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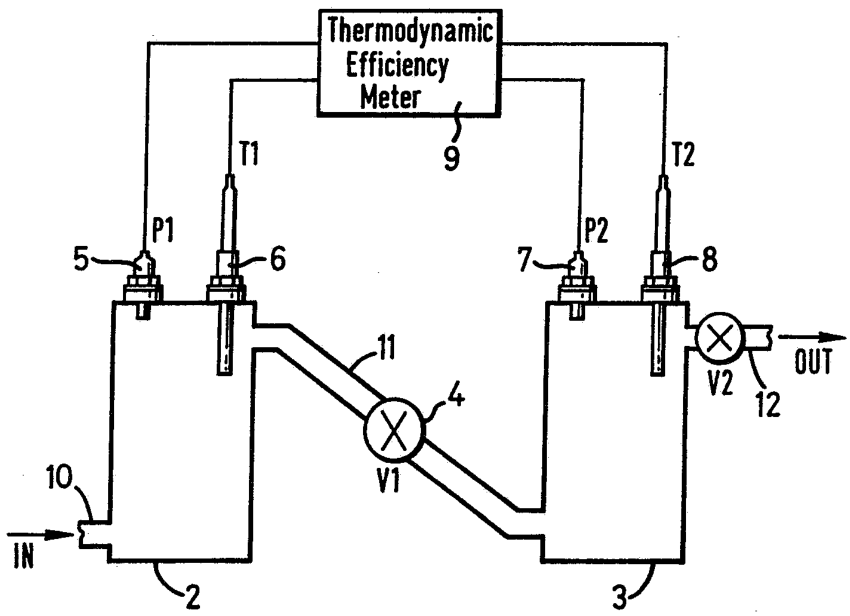

(57) Abstract

A test rig for checking the uncertainty of a pump efficiency meter is mounted within a thermally insulated environment (1) and includes a fluid inlet chamber (2) and a fluid outlet chamber (3) connected by a pipe (11) incorporating a throttle valve (4). The chambers (2) and (3) each have locations for receiving the input pressure transducers (5) and (7) and input temperature transducers (6) and (8) respectively of the meter to be tested. The actual efficiency value (Ep) is measured by the meter using the thermodynamic principle as fluid flows and the uncertainty in the actual efficiency value is determined by the formula 100.(2a.Ep-1) where a is the isothermal value of the fluid.

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CALIBRATION OF PUMP EFFICIENCY METERS

EP-A-0159152 describes a technique for monitoring and protecting hydraulic machines in order to gauge imminent failure of the pump so that the pump can be removed from service for routine maintenance before incurring lengthy and expensive repairs associated with catastrophic failure. The technique monitors pump efficiency using as its basis Poirsons equation which is over 70 years old. Indeed, it is now common place to measure efficiency of a pump per se using this equation which is reproduced below:-

$$\text{Efficiency} = \frac{1}{a + Cp.dT/g.dH}$$

where a is the isothermal factor of the fluid, Cp is the specific heat of the fluid, dT is the temperature rise across the pump, dH is the temperature differential across the pump and g is the acceleration due to gravity.

It can therefore be seen that the efficiency of a hydraulic pump, such as that used in the water or oil industry, can be measured by using equipment to find the differential temperature and pressure across the pump in use and inserting the relevant values into the equation above. Indeed, the applicant manufactures and markets a thermodynamic efficiency meter wherein temperature and head probes are inserted either side of a pump to be assessed and the meter evaluates and produces values of efficiency.

However, although every effort is made to ensure that the efficiency values are accurate, one of the problems with such a meter is that the degree of uncertainty in the efficiency value can not be measured and furthermore the uncertainty may vary according to the head of pressure that the pump is using.

It is an object of the present invention to provide a method for assessing the uncertainty in such an efficiency measurement.

According to one aspect of the present invention there is provided a method of determining the uncertainty in measured efficiency values for a pump as measured by a meter, the method comprising:-

providing means to change the rate of flow of a flowing fluid, wherein said means can be regarded as having a substantially zero efficiency state;

monitoring the pressure and temperature differential across said means, said meter producing therefrom a measured value of actual efficiency; and

determining an uncertainty value for the measured value of actual efficiency on the basis of a theoretical efficiency substantially equal to 1/2a, where a is the isothermal factor of the fluid.

