ABSTRACT: There is disclosed apparatus for treating metal parts by immersing the parts in a media of granular material and coupling the parts and the material to an elastic member that is vibrated resonantly. The parts to be cleaned are coupled by means of selectively compliant means to an elastic member in order to reduce stresses on the elastic member, to reduce the impedance, and enhance the power throughput ability of the system.
RESONANT APPARATUS FOR CLEANING CASTINGS AND THE LIKE

BACKGROUND OF THE INVENTION

It has been recently discovered that industrial parts such as castings and forgings can be rapidly and effectively cleaned, deburred, and polished by vibrating the parts at a high frequency in a cleaning media. One of the most effective systems developed for this purpose is a system in which vibrations from a sonic oscillator are transmitted by means of an elastic resonant transmission means to a part immersed in a granular cleaning media. Such a system is disclosed, for example, in U.S. Pat. No. 3,380,195, issued Apr. 30, 1968 to Mr. A. G. Bodine, Jr. The term “sonic” as used herein refers primarily to the transmission of energy by means of elastic waves through an elastic medium, whether or not at a sonic, ultrasonic or subsonic frequency. These systems are preferably designed to operate at a resonant frequency in order to obtain maximum efficiency.

A preferred form of cleaning apparatus is a form in which the present invention is directed. This form comprises a system which includes an elongated elastic member having an oscillator acoustically coupled to its midpoint and a plurality of work stations established at the outer ends of the elastic member. These stations are positioned to take advantage of the maximum amplitudes of velocity and acceleration generated by the system. This system also permits the use of a plurality of independent work stations as well as permitting the oscillator to more readily deliver its maximum power.

A work piece must be spaced a sufficient distance from the elastic bar to permit the work piece to be totally immersed in a body of cleaning media. In the case where a laterally vibrating elastic bar is used for the transmission means, this means that an extension must extend outward from the bar in a direction transverse to its longitudinal axis. This presents a problem in coupling the workpiece to the resonant bar. The coupling means must be light so as not to store too much energy and yet must be strong enough to withstand the stresses imposed by the system. In the past the workpiece has been coupled to the bar by means of a rigid arm extending downward from the resonant member the required distance. This arrangement, however, resulted in tremendous stresses being built up in the arms and a rapid failure therein. This arrangement also causes the system to act as a tuning fork because the extended moment arm and masses causes the nodes to shift toward the center of the bar. This causes the center of the bar to become a very high impedance point or area, and consequently considerably reducing the power that can be transmitted from the oscillator through the system to the work piece. Accordingly it is the primary object of the present invention to overcome the above problems in the prior art systems.

It is a further object of the present invention to provide an improved parts cleaning system having compliant coupling means.

SUMMARY OF THE INVENTION

The above and other objects of the present invention are carried out by providing a resonant parts-cleaning system having selectively compliant coupling means for coupling parts to be cleaned to the resonant transmission means of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation partially in section of a preferred embodiment of the present invention;

FIG. 2 is a side elevation partially in section of a second embodiment of the present invention;

FIG. 3 is a side elevation of a portion of the system of the present invention;

FIG. 4 is an alternate embodiment of a portion of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and more particularly to FIG. 1 there is illustrated a preferred arrangement of the system of the present invention. Numerical 11 generally designates an elongated elastic bar which is suitably supported by means (not shown) at nodal areas 12 and 13 that occur when the bar is resonantly vibrating in its lateral mode of vibration as illustrated by the wave pattern designated by lines 14 and 15. A suitable oscillator 16, which may be of any well-known type, is operatively coupled to the bar 11 substantially in the center thereof. A plurality of work stations 17 and 18 are laterally offset from oscillator 16 and preferably established adjacent the outer ends of the elastic bar or member 11. Each work station is provided with compliant coupling means comprising compliant members 19 and 20 and clamping means 21 and 22 for operatively coupling parts or work pieces 23 and 24 to the elastic transmission means 11 of this system. The clamping means at each station 19, 21, and 20, 22 extends outward from the longitudinal axis of the elastic bar 31 at the central axis thereof to enable the total immersion of parts or work pieces 23 and 24 in bodies of polishing media 25 and 26 which are suitably contained in containers 27 and 28. The compliant coupling means 19 and 20 are structured and dimensioned so as to reduce or substantially filter out on the order of two-thirds of the lateral forces imposed on the work pieces 23 and 24. The relative direction and magnitudes of the forces imposed on the work members or work pieces 23 and 24 are illustrated by the vector diagrams, FIGS. 1a and 1b.

