

The invention relates to a method of making measuring tubes of magnetic flowmeters.

5 The measuring voltage developed during magnetic flow measurements depends, inter alia, on the electrode spacing and the mean flow velocity of the medium flowing through the measuring tube. These two quantities are substantially influenced by the geometrical dimensions of the measuring tube, so that these dimensions should be as stable as possible.

10 It is known for this purpose to provide a tubular outer member, preferably a metal casing, whose surface facing toward the interior of the tube is coated with plastic by injection molding. However, compared with metals, plastic generally has a high coefficient of
'15 thermal expansion and low mechanical strength, particularly low tensile, compressive, and shear strength.

20 Since these properties can influence the geometrical dimensions of the interior of the measuring tube and, thus, the measuring voltage, the metal casing is to surround the tubular plastic lining so as to provide dimensional stability.

25 When, after completion of the injection molding, the plastic inner lining cools down, the high coefficient of thermal expansion leads to a shrinkage of the

inner lining. This shrinkage frequently results in an at least partial detachment of the inner lining from the metal casing and in permanent mechanical stresses in the plastic. The detachments change the geometrical dimensions of the measuring tube cross-section, which may result in false measuring voltages. The mechanical stresses which are not relieved increase the risk of cracks occurring in the plastic.

It is known to fill the intermediate spaces formed by the detachment between the metal casing and the plastic inner lining with suitable materials, such as silicone rubber, to ensure dimensional stability of the measuring tube cross-section. However, introducing the filler into the intermediate spaces is difficult. In addition, it is complicated to form a homogeneous internal cross-section.

DE-A-20 30 263 discloses a method of making a measuring tube of a magnetic flowmeter which comprises the steps of producing a tubular inner member of plastic which bounds the cavity of the measuring tube, and subsequently inserting the inner member into a steel tube having a lower coefficient of thermal expansion and a higher mechanical strength than the inner member. According to US-A 4,329,879, stiffening means may be embedded within the plastic inner member.

Another class of magnetic flowmeters with an internally insulated metallic measuring tube are those with a ceramic measuring tube and with capacitive electrodes on the tube which are fired on during the

firing of the tube or deposited thereafter, see, for example, EP-A 142 048.

5 The invention as characterized in independent claims 1 and 2 as well as in dependent claims 3 to 9 solves the problem of providing a simple and low-cost method of making measuring tubes of magnetic flowmeters with high dimensional stability.

10 One advantage of the invention is that after its production, the inner member can freely relax and sufficiently solidify. As a result, the probability of subsequent cracking in the inner member is largely avoided. Therefore, the subsequent coating of the inner member (cf. DIN 8580), particularly by electrolytic or chemical deposition or by plasma or
15 flame spraying, does not lead to an appreciable deformation of the cross section of the inner member.

20 Regarding to the use of term "coating", reference is made to DIN 8580 (see, for example, DIN-Taschenbuch 109, 1986, ISBN 3-410-11900-0, p. 83), where the term is defined and explained as follows: "Coating means applying a firmly adhering layer of formless material to a workpiece. The deciding factor is the state of the coating material immediately prior to the coating operation. Note: In general usage, processes such as
25 cladding, laminating, or veneering are often falsely referred to as "coating". However, since the "layer" is not formed from formless material but is connected as a geometrically defined body to the workpiece by welding, soldering, or bonding, such processes, just
30 as wallpapering or the glueing-on of floor coverings, belong to joining".

5 The coating material is preferably a non-ferromagnetic material. With the coating process, firm adhesion of the outer member to the plastic inner member is achieved. Preferred materials for the inner member are fluoroplastics, such as Teflon (PFA, perfluoroalkoxyl) or Hostaflon (ETFE, ethylene tetrafluoroethylene), which are particularly suited for being coated with copper or nickel. Coating processes, particularly electroplating, are economical and can thus be used for mass production.

