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Eljárás és berendezés fröccsöntő gép ellenőrzésére, dokumentálására és/vagy szabályozására

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

METHOD AND DEVICE FOR MONITORING, DOCUMENTING, AND/OR CONTROLLING AN INJECTION MOLDING MACHINE

Description

[0001] The invention concerns a process to monitor, document and/or regulate an injection moulding machine according to the generic term in Claims 1 and 2 as well as an injection moulding machine to carry out this process.

STATE OF THE ART

[0002] In order to control the consistency of plastic material, paste-like mixtures, emulsion and also liquids, the viscosity shall be determined in connection with shear rates. The viscosity describes dynamic shear stresses on the basis of the internal friction in moved liquids or in paste-like mixtures. The definition of viscosity is based on the approach of Newton, who states that the shear stress is proportional to the shear rate. The proportionality factor is described as viscosity (shear viscosity). The two terms shear stress and shear rate are clarified with the example of a liquid film with thickness d , which rests on one boundary surface and on the other moves with a speed v on the basis of the shear force effecting it. The shear stress corresponds with the shear force per areal unit and the shear rate corresponds with the quotients v/b and therefore the change of stress control from one boundary surface to the other divided through the distance between the two boundary surfaces.

[0003] In order to determine a relationship between the shear rate and the shear stress or rather the viscosity, viscosity measurements must be made for different shear rates. According to the Hagen/Poiseuille process, the viscosity can be determined using a capillary through which the liquid or mixture to be tested will be flowed on the basis of feed pressure. The shear stress and the shear rate and therefore the viscosity can be determined from the flow rate, the feed pressure, the pressure change along the capillary and the cross-section of the capillary. Because the shear rate depends on both the feed pressure and also the cross-section of the capillary, measurements can be made for different shear rates through the changes in these sizes.

[0004] For example, from US-GS-3 438 158 it is known how to determine the yield stress and the viscosity of a non-Newtonian fluid. In doing so the fluid will be pumped through a pipe with a known diameter with known flow speed. Through repeatedly measuring the differences in pressure or respectively the fall in pressure along a given length of pipe under different conditions in each case, then the above mentioned rheological parameter shall be determined.

[0005] From DE 10 2005 032 367 A1 a process to monitor and/or regulate filling melt of at least one cavity of an injection moulding machine is known. According to this print type publication, fluctuations in viscosity or respectively material can be indirectly

determined, monitored and regulated, and the differences in filling times of the melt from cycle to cycle can be analysed. With such a process differences in viscosity can be recognised and, where applicable, corrected, but a true course of viscosity in the physical unit Pascal per second (Pa s) can therefore not be determined. But in order to be able to quantify a change in viscosity, this must be known in the real physical unit.

[0006] In classic rheometry the viscosity is commonly determined to determine materials in the laboratory as a

quotient from the shear stress and shear speed. So-called rheometres are used here, which possess a nozzle and a precisely defined melt channel to determine viscosity, whereby - in contrast with an injection moulding process - they command isothermal conditions. That is, both the metal nozzle and the plastic melt have the same temperature. There are two melt pressure sensors on a rheometre to take measurements (cavity pressure sensors) which are arranged with a particular spacing and measure the fall in pressure along this distance. The shear stress can be calculated through the geometry of the melt channel, which can be laid out as a bore or as a rectangular duct, and through the drop in pressure. In doing so the melt injected through the nozzle can be pressured out (extruded) with different speeds or under different pressures, so that different pressure rates (Δp) are produced. Each individual pressure rate produced its own shear stress and therefore a value in the course of a viscosity curve.

[0007] At the same time again the geometry of the melt channel and the time which passes until the melt goes from the first melt pressure sensor to the second melt pressure sensor will be used to calculate the corresponding shear speed.

[0008] Finally there is still an easier process to determine viscosity where only one melt pressure sensor is used. It measures the drop in pressure from the sensor up to atmospheric pressure of 1 bar. With this process, however, there must be computer correction - the so-called "Bagley Correction" - to compensate for pressure lost through leaks. These losses in pressure from leaks arise if the melt is released from the channel and spreads out. Otherwise the other approach corresponds with the process of a rheometre.

[0009] A further process to monitor injection mould processes is shown in US 4,833,910. Here two pressure sensors are positioned with a known interval in the direction of flow of the melt in a hot channel. One pressure sensor sets a pulse generator in motion when the melt arrives, the other pressure sensor determines particular stress differences across two pressure pins, whereby the corresponding values must be converted. The viscosity is determined through the pressure difference, time difference, the radius of the channel and the difference between the two sensors determined in this way.

AIM OF THE INVENTION

[0010] The aim of the present invention is to practically monitor and, where applicable, to regulate an injection mould process.

THE SOLUTION TO THE AIM

[0011] The features labelled in Claims 1 and 2 lead to the solution of the objective.