Illustrated in FIG. 2 is a second embodiment of the present invention in which an elongated elastic member 31, supported at nodal areas 32 and 33, is shown in an exaggerated position of maximum displacement. An oscillator 34 is operatively coupled at substantially the center of the elastic member 31 between nodal areas 32 and 33 and adapted to drive the resonant member 31 at the resonant frequency in a lateral mode of vibration. A plurality of work stations 35 and 36 is illustrated as being at the outer most ends of member 31. Compliant coupling means 37 and 38 operatively couple work pieces or parts 39 and 40 to elastic transmission means 31 at the work station 35 and 36. The compliant coupling means 37 and 38 is preferably coupled to the elastic bar 31 at the central axis thereof 41 and 42. The parts 39 and 40 to be cleaned are immersed in a body of cleaning media 43 and 44 contained respectively in containers 45 and 46. In FIG. 3 is illustrated an alternate embodiment of the elastic compliant coupling means in which an elastic bar 49 is coupled by the elastic coupling means 50 to suitable clamping means 51 which is coupled to the work piece, not shown. Compliant coupling means 50 may be adjusted in the illustrated embodiment such as by altering the number of leaf springs 52 through 55 coupled thereto in any suitable manner such as by means of a clamp 56. The embodiment of FIG. 4 illustrates an elastic member 59 which is coupled through elastic means 60 to a suitable clamp means 61 which is operatively coupled to a workpiece, not shown. Compliant means 60 comprises hinge means which includes a pair of relatively movable members 62 and 63 pinned together by an adjustable pin or bolt 64 which may be adjusted to adjust the friction between cooperative surfaces on members 62 and 63.

Thus from the above description it can be seen that I have described and disclosed an apparatus for cleaning parts including a body of cleaning media in which the parts to be cleaned can be totally immersed, an oscillator, an elastic vibration transmission means operatively coupled to the said oscillator and a plurality of work stations laterally offset from said oscillator including clamping means extending from said transmission means for coupling a part to be immersed in said media to be cleaned, with the improvement comprising compliant means coupling each of said clamp means to said transmission means at each of said work stations, said compliant means structurally dimensioned to reduce the accelerating forces imposed on said part by said transmission means in the
plane of movement parallel to the longitudinal axis thereof while permitting maximum acceleration forces in a plane transverse to said longitudinal axis.

We claim as our invention:

1. In an apparatus for cleaning parts, said apparatus comprising: a body of cleaning media of a size such that a part to be cleaned can be totally immersed; an oscillator; an elastic resonant vibration transmission means operatively coupled to said oscillator; and, a plurality of work stations laterally offset from said oscillator including a clamp means at each of said work stations extending from said transmission means for coupling to a part to be immersed in said media to be cleaned; the improvement comprising compliant coupling means operatively coupling each of said clamp means to said transmission means at said work stations; and, said compliant means being structurally dimensioned to reduce the accelerating forces imposed on said part by said transmission means in the plane of movement parallel to the longitudinal axis thereof while permitting maximum acceleration forces in a plane transverse to said longitudinal axis.

2. The apparatus of claim 1 including adjusting means operatively associated with said compliant means to adjust the compliance thereof.

3. The apparatus of claim 2 wherein said compliant means includes a composite leaf spring wherein said compliance may be adjusted by varying the number of leaves in said spring.

4. The apparatus of claim 2 wherein said compliant means comprises:
   hinge means including a pair of relatively movable members and adjustable friction means therebetween.

5. In a resonant apparatus for cleaning parts, said apparatus comprising:
   an elongated elastic member supported for resonant elastic vibrations transverse to the longitudinal axis thereof; an oscillator operatively coupled to said elastic member substantially in the center thereof and operative to apply periodic transverse forces thereto at a frequency and magnitude to establish resonant vibrations therein; a plurality of work stations spaced at selected positions laterally from said oscillator along said elastic member adjacent the outer ends thereof, and said work stations including clamp means depending therefrom and adapted to hold a workpiece; and,
   a body of granular cleaning media positioned adjacent said work stations and adapted to receive said workpieces;
   the improvement comprising compliant coupling means operatively coupling said clamp means to said elastic member at said work stations; said compliant means being operative to permit maximum transfer of forces from said elastic member to said work piece along a line normal to the longitudinal axis of said elastic member, and to substantially reduce said force transferred thereto along a line substantially parallel to said longitudinal axis.

6. The apparatus of claim 5 including adjusting means operatively associated with said compliant means to adjust the compliance thereof.

7. The apparatus of claim 6 wherein said compliant means includes a composite leaf spring wherein said compliance may be adjusted by varying the number of leaves in said spring.

8. The apparatus of claim 6 wherein said compliant means comprises: hinge means including adjustable friction means.