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**Description**

The invention relates to a measuring device for capturing the pressure in a cavity of a mould of a particle foaming tool during a foaming process of particle foams, having a measuring head which is arranged in a wall of the mould and in which a pressure recording device is arranged, to which pressure recording device the internal pressure in the cavity can be applied and by means of which the recorded pressure can be supplied to a pressure sensor and can be converted by the pressure sensor into a corresponding electrical pressure signal, wherein the measuring head has a flexible diaphragm, to which the pressure in the cavity can be applied and which can be deflected on its side which faces the cavity and extends transversely to the plane thereof.

Arranging a moveable pressure disc, to which the pressure in the cavity can be applied and which has a plunger on its side facing away from the cavity, in a recess in the wall of the mould is known in a measuring device of this type. The free end of the plunger, which is guided axially in a collar seal, acts upon a diaphragm of a flow amplifier, which in turn is connected to a manometer. The pressure disc and the diaphragm of the flow amplifier thus have cross-sections of equal size in order to be able to charge the manometer with the same compressive force as the foaming compressive force in the cavity.

This design is elaborate and requires a large installation space. Moreover, the guides of the plunger are subjected to friction, which leads to a change in the force exerted by the plunger on the diaphragm of the flow amplifier relative to the force acting upon the pressure disc that is to be measured. The pressure recorded by the manometer is thus significantly different from the interior foam pressure to be measured during the foaming process.

A measuring device of the aforementioned type is known from US 2013/000384 A1. Here, the piston forms an axially displaceably

mounted pressure transmission pin, which extends as far as the pressure sensor and impinges upon it.

5 A device having an oil-filled pressure probe for measuring foaming pressure is known from DD 214 207 A1. The pressure probe is sealed off from the cavity by a diaphragm. A channel leads from the pressure probe through a valve combination to an oil-filled pressure cylinder, one side of which is sealed by a further diaphragm, which acts upon a pivotable yoke via a plunger.  
10 The pivotable yoke, in turn, acts upon a piezoelectric detector. The passage through the valve combination is closed during normal operation and is opened only when required for a measurement. During normal operation, the pressure cylinder communicates with the atmosphere.

15 A hydraulic pressure transducer for recording the pressure in a hydraulic path is disclosed in DE 10 2005 035 931 A1. In addition, a base body is arranged in a flange of the hydraulic path. On the side of the hydraulic path, a separating diaphragm covers a  
20 capillary line that is formed in the flange and that opens on the side facing away from the hydraulic path, wherein a pressure chamber filled with transmission fluid is formed between the separating diaphragm and flange on the side of the capillary line. The pressure chamber is connected to a pressure  
25 measurement cell via the capillary line.

The problem addressed by the invention is therefore that of producing a measuring device of the aforementioned type, which has a simple design, requires little installation space and  
30 records the interior foaming pressure in the cavity with significantly higher accuracy and without negative influence on the pressure sensor by the high temperatures of the foaming process.

35 This problem is solved according to the invention in that the flexible diaphragm can be deflected in a fluid space which is formed on its side facing away from the cavity in the measuring head, is filled with a fluid, and from which a channel leads to

a transmitter head which is at a distance from the particle foaming tool and in which the pressure sensor is arranged, to which the fluid is applied, wherein a mould temperature sensor is arranged in the measuring head, which mould temperature sensor is arranged in an edge region of the measuring head close to a wall of the mould and from which a second signal line leads to the transmitter head, and wherein the mould temperature sensor is in touching contact with a wall of the mould.

As a result of this configuration, the pressure sensor can be disposed at a significant distance from the mould, which experiences high temperatures during the foaming process, and so these high temperatures cannot exert a negative influence on the pressure sensor. At most, negligible losses occur as a result of the hydraulic transmission of the pressure, and so an at least largely lossless measurement of the interior pressure in the cavity can be recorded by the pressure sensor.

The pressure sensor is preferably an electronic pressure sensor, such as a piezoresistive or piezoelectric pressure sensor or a capacitive pressure sensor, which permits highly accurate pressure measurements and preferably produces a digital pressure signal.