By employing the method of the invention, a simple and convenient test can be produced for evaluating the accuracy of a meter which is employed to monitor the efficiency of a pump. It will be apparent that the method can be employed on site or by taking the meter to a test location.

Preferably, the method includes the step of providing the means to change the rate of flow of a flowing fluid as a throttling valve. This serves as a simple and convenient way of changing the rate of flow of a fluid flowing in a pipe between two chambers say. Moreover, the determination of theoretical efficiency can be automatically performed so that a quick and easy determination of the uncertainty in measured values is given. This allows the meter to be easily and quickly calibrated.

According to another aspect of the present invention there is provided apparatus for testing pump efficiency meters, the apparatus comprising means for connecting and changing the rate of flow of a fluid flowing between a source and an outlet, wherein said means can be regarded as having a substantially zero efficiency state; and locations at the source and outlet for receiving temperature and pressure sensors; wherein, in use, a meter to be tested is connected to said sensors to determine actual efficiency values and an uncertainty value for the determined value of actual efficiency is evaluated on the basis of a theoretical efficiency substantially equal to 1/2a, where a is the isothermal factor of the fluid.

Thus, apparatus is provided in which the sensors from a meter under test can be connected so that the meter determines efficiency values of the flowing fluid whilst the theoretical value of efficiency is calculated according to the formula 1/2a. This is a very simple and convenient way of testing the accuracy of the meter under test and by using the apparatus over a range of heads for the flowing fluid, the meter can be calibrated. It will be apparent that the test can be performed at the location of the meter or the meter can be removed to another location for testing.

Conveniently, the two said locations comprise respective chambers connected respectively to a source of fluid of known head and to a fluid outlet. The apparatus preferably includes control means connected to the meter under test and connected to receive data concerning the fluid head and fluid temperature and calculating automatically theoretical values of efficiency against monitored values of head for the flowing fluid. Preferably, means are provided for altering the head of the fluid source. A throttle valve in a pipe is preferred to connect together the two chambers.

An example of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 illustrates an apparatus using the method embodying the present invention,

Figure 2 illustrates the uncertainty in the efficiency value measured by the meter against head.

Referring to figure 1, a test rig for checking the uncertainty of a pump efficiency meter is mounted within a thermally insulated environment 1 so that the rig functions substantially at a constant temperature. The rig includes an fluid inlet chamber 2 and a fluid outlet chamber 3 connected by a pipe 11 incorporating a throttle valve 4. The chamber 2 includes locations for receiving the input pressure transducer 5 and input temperature transducer 6 of the meter to be tested and the chamber 3 includes locations for receiving the output pressure transducer 7 and output temperature transducer 8 of the meter. The input and output transducers are connected in known manner to the control unit 9 of a known pump efficiency meter which is to be tested.

Fluid of known temperature and head flows into the chamber 2 via an inlet 10, through the pipe 11 and valve 4 into the chamber 3 and out therefrom via an outlet 12. A typical value is 1 litre per sec and a head up to 100 metres. Whilst the fluid is flowing, the actual efficiency value is measured by the meter using the thermodynamic principle. The uncertainty in the actual efficiency value is determined as follows.

The efficiency of a turbine can be regarded as

$$a - \frac{dT.Cp}{g.dH}$$

The valve 4 acting as a throttling calorimeter may be regarded as a turbine having zero efficiency, i.e. no work output. Consequently, in a zero efficiency state

$$a - \frac{dT.Cp}{g.dH} = 0$$

therefore $dT = \dfrac{a.g.dH}{Cp}$ .... 1)

If a thermodynamic efficiency meter operating in the pumping mode is connected across the valve 4 as above, then the meter will determine pump efficiency Ep according to the equation

$$\text{Pump efficiency} = \frac{1}{a + Cp.dT/g.dH} \qquad \text{.......... 2)}$$

Inserting equation 1) above into equation 2) will give the theoretical efficiency ETH

$$ETH = 1/2a$$

Thus, the uncertainty of the measured pump efficiency as a percentage is

$$\frac{Ep - ETH}{ETH} = \frac{Ep - 1/2a}{1/2a} \cdot 100$$

Therefore, uncertainty = 100 . (2a.Ep-1) .... 3)

Alternatively,, the equations can be viewed as follows:-

$$\frac{ETH - Ep}{ETH} = 1 - \frac{Ep}{ETH} = 100\ (1-2a.Ep)$$

As an example, if in a test on water at 10 degrees Centigrade where a has a value of 0.9779, the actual efficiency value Ep is measured to be 0.5, then the uncertainty calculated from equation 3) is 2.21%. Figure 2 illustrates a plot of the percentage uncertainty against head of a known pump efficiency meter for water.