[0012] According to the present invention the process in accordance with a first preferred example of execution implements this in a simple way by determining the viscosity using at least one cavity pressure sensor and at least one cavity wall temperature sensor. The pressure of the melt will be measured once upon meeting the cavity pressure sensor and again when meeting the cavity wall temperature sensor. The loss in pressure here corresponds directly with the pressure value which prevails at the time of an increase in temperature, so that a second pressure value is not necessary since the difference in pressure between the atmospheric pressure and this value is supposed. To determine the shear stress, the time which the melt requires between the two sensors will be drawn upon.

[0013] In doing so it is advantageous if the cavity pressure sensor is provided close to the melt entrance in the cavity and the cavity wall temperature sensor in the following course of the flow path or close to the end of the flow path of the melt. If e.g. the cavity wall temperature sensor sits close to the end of the flow path, it can at the same time also be used as an automatic switch for the so-called dwell pressure, but in the case of positioning the cavity wall temperature sensor somewhere in the course of the melt flow, the process in accordance with the invention also works best.

[0014] If in the present invention the cavity wall temperature or respectively the cavity pressure sensor are discussed, this means that both sensors are preferably arranged in the inner wall or close to the surface of the cavity, i.e. in the first case they come into direct contact with the melt, in the second case they are only a thin division bar from the melt.

[0015] As an appropriate second example of implementation it can be foreseen that the viscosity will only be determined with the use of at least one cavity wall temperature sensor provided in the flow path of the melt in the area of the cavity, whereby the differences in

pressure in the injector nozzle of the injection moulding machine shall be used to determine the shear stresses, and the distance between the entry of the melt in the cavity up to the position of the cavity wall temperature sensor will be used as the basis to determine the shear speeds. Instead of the pressure differences in the injector nozzle, here the pressure differences in the hydraulics of the injection moulding machine or in the hot channel can also be used. In doing so the melt pressures correspond with true pressure values which do not need to be converted, while the hydraulic pressure must be converted to genuine pressure values according to the cross-section of the hydraulic piston and the cross-section of e.g. the screw cylinder used.

[0016] The process measuring the hydraulic pressure is relatively cost-effective since, in contrast with the melt pressure measurement in the machine nozzle or in the hot channel, no additional sensor needs to be built in. This process is however not so precise because of the loss of friction.

[0017] Finally it is also possible that the losses in pressure during the injection phase of the melt is determined through a force measurement, since alongside the classic hydraulic machines, electric injection moulding machines will be used in addition, which are used above all to save energy. Since here it is not pressure but force which is measured, the loss in pressure during the injection phase will also beneficially be determined indirectly through a measurement of force. The determination of the shear speeds can then be made with such a force measurement analogously to the second example of implementation, and where the time along the flow path between cutting the part and the position of the cavity wall temperature sensor is measured and evaluated.

[0018] Reference should again be expressly made to the fact that the present invention does not use the rheometre. Contrary to determining the viscosity with the rheometre, with the present invention the injection moulding process is monitored permanently. A viscosity value will be monitored in the first place if it changes, will react according to the process that namely, for example, will again return to this viscosity value.

DESCRIPTION OF FIGURES

[0019] Further details and benefits of the invention arise from the following description of several examples of implementation as well as using the drawing; this shows:

Fig. 1 a schematic side view of an injection moulding machine in accordance with the invention,

Fig. 2 as first example of implementation a fundamental construction of a cavity provided with measuring sensors of an injection moulding tool, and indeed with a cavity pressure sensor and a cavity wall temperature sensor,

Fig. 2a a schematic representation of different arrangements of pressure or respectively temperature sensors in a cavity with accompanying graphs of the pressure and temperature courses over time;

Fig. 3 a graph of the course of the pressure and temperature over time, which were created on the basis of the data determined with the first example of implementation according to Fig. 2,

Fig. 4 as the second example of implementation a schematic representation of a cavity of an injection moulding tool with only one cavity wall temperature sensor.

[0020] In Fig. 1 an injection moulding machine P is schematically represented and includes in the known manner an injection moulding tool 1 with a cavity 1.1 and a nozzle 2, through which a melt of plastic material is brought in in cavity 1.1. Nozzle 2 is again connected with an extruder 3, which is attributed a funnel tube 4 for plastic granules.

[0021] A measurement section to measure the cavity wall temperature - and indeed the internal wall temperature of the cavity - is indicated with an arrow 5, whereas an arrow 6 is provided at that position where in the injection nozzle area the melt pressure is measured. Furthermore, an arrow 7 indicates the position where the hydraulic pressure is decisive as a standard.

[0022] The fundamental construction of a cavity 9 represented in Fig. 2 as the first example of implementation with a rectangular cross-section with the measurements height H and width W to determine the particular geometry is only as an example. A cavity pressure sensor 10 is provided close to a cutting 19 and a cavity wall temperature sensor 11 at a distance S(9) from this, whereby with 12 the cavity wall is indicated as "cold" and the inside of the cavity 9 is "warm" when the melt is filled in.