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15 The outer member may be made up of layers of different materials. These are formed, for example, by means of different electroplating baths. By additional use of masks attached to the inner member, function-adapted regions can be created, e.g. for ferromagnetic pole pieces, chemically resistant electrodes with preferably capacitive tap, and the like. In particular, when using layers of different materials, regions of different conductivities and/or nonconducting regions can be formed which advantageously serve to prevent eddy currents.

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25 To form the outer member, a connecting layer adhering particularly firmly to the plastic of the inner member may be applied, on which further layers may then be formed by plasma spraying.

For further embodiments and their advantages, reference is made to the subclaims and the following explanation with the aid of the drawings, wherein:

30 Figure 1 shows the general principle of the magnetic flow measurement;

Figure 2 is a plan view of a measuring tube made according to the invention;

Figure 3 is a section taken along the line III-III of Fig. 2;

5 Figure 4 is a partially sectioned plan view of another measuring tube according to the invention, and

10 Figure 5 is a section through the wall of the measuring tube taken along line V-V of Fig. 4.

In Figures 1 - 5, like reference numerals have been used to designate corresponding parts.

As shown in Figure 1, the basic construction of a magnetic flowmeter is as follows:

15 Through a measuring tube 1 an electrically conductive liquid whose volumetric flow rate is to be determined flows with velocity v . Two exciting coils 2, 3, which are traversed by the current I and which are operated with an alternating voltage or a pulsating direct
20 voltage, generate in the interior of the measuring tube 1 a magnetic field B . The induced voltage is taken from two insulated electrodes 4, 5 fixed in the wall of the measuring tube 1.

25 The measuring tube 1 has an inner member 6 in the form of a plastic inner lining, and an outer member 7, preferably a stainless steel tube. The function of the

inner member 6 is to insulate the metallic outer member 7 from the electrically conductive fluid.

Figure 2 is a plan view of a measuring tube 1 made according to the invention, showing a projection 8 provided with a hole into which an electrode 4 or 5 is to be pressed. In the plane of the paper, coil cores 9 and 10, which support exciting coils 2 and 3, respectively, extend from the measuring tube 1 perpendicular to the longitudinal axis of the tube.

Besides magnetizing the coil cores 9 and 10, the exciting coils 2 and 3 magnetize pole pieces 11 and 12 which are disposed between the inner member 6 and outer member 7. This has the advantage that the pole pieces 11, 12 are located close to the fluid to be measured, so that the reluctance is reduced.

The ends of the measuring tube 1 form mounting flanges 13 and 14. The external surface of the measuring tube is provided with groove-like depressions 15. As shown in Figure 3, the measuring tube 1 is stiffened by flat bridge members 16 whose outer edges 17 extend from the flanges 13, 14 to the external surface of the measuring tube 1. Figure 3 also shows that by removing a portion of the outer member 7 in the area of a projection 8 and subsequent machining, shield sleeves 18 can be formed for the electrodes 4, 5 in a simple manner.

From Figures 2 and 3 it is apparent that if the inner member 6 is of a suitable design and with the outer member 7 already essentially applied thereto, in a

further stage of the subsequent machining of the outer member 7, the aforementioned function-specific elements (projections 8, coil cores 9, 10, pole pieces 11, 12, flanges 13, 14, grooves 15, stiffening members 16, shield sleeves 18) and the like can be implemented in a simple manner by removing portions of the outer member 7.

According to another variant of the invention, electrodes with capacitive tap can advantageously be incorporated into the production of the measuring tube. This is illustrated in Figures 4 and 5, Figure 5 being an enlarged section, not true to scale, taken along line V-V of Figure 4. To form the electrodes 4, a first electrically conductive layer 41 (indicated in Fig. 4 by a dotted line) is applied to a portion of the surface of the inner member 6. In operation, this first conductive layer 41 forms one plate of a capacitor whose dielectric is the nonconducting inner member 6 and whose other plate is the electrically conductive medium which flows through the measuring tube 1 in the direction of the arrow of Figure 4.

