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HIGH-PRESSURE METAL FORMING

The use of extraordinarily high pressures offers a new approach to metal-forming problems.

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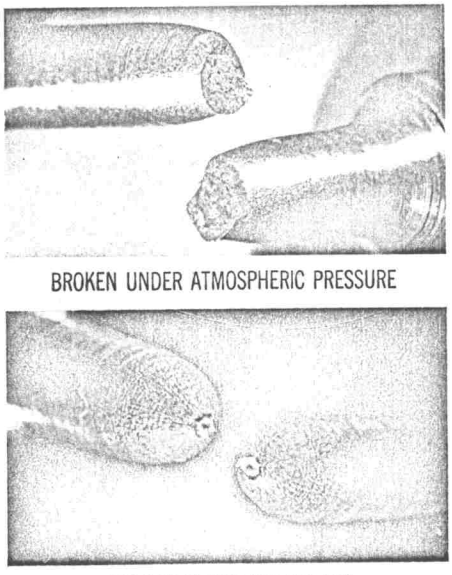
ABSTRACT

It has long been known that in an environment of very high pressure the ductility of most metals increases dramatically. In the past little practical use has been made of this remarkable phenomenon; however, recent developments today indicate that the forming and working of metals under high environmental pressures will soon become an industrial process of considerable importance. Specifically a pressure vessel capable of repeatedly generating fluid pressures up to 500,000 psi has been constructed, and economical techniques have been developed for using high pressures to perform extrusion, tube expansion, deep drawing, tube flanging, and cutting operations. With the completion of current research an essentially new approach to metal-forming problems will be made available to the materials engineer.

THE WESTERN ELECTRIC Engineering Research Center is currently exploring the nature of high-pressure metal forming. The work, which was undertaken in search of techniques for exploiting this comparatively new process in regular manufacture, is still in its early stages, but the results to date have been gratifying. By the use of high-pressure techniques, ways have been found to make metal parts of improved quality at reduced cost. Similarly, complex parts have been made in a single operation in cases in which several operations were previously required.

Although in one sense all metal forming involves the use of high pressures (because high contact forces are needed to move the material plastically), high-pressure metal forming is characterized by the use of high forces to alter the basic formability of the material. As described in the BACKGROUND on page 30, the fact that such alteration is possible has long been known as a laboratory phenomenon; however, until recently this phenomenon has not been developed as an industrial process. Now as a result of recent developments high-pressure forming includes a variety of processes that are designed to take advantage of the changes that occur in metals when they are subjected to enormous pressures.



BROKEN UNDER ATMOSPHERIC PRESSURE

BROKEN UNDER 150,000 PSI

Figure 1. Increase in the ductility of steel under large hydrostatic pressure.

PROPERTIES OF METALS UNDER PRESSURE

Of such changes the most dramatic is an increase in the ductility of the metal. As shown in the upper half of Figure 1, under normal atmospheric pressure a rod of 1112 steel pulled laterally in a test of tensile strength is subject to a certain degree of deformation before breakage occurs. As shown in the lower half of the same illustration, however, in an environment pressurized (hydraulically) to 150,000 pounds per square inch an identical rod tested in the same fashion is deformed to a much greater extent before breakage occurs.[1]

The degree of deformation, or the measure of ductility, can be taken to be the ratio of the original cross-sectional area of the rod to the area of the neck of the deformed specimen. As shown in Table I, the increase in ductility so measured varies considerably with both the kind of metal and the pressure employed; however, in particular cases such as that of copper and certain types of steel the increase in ductility can be remarkable.

At the same time the metal is not softened in any sense of the word; in fact, metal deformed under pressure can become harder and stronger than is usually the case. Again, as shown in Table I, the true stress at fracture in the test previously described is much higher under conditions of high pres-

[1] The illustration pictures a ¼-inch tensile specimen pulled at the Western Electric Engineering Research Center in 1964.