

33.3 DOT GAIN

It is customary in the printing industry to quote the sizes of half-tone dots in terms of their areas. Thus, a 50% dot is one that covers half the area of the paper, a 25% dot one that covers a quarter of the area, and so on. But the amount of light absorbed by printed dots is usually greater than that corresponding to the area of the dot on the printing surface. This is known as *dot gain*. There are two forms of dot gain, mechanical and optical. By mechanical dot gain is meant the increase in size of a dot as a result of pressure on the ink during printing; by optical dot gain is meant increased absorption of the light by the ink because of diffusion by the substrate. The effects of dot gain have to be included in setting up printing parameters (see Section 28.15).

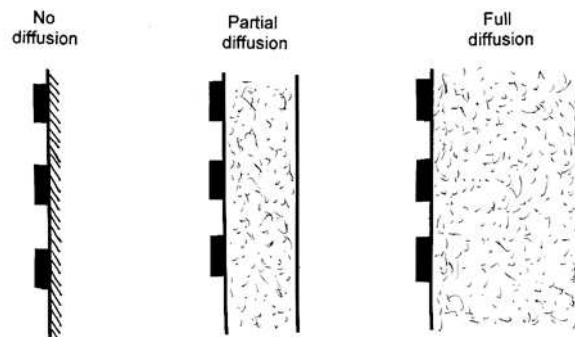


Fig. 33.2. The basis of optical dot gain. On the *left*, dots have been printed on a material, such as metal, in which no diffusion occurs, and the light is attenuated by the dots only once. On the *right*, dots have been printed on a material, such as a fluffy paper, in which complete diffusion occurs, and the light is attenuated by the dots twice, once on entering the paper, and a second time on leaving it. The *centre* diagram represents intermediate amounts of diffusion as occurs in most papers.

The nature and extent of optical dot gain can be seen by considering different amounts of diffusion of the light by the substrate on which the image is printed. In Fig. 33.2 three different amounts of diffusion are illustrated. The left-hand diagram illustrates the case where there is no diffusion; this occurs, for example, when the ink is being printed on to a metal surface such as aluminium (or on to transparent film as in overhead projection slides). The light is not diffused by the substrate at all, and, assuming for the moment that the ink absorbs all the light, the proportion of light reflected (or transmitted) is simply equal to $1 - A/100$, where A is the percentage dot size. Thus if A is equal to 50%, then half the light will be reflected; if A is equal to 75%, then 25% of the light will be reflected. The corresponding density is then given by:

$$D = \log\{1/[1 - (A/100)]\}$$

The right-hand diagram of Fig. 33.2 illustrates the case where there is complete diffusion; this might occur if the ink were printed on to a very fluffy paper. In this case, the incident light passes through the dot structure into the substrate, where it is diffused and then reflected to pass through the dot structure a second time. The double pass through the dot structure results in the density being double that for the no diffusion case, so that the density, D' , is given by:

$$D' = 2D$$

For typical papers used in the printing industry the amount of diffusion is intermediate between these two cases, represented by the centre diagram of Fig. 33.2, and the density, D' , must then be represented by a more complicated formula, one example of which is the Yule-Nielson equation (Yule and Nielson, 1951):

$$D' = n \log \{1/[1 - (A/100)(1 - 10^{-d/n})]\}$$

where n is a factor that depends on the amount of diffusion in the substrate, and d is the solid ink density (that is, the density of the ink when it completely covers the paper); n is equal to 1 if there is no diffusion, but increases to values up to about 3 for very high diffusion.

In Fig. 33.3, density is plotted against % dot area for the cases of no diffusion, D , complete diffusion, D'' , and a typical practical amount of intermediate diffusion (Yule, 1967) such as occurs with paper, D' ; in all cases it is assumed that the solid ink density is 1.52 (corresponding to a reflectance factor of 3%). Also plotted in Fig. 33.3 is the comparable relationship between the CIE approximately uniform correlate of lightness, L^* , and density; the L^* scale is set so that 100 is at 0% dot area, and 20 is at 100% dot area, because $L^* = 20.04$ for a reflectance factor of 3%. It is clear from the figure that the L^* values lie between those for D'' and D' , but well away from those for D . This indicates that if no diffusion occurs the relationship between dot area and lightness is very non-uniform, lightness varying much more rapidly with dot area with large dots than with small dots. But, for the practical case of printing on paper, the relationship is more nearly uniform. If the D' curve had been exactly the same as the L^* curve, then only 90 dot sizes uniformly spaced along the dot area axis would have been necessary; but because the D' curve is not quite the same as the L^* curve, the number of dot sizes has to be increased to about 100. This means that, instead of being able to form half-tone dots in an 9×10 array of micro-dots, it is necessary to use an array of 10×10 micro-dots, as shown in Fig. 33.4.

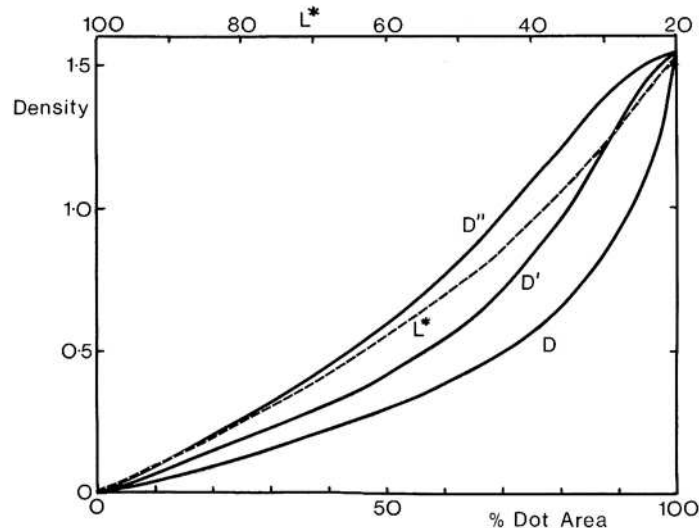


Fig. 33.3. Density is plotted against per cent dot area, for a solid ink density of 1.52, for: D , no diffusion; D'' , complete diffusion; and D' , partial diffusion typical for paper. The broken curve shows the relationship between L^* and density, with a uniform scale of L^* set with $L^* = 100$ at zero dot area, and $L^* = 20$ at 100% dot area (L^* has this value for a density of 1.52).