The first conductive layer 41 is then coated, at least in part, with a first insulating layer 42, which is then covered, at least in part, with a second electrically conductive layer 43 to form a shield electrode, particularly against stray capacitances. The layer 43 is advantageously connected to ground, which may be done via a further conductive layer (not shown). If the second conductive layer 43 is coated with a second insulating layer 44, then copper, for example, can be used as the material for the dimension-stabilizing outer member 7. The extent of the two

insulating layers 42, 44 may either be limited to the regions formed by the first conductive layer 41 and/or second conductive layer 43 or cover the entire external surface of the measuring tube 1.

5 In the specific embodiment shown in Figures 4 and 5, the first and second insulating layers 42, 44 and the second conductive layer 43 have aligned cutouts which together form an opening leading to the first
10 conductive layer 41. This makes it possible to make contact to the first conductive layer 41 (measuring electrode) in a simple manner. By performing steps corresponding to those described with the aid of Figures 4 and 5, further electrically conductive layers and further insulating layers can be applied. If at
15 least one of the further conductive layers is connected to ground, for example, the shielding of the measuring electrode will improve, with the load on the above shield electrode being simultaneously reduced.

The embodiment shown in Figures 4 and 5 illustrates that the production method according to the invention is particularly suitable for measuring tubes with capacitive electrodes, since the structure of capacitive electrodes is formed essentially by
25 superposed layers (dielectric, capacitor plate, insulation, shield electrode, etc.), which can be easily applied in connection with the invention.



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C L A I M S:

1. A method of making a measuring tube (1) of a magnetic flowmeter, comprising the steps of:

- producing and stress-relieving a tubular inner member (6) of plastic which bounds the cavity of the measuring tube and has electrode projections formed integrally thereon;
- subsequently surrounding the inner member (6), at least in part, with a dimension stabilizing, firmly adhering outer member (7) by coating it with another material which has a lower coefficient of thermal expansion and a higher mechanical strength than the material of the inner member (6); and
- pressing an electrode (4, 5) into each electrode projection (8) for providing an electrical tap.

2. A method of making a measuring tube (1) of a magnetic flowmeter, comprising the steps of:

- producing and stress-relieving a tubular inner member (6) of plastic which bounds the cavity of the measuring tube;
- applying a first electrically conducting layer (41) to at least a portion of the outwardly



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directed surface of the inner member (6) to form a measuring electrode providing a capacitive tap;

- applying a first insulating layer (42) to at least a portion of the first conducting layer (41);
- applying a second conducting layer (43) to at least a portion of the first insulating layer (42),
- applying a second insulating layer (44) to the second conducting layer (43); and
- surrounding the inner member (6) so coated, at least in part, with a dimension-stabilizing, firmly adhering outer member (7) by coating it with another material which has a lower coefficient of thermal expansion and a higher mechanical strength than the material of the inner member (6).

3. A method as claimed in claim 2, comprising the steps of applying at least one further electrically conducting layer, of which at least one is connected to an electric potential, particularly to ground potential of an amplifier, and at least one further insulating layer to the second insulating layer (44).

4. A method as claimed in claim 2 or 3, comprising the step of providing the insulating layers with recesses so that at least one conducting layer can be contacted from outside.

5. A method as claimed in any one of claims 1 to 4 wherein the inner member (6) is composed of several plastic parts.



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6. A method as claimed in any one of claims 1 to 5 with an inner member (6) of fluoroplastics.

7. A method as claimed in any one of claims 1 to 6 with an outer member (7) of copper.

5 8. A method as claimed in any one of claims 1 to 7, comprising the steps of machining and shaping the outer member (7) after its application.

10 9. A method as claimed in any one of claims 1 to 8, comprising the step of incorporating at least one function-related subassembly during the application of the outer member (7).