The flexible diaphragm prevents possible friction losses.

The channel can be in the form of a capillary tube.

By means of the mould temperature sensor, the measuring head serves a double function of recording the interior pressure in the cavity as well as the temperature of the mould, and the transmitter head serves to emit signals corresponding to the recorded interior pressure in the cavity and the recorded temperature of the mould.

Since the mould temperature sensor is freely in touching contact with a wall of the mould, an especially accurate recording of the temperature of the mould is possible.

A foam temperature sensor, which is freely connected to the cavity and from which a first signal line leads to the transmitter head, can also be arranged in the measuring head  
5 without any additional installation effort. The measuring head thus serves a double function of recording the interior pressure in the cavity as well as the foam temperature, and the transmitter head serves to emit signals corresponding to the recorded interior pressure in the cavity and the recorded foam  
10 temperature.

A particularly high level of integration is achieved in the measuring head when the moveable diaphragm, the foam temperature sensor and the mould temperature sensor are arranged in the  
15 measuring head and/or the transmitter serves to emit signals corresponding to the recorded interior pressure in the cavity, the recorded foam temperature and the temperature of the mould.

To this end, the transmitter head can have one or more connection  
20 contacts at which the signals from the pressure sensor and/or the signals from the foam temperature sensor and/or the signals from the mould temperature sensor can be tapped off.

The channel leading from the fluid space to the transmitter head  
25 and/or the first signal line and/or the second signal line may be arranged in a spacer arranged between the measuring head and the transmitter head, whereby the installation is simplified and the required installation space is reduced.

30 The installation is especially simple and space-saving when the measuring head, the spacer and the transmitter head are permanently connected to one another.

The measuring head and, if appropriate, the integrally  
35 permanently interconnected elements measuring head, spacer and transmitter head, can be permanently inserted along with the measuring head into a recess in the wall of the mould.

In this way, no further mounting elements are required for the measuring device.

An exemplary embodiment of the invention is illustrated in the drawing and will be explained in greater detail below.

Figure 1 shows a particle foaming tool in a longitudinal section.

Figure 2 shows an enlarged detail "X" of Figure 1.

The particle foaming tool illustrated in the figures comprises a mould 1 with a cavity 2, into which the plastic particles are filled. During the foaming process, as superheated steam is blown in at a high temperature (e.g. 140°C), the plastic particles expand, fill the cavity 2 of the mould 1 and fuse together. In so doing, a pressure develops in the cavity 2.

To be able to control the foaming process, it is important to permanently record the conditions during said process. These conditions are the pressure in the cavity, the temperature of the foam in the cavity 2 and the temperature of the mould 1.

To do so, a measuring device 3 is provided, which consists of a measuring head 4, a rod-like spacer 5 and a transmitter head 6, which are permanently connected to one another.

The mould 2 has a recess 7, which is continuous from the outside to the inside, which has a preferably round cross-section, and into which the measuring head 4 with a corresponding cross-section is permanently inserted.

The measuring head 4 has a fluid space 8 that is filled with a fluid, e.g. an oil, and its opening, which is oriented toward the cavity 2, is sealed by a flexible diaphragm 9.

A channel 10, which is likewise filled with the fluid, leads from the fluid space 8 through the spacer 5 to the transmitter

head 6 and a pressure sensor (not illustrated) that is arranged in the transmitter head 6, and so the fluid is applied to the pressure sensor.

5 Also arranged in the measuring head 4 is a foam temperature sensor 11, which projects into the cavity 2 and by which the respective temperature of the foam during the foaming process is recorded and which generates a corresponding signal, which is conducted by a first signal line 13 leading through the  
10 measuring head 4 and the spacer 5 to a first connection contact 12 in the transmitter head 6.

Additionally arranged in the measuring head 4 is a mould temperature sensor 14, which is in touching contact with a wall  
15 18 of the mould 1 and which records the respective temperature of the mould and generates a corresponding signal, which is conducted by a second signal line 15 leading through the measuring head 4 and the spacer 5 to a second connection contact 16 in the transmitter head 6.

