GETTING TECHNICAL

In this, the second in a series of technical articles, Mr Wilbert Streefland of Technology Coaching BvbA looks at colour to colour registration.

THE AFFECT OF PRINTING EQUIPMENT ON COLOUR TO COLOUR REGISTRATION

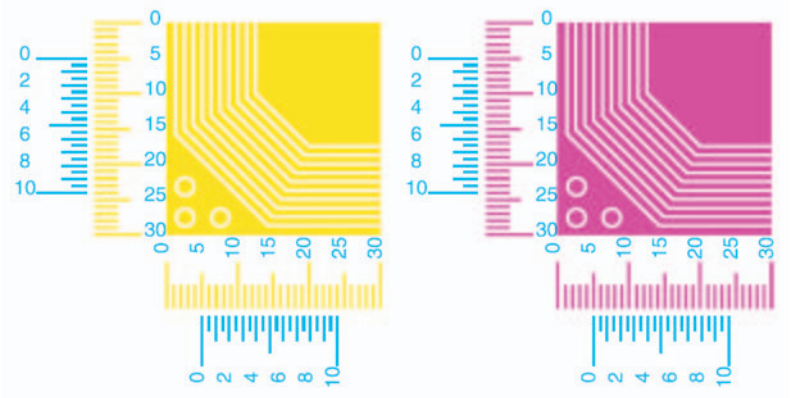
When a customer and boxmaker talk about register, what do they mean? Is it the colour to colour register or the print to structure register? Both are important. The colour to colour register is affected by how the individual print units of a printing machine perform. The second is affected by the interaction between printing and converting.

The reality is that when printers set-up the colour to colour register of their equipment, they mostly check one position on a sample sheet. There is no means of testing if this print is or will be representative of the total production. Also, when using advanced vision systems, the register is mostly checked in one position. Checking in one position means that it is unlikely that the whole print is in register. It might be, for various reasons, that the machine operator can not get the total print in register. Let us have a look at why.

We will start with colour to colour register and first give a definition. Colour to colour registration error is the distance between the printed positions of two separately printed elements that had the same position in the original.

Measurement method

How do we measure colour to colour register in an accurate way? One practical option is to use printed vernier scales on a print test form. Each colour has a vernier scale relative to cyan, in this case the reference colour, for print direction and cross print direction. Below is how it could look for a 3 colour test.



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You can add as many colours as you want, still using just one colour as the reference. The element is positioned at several positions on the print form. The suggestion is to have two measuring positions, one on the operator side and one on the drive side and then diagonal on the print. But first you must do a test to understand more about the machine register variation.

Notice that we measure in nearly the same position in print direction and in cross print direction. The verniers allows us to measure the register with a resolution of 0.025 mm. What is important during production is the colour to colour variation. You need to measure in all positions and measure several sheets. The more the better, but it can get tedious. However, once done, you know the capabilities of your machine in terms of register. Doing this test might explain various problems (for which you didn't have the answer before) that affect your set-up waste figures.

Data analysis

The registration error is a distance between two points. To calculate the distance from the measured data we use the following equation:

$$R_{error} = \sqrt{PD_{error}^2 + CPD_{error}^2}$$

R_{error} = Distance between two positions
PD_{error} = Print direction distance between two positions
CPD_{error} = Cross print direction distance between two positions

To assess the machine capabilities of the first to second colour register we take a number of consecutive sheets at the beginning of a print run and at the end of the run. How many we asses at each sampling point depends on the confidence with which we wish to determine the variability.

In the first analysis of the machine, we should be prepared to do a thorough job of quantifying its capabilities. To do this we must be prepared to make a large number of measurements. We will use a simple, pictorial display of our data to present the variability in which we are interested.

When presented with a large number of measurements which will be recorded on a computer, probably in a spread-sheet, the temptation to use the available statistical summarising functions is almost overwhelming. To begin to understand your printing machine you need to study its performance over the duration of a print run and between individual prints.

