13. Coupling, Choice of Probe and Measuring Frequency

13.1 Condition and Preparation of Surface

In any ultrasonic test the shape and roughness of the surface is of decisive importance. On the one hand these factors often limit the sensitivity of the method applied, making it necessary to first prepare the surface. On the other they have a decisive influence on the wear of the probe used for continuous and routine tests if in direct contact with the specimen. The surface conditions, therefore, greatly influence the economics of testing.

All methods make uniform surface conditions desirable for reliable flaw evaluation. In the case of direct contact where the probe is pressed against the specimen covered by a thin film of coupling liquid, foreign particles or layers are very disturbing because they can considerably vary the thickness of the liquid film, and thus its transmission between different test points (Fig. 1.17). It is therefore absolutely necessary to remove any dirt, loose scale and sand, for which rags, cotton waste and steel brushes are required. Often it is more effective to use a scraper, particularly in the case of loosely adhering layers of rust or paint which form air gaps with the base, which may completely prevent the penetration of sound. In some cases a hammer or grinder may be used, preferably a rotating emery disc with flexible backing which adapts itself to the surface to be treated. Care must be exercised when using rotating grinding wheels to prevent the creation of slightly concave spots, resulting in bad or erratic coupling. If large surfaces have to be treated, as in the case of automated testing, blasting with sand or steel pellets gives best results.

Uniformly and strongly adhering films such as thin oxide layers or even paint, may not necessarily interfere and are often preferable to an unevenly cleaned surface.

Where the surface can be dressed mechanically, it is more important to obtain a uniformly curved shape than high surface quality with an irregular contour. High surface quality is less important for the commonly used frequencies because a surface roughness of less than approx. 1/10
wave length, i.e. of the order of 0.1 mm or less, contributes only relatively little to an increase in sensitivity. On the contrary, polished flat surfaces are often awkward to test because the probes stick due to suction and, therefore, cannot be slid along easily. Furthermore, the echo attains its maximum value on such surfaces slowly only, viz. after the liquid has escaped from the narrow coupling gap. In the case of contact tests on test blocks a planed surface is therefore preferable in view of the better reproducibility of the echoes.

A roughness of more than 1/10 wave length difference in height impairs the coupling markedly. The acoustic pressure in axial direction is reduced and greater lateral scatter occurs. This also impairs the beaming accuracy and increases the risk of lateral reflections simulating flaws along the axis. Roughness of a uniform pattern, such as turning grooves, can strongly amplify the lateral radiation at certain angles, like an optical grating, resulting likewise in possible locating errors. Finally, very rough surfaces act on the sound beam like frosted glass on light: the beam becomes diffused and is scattered in all directions, making position fixing impossible.

In the case of irregular, uneven surfaces, e.g. with ripples as large as the probe, the coupling layer affects the ultrasonic beam very detrimentally: it is deflected irregularly from the normal and is focussed or defocussed. It is then pure chance to accidentally find a spot where the beam is still sufficiently undistorted to reach a given flaw. A similar effect can be produced, however, also by the material itself due to locally varying acoustic velocities, e.g. in grey cast iron. In such cases a method might be applied in which a given spot in the test piece is irradiated successively along many different beam paths and from different surface points: this would require that the probe changes its incident beaming direction when changing the coupling point, so as not to lose the target. The statistically distributed, favourable couplings then should make an individual flaw conspicuous against the interfering background. Some clever operators already make use of similar practices without the aid of mechanical devices: the probe, particularly if using an elastic protective layer and a liberal supply of couplant, can be simultaneously shifted and slightly tilted: if during this procedure occasionally an echo suddenly appears indicating a flaw the surface may be improved for a more accurate test.

13.2 Curved Surfaces

Most test surfaces are cylindrical, and of these convex surfaces are better for contact making than concave surfaces. On a convex, cylindrical surface the commonly used flat probe has a reduced contact face in the