It can therefore be seen that the method and apparatus of the present invention gives a very simple and easy way of testing the uncertainty of a thermodynamic efficiency meter which can allow the meter to be calibrated to give accurate values.

CLAIMS

1. A method for determining the uncertainty in measured efficiency values of a pump as measured by a meter, the method comprising:-
providing means to change the rate of flow of a flowing fluid, wherein said means can be regarded as having a substantially zero efficiency state;
monitoring the pressure and temperature differential across said means, said meter producing therefrom a measured value of actual efficiency; and
determining an uncertainty value for the measured value of actual efficiency on the basis of a theoretical efficiency substantially equal to 1/2a, where a is the isothermal factor of the fluid.

2. A method as claimed in claim 1 including the step of providing the means to change the rate of flow of a flowing fluid as a throttling valve.

3. Apparatus for testing pump efficiency meters, the apparatus comprising means for connecting and changing the rate of flow of a fluid flowing between a source and an outlet, wherein said means can be regarded as having a substantially zero efficiency state; and locations at the source and outlet for receiving temperature and pressure sensors; wherein, in use, a meter to be tested is connected to said sensors to determine actual efficiency values and an

uncertainty value for the determined value of actual efficiency is evaluated on the basis of a theoretical efficiency substantially equal to 1/2a, where a is the isothermal factor of the fluid.

4. Apparatus as claimed in claim 3 wherein the two said locations comprise respective chambers connected respectively to a source of fluid of known head and to a fluid outlet.

5. Apparatus as claimed in claim 3 or 4 including control means connected to the meter under test and connected to receive data concerning the fluid head and fluid temperature and calculating automatically theoretical values of efficiency against monitored values of head for the flowing fluid.

6. Apparatus as claimed in claim 5 further including means for altering the head of the fluid source.

7. Apparatus as claimed in any one of claims 3 to 6 wherein the apparatus is provided within a thermally insulated environment.