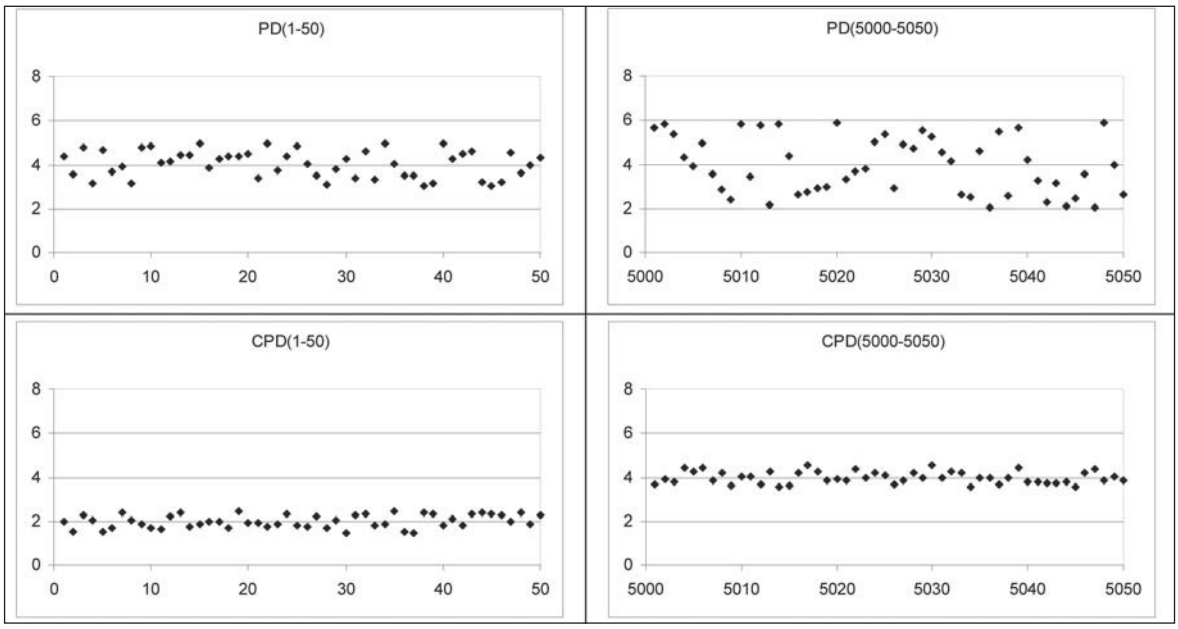
The suggested analysis of data is set-out below in some detail for first to second colour register measured in one position. The first sample measured yields results for PD(1) and CPD(1), the second sample giving PD(2) and CPD(2), etc. If we sample the first 50 prints and the last 50 prints in a run of 5050 prints, we obtain a table of results:

PD(1) and CPD(1) | PD(50) and CPD(50)	Mean PD	Mean CPD
PD(5000) and CPD(5000) | PD(5050) and CPD(5050)	Mean PD	Mean CPD

The first step is to plot this data in print order. We have allowed ourselves one summary statistic to be displayed with all of the data, that is the mean value for the first 50 and the mean for the last 50 prints;

- Visual inspection of our data will show immediately a number of features. In the example presented the PD(0-50) shows the range of values about the mean and the individual values apparently randomly distributed about the mean.
- The PD(5000-5050) shows the range of values to be greater than the PD(0-50) range but the mean is unchanged and individual values are randomly distributed.
- The CPD(0-50) plot shows the range of CPD values to be less than the range of PD values. The CPD(5000-5050) shows the mean CPD value to be less then the CPD(0-50) value but the range to be similar.

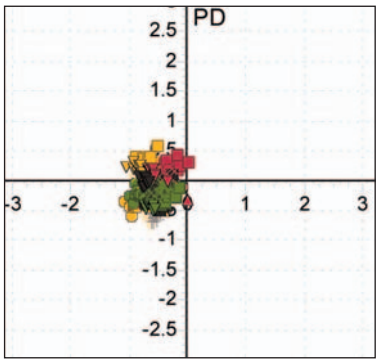
The questions to be asked are obvious. Did the increase in range of PD values happen gradually over the run or was there a sharp change at some point? Did the mean CPD value reduce gradually or was there some point at which it changed?



To answer those questions we need to analyse intermediate samples, but this visual inspection of data shows the importance of not losing the "time" related characteristics in summary statistics. The measured data for all positions and sheets can also be presented as shown in the graph. If the data is collected in a structured way then this will allow for a thorough analysis of the machine.

Factors affecting register

Let's make a list of the elements effecting register:



— The printing plate:
- The film used for making the printing plate
- The mounting of the plates;
- The storage and handling of the plates;

— The substrate. Is it a stable web or sheet or is the sheet warped or are we printing on an unstable web;

— The machine itself:
- The function of the feeder;
- The status of the gear train. (Think of backlash between gears or are we using direct drive motors);
- The diameter of the cylinders in the machine. Is the undercut of the plate cylinder correct in relation to the height (thickness) of the printing plate;
- The TIR of the cylinders or roundness;
- The diameter difference of the cylinder over the cylinder width;
- The alignment of the cylinders.

All these points have an effect on print register but also show other areas that might affect print.

When did you last check your machine? What procedures do you have in place for checking the effect of costly maintenance? Or what do you do when you purchase a multi million euro machine and how to agree on the performance of that machine? The print customer may only complain when the print is not in register. This can be either colour to colour register or print to structure register. What you need to check is if the machine prints in register and if it prints in register on the total product.

