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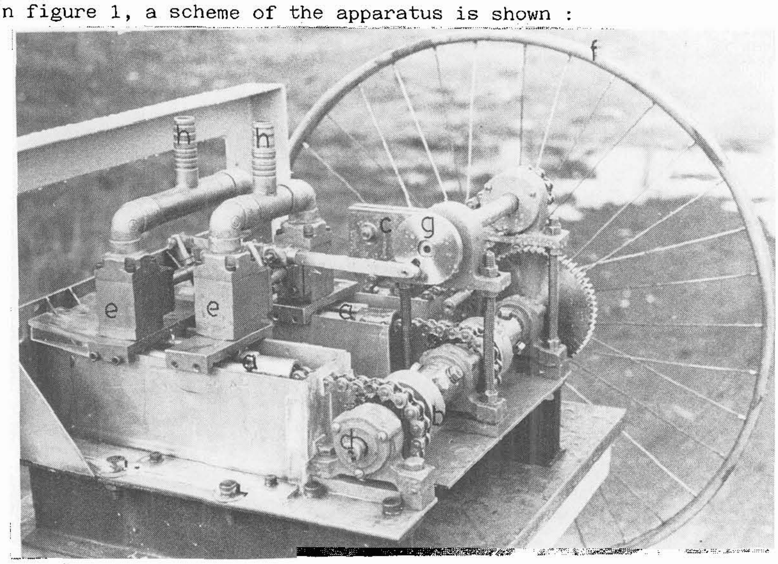
Several heat engines which use the shape memory properties associated with the martensitic transformation in NiTi and Cu base alloys have already been developed (1-5). Their advantage is that thermal energy with only small differences between the cold and warm reservoirs can be converted into mechanical energy. Generally, polycrystals are used which, due to their large shape changes, are prone to fatigue failure. In this work a machine is presented and described by a movie film, which uses single crystal rods of CuZnAl alloys, which are quite easy to prepare.

The prototype is based on :

a) two thermodriving elements fabricated with a CuZnAl alloy in a rod shape of about 300 mm length and 6 mm diameter, which have been grow into a single crystal structure.
b) a cluth system with an angular movement free in onne direction, which converts the axial movement of the thermodriving elements into a rotational one on a principal axis.
c) a multiplier of the angular velocity (~ x 100).
d) a principal axis with low angular velocity.
e) a four valve distribution system for cold and hot water.
f) a flywheel.
g) secondary transmission movement elements.
h) tubes for distribution and recuperation of water.

In figure 1, a scheme of the apparatus is shown :



Each thermodriving element (rod) is stress assisted transformed into the martensite phase at room temperature, by means of a spring which apply a force through a chain on the free end of the rod, while the other end is fixed. The spring is stretched with a regulating screw on the other end.

The axial movement of the thermodriving elements which occurs during the transformation-retransformation cycle, is converted into a rotational one by means of the clutch system which is mounted on a principal axis.

A typical frequency for the cycle, is about 15 times/minute, leading to an angular velocity of the principal axis of 2 turns/minute. The resultant angular momentum is too low for self-maintaining the movement (instead with only two rods). Using a multiplier of the angular velocity (~ x 100) which connects to a flywheel, the necessary angular momentum is attained.

The transformation-retransformation cycle, is obtained by periodically spraying the rods with hot and cold water. The hot water which comes through one tube divides into two branches, where a valve existing on each one regulates the stages of on-off "wetting" the rods. The same holds for the cold water, which is distributed by other two branches with the corresponding valves. The valves are driven by means of transmission elements moved by a secondary axis connected to the multiplier, which with an adequate angular velocity produce the opening and closing of the valves.

The described prototype, can generate a maximum mechanical energy of about 70 watts, at an angular velocity on the flywheel of 200 rpm. It is possible to increase the output power, by setting into parallel or in series another thermodriving elements. In the first case, there is a linear increase of power because of an increase in the force if the rod actuates on the same clutch or of an added mechanical work on the main axis due to a new rod. In the second case, the displacement of the rod increases linearly with the rod length and consequently the mechanical work.

The output power, can be optimized varying the rod diameter. Thick rods will give higher forces but low frequency, while the opposite is valid for thin rods. An adequate balance, together with considerations of mechanical behaviour of the CuZnAl single crystals rods under fatigue and heat transmission will lead to the best choice.

The lifetime of the rods have reached in some cases up to 150 hours, which corresponds to approximately $1{,}35 \times 10^4$ cycles. In other rods, failure fracture accomplishes from after ~ 10 hours of working. The big dispersion is studied in connection with single crystal fabrication process and ageing effects of the material.

An advantage of this design, is that the rods work under tension stress which enables the use of all the cross section and external force produced in the retransformation stage (this force produces the mechanical work on the machine), likewise the maximum displacement involved in the cycle. In other designs, thermodriving elements are hold into more complex deformation modes like torsion or bending.

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