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VIBRATIONAL WORKING OF METAL

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One of the problems in plastic metal working is to get uniform deformation, with a consequent increase of ductility and improvement in the quality of the worked metal. The author has studied the effect of vibration on the upsetting of cylinders of certain aluminum alloys between flat ground plates at room temperature. The vibrating system in the machine weighed 1. 2 m. tons (1. 3 N. T), the vibration frequency was 37 cps with an amplitude of up to 1 mm. (0. 04 in).

It was found that vibratory loading consisting in the application of comparatively weak blows at a reasonable frequency produced quite a different deformation pattern from that caused by a "static" force. The enhanced plasticity of the metal, with a reduction of the specific deformation pressure, shows the benefit of vibrational working of the alloys studied. It was found that the intragranular stresses were lower in the vibrationally worked, than in the statically worked metal. Thus for the same reduction, vibrational working strain hardens the metal less than static loading.

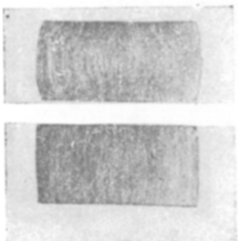

Fig. 1. Longitudinal macrosections of statically (upper) and vibrationally (lower) upset specimens

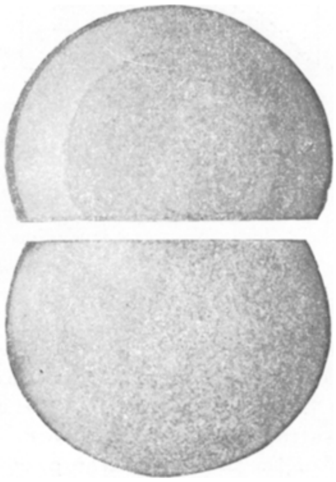

Fig. 2. Transverse macrosections of specimens similar to those in Fig. 1.

Fig. 1 shows longitudinal macrosections through specimens of the aluminum alloy AMtsM upset 45%. The upper specimen was compressed on a hydraulic press, the lower one on a vibrating machine. The structure of the upper specimen is the usual; the fibers are distorted, and there is a distinct "shearing cross" dividing the specimen into parts deformed to different extents. In the vibrationally worked specimens, inhomogeneous deformation is practically absent. The transverse macrosections in Fig. 2 of similar specimens, upset by 65%, show also that the vibrationally worked specimen is the more uniform.

This great uniformity in vibrational working explains the smaller degree of barreling which this treatment causes.

To get more precise information, the diameters of the ends and "barrels" of a series of specimens of lead and AMtsM, were measured after different reductions of height to find the differences in the change in shape under static and vibrational loadings. Fig. 3 shows the results: Curves 2 and 4 were obtained under static, and Curves 1 and 3 under vibrational, loading. There is considerably less barreling of vibrationally worked specimens, than in those subjected to a static load, up to 70% reduction. The contact friction between specimen and tool is evidently much lower in vibrational than ordinary forming.

There are no maxima on the vibrational curves we obtained. It is reported [1] that in static upsetting, there is a bend on the curve at 45-50% reduction because of a change in the nature of the contact friction: "plastic slip" on the ends commences. Presumably there is no change in the nature of the friction during vibrational working. This explains the absence of two end zones on the flat surfaces of the specimens, which can be clearly seen on the end surfaces of those exposed to a static load. Micrographs of vibrationally worked specimens also show them to have a more uniform structure than the static specimens. Evidently, under vibrational working, there is a lower contact friction between tool and specimen, this increasing the uniformity of deformation throughout the specimen.

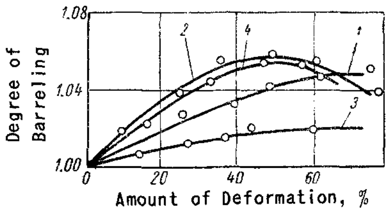

Fig. 3. Effect of form of loading on the barreling of specimens of: 1 and 2 = AMtsM; 3 and 4 = lead.

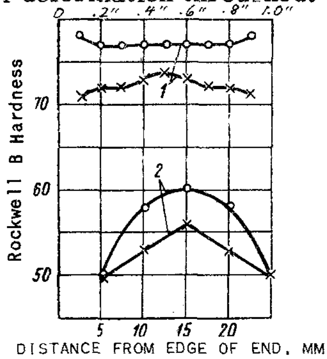

Fig. 4. Distribution of hardness across end faces of upset specimens. 1=AMtsM, 70% reduction (60 kg load); 2=D16M, 60% reduction (100 kg load); circles=static, crosses=vibrational, loading.

Fig. 4 shows the variation in hardness across the end faces of the specimens of alloys D16M and AMtsM. The surface hardness of the vibrationally worked specimens is lower than that of the static specimens, and the variation of hardness across the diameter is lower. Transverse measurements of hardness on specimens of these alloys also prove that there is a more uniform distribution of hardness within the vibrationally worked specimens.

CONCLUSIONS

Vibrational working (upsetting) produces a more uniform structure and hardness distribution within the reduced specimen than static loading. This is apparently the main reason for the better forming properties of metals in vibrational working. The strain hardening of the end surfaces of the vibrated specimens is less than that of those subjected to a static load [for the same reduction].

Reference

1 L. I. Zhivov, Machines and Methods of Plastic Metalworking, Collected Papers from the Moscow (Bauman) Higher Technical College, Mashgiz, 1952.