20

Furthermore, the transmitter head 6 has also a third connection contact 17, to which the signal generated by the pressure sensor is supplied.

25 By means of the measuring device, which forms one single unit, the pressure in the cavity 2, the temperature of the foam in the cavity 2 and the temperature of the mould 1 can be recorded during the foaming process and can be supplied via the connection contacts 12, 16 and 17 to a control apparatus (not illustrated)  
30 for controlling the foaming process.

**List of Reference Signs**

|    |    |                           |
|----|----|---------------------------|
|    | 1  | Mould                     |
|    | 2  | Cavity                    |
| 5  | 3  | Measuring device          |
|    | 4  | Measuring head            |
|    | 5  | Spacer                    |
|    | 6  | Transmitter head          |
|    | 7  | Recess                    |
| 10 | 8  | Fluid space               |
|    | 9  | Diaphragm                 |
|    | 10 | Channel                   |
|    | 11 | Foam temperature sensor   |
|    | 12 | First connection contact  |
| 15 | 13 | First signal line         |
|    | 14 | Mould temperature sensor  |
|    | 15 | Second signal line        |
|    | 16 | Second connection contact |
|    | 17 | Third connection contact  |
| 20 | 18 | Wall                      |

## Patentkrav

1. Måleanordning (3) til måling af trykket i en kavitet (2) i en form (1) på et partikel-skumværktøj under en skumproces af partikelskum med et i en væg (18) i formen (1) placeret målehoved (4), i hvilket der er placeret en af det indvendige tryk i kaviteten (2) påtrykkelig trykoptagsanordning, ved hjælp af hvilken det optagede tryk kan føres til en tryksensor og fra tryksensoren kan omdannes til et tilsvarende elektrisk tryksignal, idet målehovedet (4) har en fleksibel membran (9), som på den side, der vender mod kaviteten (2) og strækker sig på tværs af dens niveau, kan påtrykkes og forskydes af trykket i kaviteten (2), den fleksible membran (9) kan forskydes i et væskerum (8) fyldt med væske dannet i en side, som vender væk fra kaviteten (2) i målehovedet (4), hvorfra en kanal (10) fører til et med afstand til partikelværktøjet placeret transmitterhoved (6), hvori tryksensoren er placeret og er påtrykt af væsken, kendetegnet ved, at der i målehovedet (4) er placeret en formtemperatursensor (14), som er placeret i et i randområde på målehovedet i nærheden af en væg (18) i formen (1), og hvorfra en anden signalledning (15) fører til transmitterhovedet (6), og idet formtemperatursensoren (14) er i berøringskontakt med en væg (18) i formen (1).
2. Måleanordning ifølge et af de foregående krav, kendetegnet ved, at kanalen (10) er udformet som kapillarrør.
3. Måleanordning ifølge krav 1, kendetegnet ved, at der i målehovedet (4) er en skumtemperatursensor (11), som rager frit ind i kaviteten (2), hvorfra en første signalledning (13) fører til transmitterhovedet (6).
4. Måleanordning ifølge et af de foregående krav, kendetegnet ved, at transmitterhovedet (6) har en eller flere tilslutningskontakter (12, 16, 17), hvorpå signalerne fra tryksensoren og/eller signalerne fra skumtemperatursensoren (11) og/eller signalerne fra formtemperatursensoren (14) kan

opfanges.

5. Måleanordning ifølge et af de foregående krav, kendetegnet ved, at den fra væskerummet (8) til transmitterhovedet (6) førende kanal (10) og/eller den første signalledning (13) og/eller den anden signalledning (15) er placeret i et mellem målehovedet (4) og transmitterhovedet (6) placeret afstandselement (5).
- 10 6. Måleanordning ifølge krav 5, kendetegnet ved, at målehoved (4), afstandselement (5) og transmitterhoved (6) er fast forbundet med hinanden.
- 15 7. Måleanordning ifølge et af de foregående krav, kendetegnet ved, at målehovedet (4) er indsat fast i en fordybning (7) i væggen (18) på formen (1).