Let us have a look at the effect of plate cylinder diameter differences on colour to colour register. In the past I have found many machines that had different plate cylinder diameters. This is often because print stations of different machines where merged together to increase the number of print stations available. The effect of incorrect thickness of printing plates results in the wrong diameter of the plate cylinder. All cylinders in print stations are 'geared' together. This means that the designer of the machine worked with nominal diameters for the individual cylinders and transport rolls which are determined by the pitch-circle diameter of the gears (the number of teeth on the gears and the teeth module) which must be in the required ratio. If all diameters correspond with the design, assuming the designer did not make an error and the meshing gears contact on their pitch circle, then this will result in the velocities on the surface of all rolls being identical. Now imagine if the diameter of one plate cylinder including printing tool is larger then the nominal diameter. The velocity on the surface of that plate cylinder is higher. The result is that this print station prints shorter. It is ready to print the repeat length before the other cylinders and then takes a 'longer break' to start at the same position. Thus at the leading edge it is in register and at the trailing edge it is not. It all gets worse if the gears are not in contact on the pitch circle. In this case, the gears and therefore the cylinders do not rotate at the designed ratio but 'hunt' in speed until the same pair of teeth are again in contact.

Does this happen in reality? It all started after the introduction of foam backing material in the flexo printing industry. The printing plates were made thinner and then compensated for with foam backing which is compressible. When using foam backing, the diameter of the cylinder and the printing plate is also dependent on the impression setting. A high impression results in a smaller than nominal diameter of the plate cylinder including printing plate and thus stretching of the print for this colour occurs. I have noticed this many times and used this to stretch the individual colours by increasing pressure in order to get leading edge and trailing edge of the print in register. I even used it to stretch print so it fitted the die-cut. It does not take a lot of imagination to realise how many boards I was wasting before getting a good result!

Having more options for adjusting also means more waste during set-up and a longer set-up time.

To explain the effect of too large or too small an impression cylinder on register is more difficult. There will be slip. The product printed has to decide whether it follows the speed of the plate cylinder including the printing plate or the impression cylinder. Nominal diameter differences between screen roll and plate cylinder are also common. Screen rolls that are too large and/or plate cylinders that are too small results in the screen roll rotating faster than dictated by the gear train. Due to the fact that there is backlash between the gears, the screen roll will move forward and than be slurred backwards, often resulting in cross print direction strips in full tone areas — better known as gear marks. If it is the other way around, then it will result in a continuous slur and higher driving force of the gear train.

There is also the effect of TIR on register. Total indicated run out will first result in a continuous change of the distance between the cylinders. It can happen that print partially disappears and then returns — this can be a random occurrence in the same position of the print when looking at a number of prints. Often, the operator increases the pressure between the roll and squashes the print to overcome the problem of missing print.

But how does it show in register? Assuming it is just one cylinder that has a high TIR, it means that at the start of one revolution the surface speed can be OK. Then it starts to decrease to a certain point, then it might start to increase to above the nominal speed before going back to the original speed. When the speed is decreasing it is stretching the print relative to the other colours and when it is increasing, it is shrinking the print relative to the other colours. It can happen that leading and trailing edge of the print are in register but in the print direction, in the centre, the register is out. If the TIR is only high on one side of the print then the product might even skew and skew back.

How much difference is needed to see this? The calculation is easy. A 0.1mm difference between nominal plate cylinder diameter and actual plate cylinder diameter will result in 0.314mm register difference in print direction for full repeat length print. Remember that we speak about diameter and not radius. If you ask the flexo plate manufacturer about height differences in printing plates than they talk about 0.2mm. That is the thickness of the plate, thus in diameter of the plate cylinder it is 0.4mm resulting in 1.252mm in full repeat length of the cylinder. That gives concern about constant error, but again it is 2 plate cylinders interacting, thus the error might be twice the indicated value.

So a potential print error of 2mm has been indicated and there is not much the printer can do about it. I have checked hundreds of plate cylinders and found many have a TIR of more than 0.05mm. The above explains that the register error caused between 2 cylinders having a TIR of 0.05 can be 0.314mm. This luckily will show as a systematic error but if the TIR is in the impression cylinder and results in gap variation compressing randomly the foam backing then it all becomes random.

Conclusion:

- Study and understand your press capabilities;
- Keep and update your process capability studies;
- For new press purchases get the supplier to do the study and certify the results as part of the purchase agreement;
- To overcome TIR related problems check the TIR of all cylinders, agree with suppliers about the level you allow and avoid the use of backing material on your printing plates. If you have no TIR and an excellent gap setting in combination with a stable substrate than that resolves mostly your wash boarding;
- Checking and correcting the printing equipment cylinders for TIR and diameter will help to reduce product waste during set-up.

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