of register variation then that is enough. Digital register controlling/measuring equipment might only be useful during set-up and for providing evidence of the quality produced in terms of colour to colour register.

Wilbert Streefland can be contacted at: wilbert@tcbvba.be