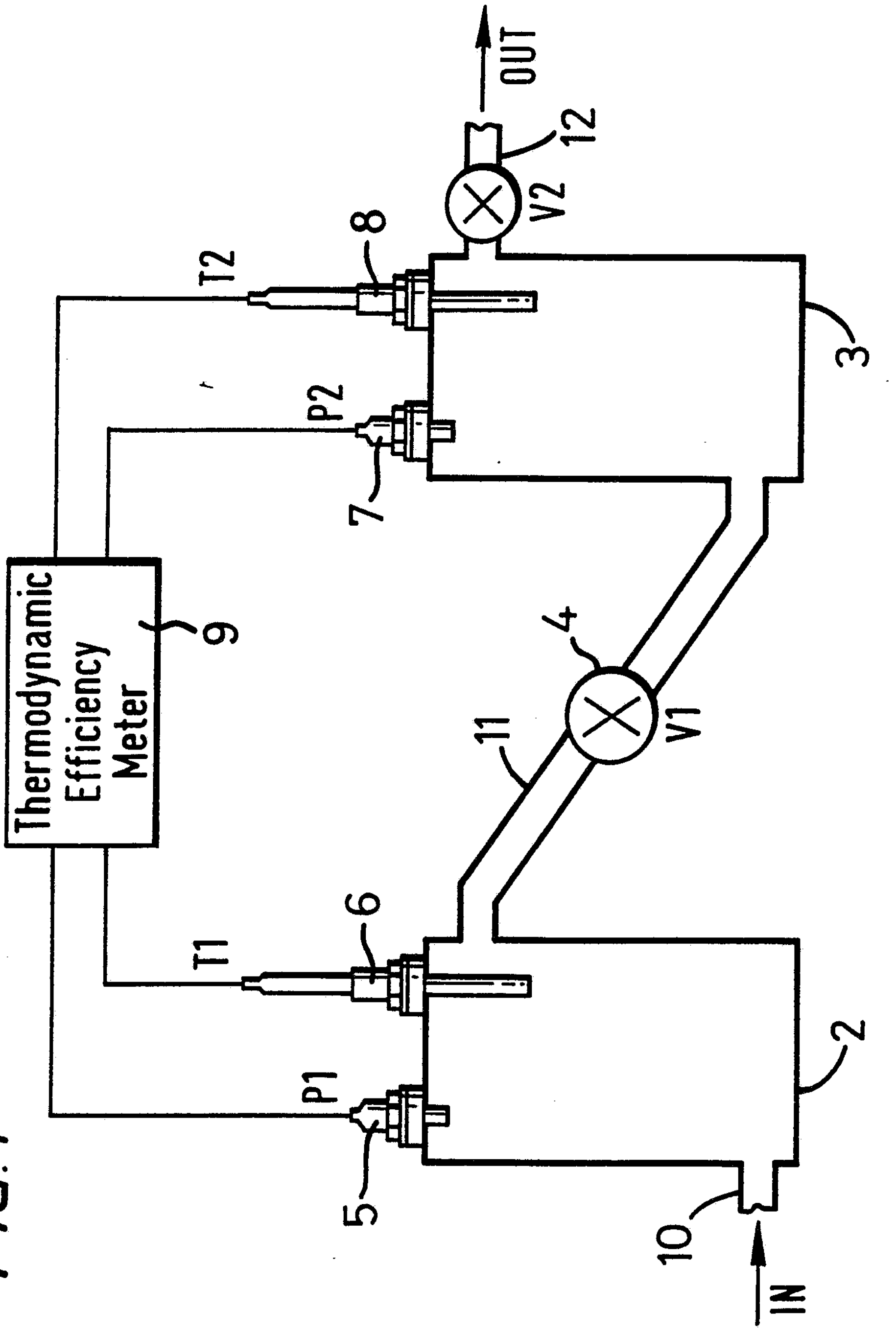
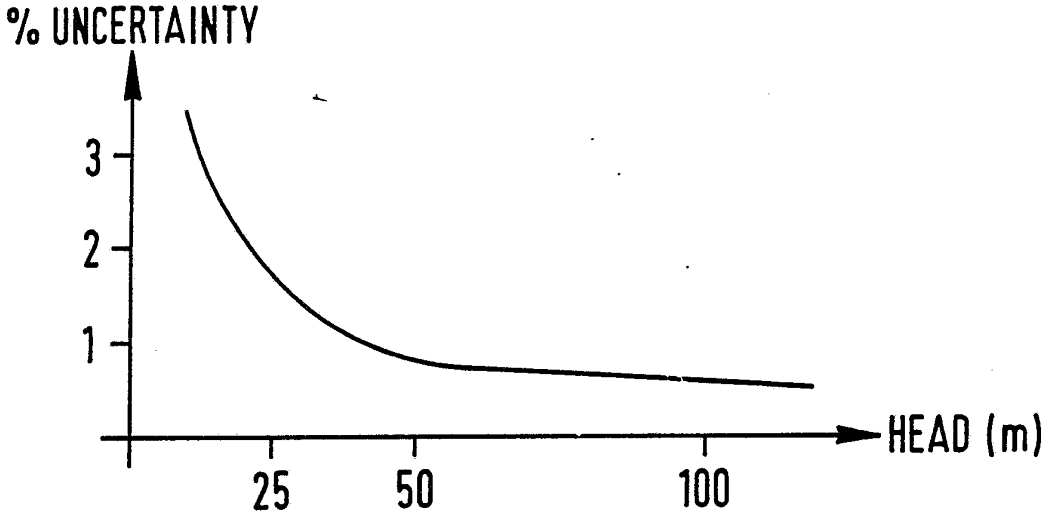

Thermodynamic Efficiency Meter
9
T1
T2
P1
P2
5
6
7
8
V1
V2
4
11
12
2
3
10
IN
OUT

FIG.1

FIG.2



Uncertainty v Head.