[0023] The graph shown in Fig. 3 was created on the basis of measurements which have been determined with the arrangement of sensors in the cavity 9 according to Fig. 2. The time t , in seconds is given on the x-coordinate, on the left ordinate the pressure p is stated and on the right ordinate the temperature (abstract) is stated, whereby a curve 13 represents the cavity pressure course and a curve 14 represents the cavity wall pressure course. At one point of intersection of both curves, an arrow 15 shows the pressure value at the time of the increase in temperature, i.e. there is an automatic

calculation of a shearing stress on the basis Δp . The shear speed is calculated automatically on the basis of Δt .

[0024] As a second example of implementation, in Fig. 4 a cavity 17 is schematically represented which shows only one cavity wall temperature sensor 18, which is arranged in a distance S(17) from the entrance of the melt (cutting 19).

[0025] The process according to the invention to determine the viscosity course of a melt in a cavity of an injection moulding tool of an injection moulding machine, to monitoring, documenting and/or regulating it runs as follows:

[0026] Starting from the first example of implementation according to Fig. 2, during the injection phase the viscosity of the melt flowing in cavity 9 over nozzle 2 of the injection moulding machine P is determined in that the individual quotients are determined for this from the particular shear stresses and shear speeds using the pressure differences present in cavity 9 and the geometry (H x W x total length of cavity 9). Based on the example of implementation according to Fig. 2 this means that the cavity pressure sensor 10 close to the melt entry measures the pressure when the melt enters. As soon as the melt reaches the cavity wall temperature sensor 11, the pressure is measured again and the difference in temperature measured corresponds exactly with the pressure value which dominates at the time of the temperature increase shown in Fig. 3. A second pressure value is therefore not necessary since the pressure difference between the atmospheric pressure (1bar) and this value is assumed. The advantage of this process also lies in the fact that the temperature sensor 11 can at the same time be used to automatically convert to dwell pressure. Furthermore, the temperature sensor 11 can sit somewhere in the course of the melt flow. This is made especially clear in Figure 2a, where in three examples of implementation different arrangements of pressure sensor 10 and temperature sensor 11 are shown. The corresponding graph applies analogously to Figure 3. Irrespective of where pressure sensor 10 or respectively temperature 11 sits, the shear stress Δp and the shear speed Δt will be determined when reaching temperature sensor 11 and the viscosity value calculated from this. If this value lies at or close to a predetermined value, nothing needs to be changed for the injection moulding process. If this value changes, however, the injection moulding process can e.g. be changed with relation to the temperature of the melt and/or the pressure or such parameters until the desired viscosity value is determined again.

[0027] Regarding the first example of implementation a measurement then means, with the second example of implementation according to Fig. 4, a simplification because only on cavity wall temperature sensor 18 is arranged in the course of the flow path of the melt.

In order to calculate the particular shear stresses, here either the pressure differences in the hot channel system and/or in the nozzle 6 of the injection moulding machine P and/or the pressure differences in the hydraulics will be used. The distance S(17) from cutting 19 of the moulded part up to the position of the cavity wall temperature sensor 18 serves as the basis to calculate the shear speeds.

[0028] The advantage of this process is that the melt pressures in the hot channel and in the machine nozzle represent real pressure values which do not need to be converted., while the hydraulics pressure needs to be converted to real pressure values according to the cross-section of the hydraulic piston and the cross-section of the screw cylinder. The most cost-effective process is however the measurement of the hydraulic pressure, since for this, in contrast to the melt pressure measurement in the machine nozzle or in the hot channel, no additional sensor needs to be built in, since the hydraulics are always measured and used to control the machine. Due to the friction loss this method is also the least precise.

[0029] The viscosity course is ultimately produced from the different individual shear stresses and shear speeds.

[0030] The first example of implementation in particular proved its value in practice. In doing so the viscosity is determined as stated and monitored in the known manner, whereby the viscosity course determined in this way can at the same time also be documented and regulated.

[0031] Fundamentally different viscosities are not desired since they lead to different sub properties. Causes for different viscosities are either different process conditions or different material properties (fluctuations in charge). It is therefore also possible to use the process according to the invention and the device for testing materials upon receipt.

ELJÁRÁS ÉS BERENDEZÉS FRŐCCSÖNTŐ GÉP ELLENŐRZÉSÉRE, DOKUMENTÁLÁSÁRA ÉS/VAGY SZABÁLYOZÁSÁRA

Szabadalmi igénypontok

1. Eljárás egy fröccsöntő szerszámmal (1) rendelkező fröccsöntő gép (P) ellenőrzésére, dokumentálására és/vagy szabályozására, amely fröccsöntő gép fröccsöntő szerszámba egy ömledéket vezetünk be, ahol az ömledék viszkozitását a fröccsöntő szerszámban (1) közvetlenül a nyírófeszültség és a nyírósebesség mindenkorai hányadosai révén, nyomáskülönbségek (Δp), a szerszáműreg (1.1; 9; 17; 20) geometriája és az ömledék áramlási sebessége (Δt) alapján állapítjuk meg,

azzal jellemezve,

hogy a viszkozitást legalább egy szerszám-belsőnyomás érzékelő (10) és legalább egy szerszámfal-hőmérséklet érzékelő (11) révén állapítjuk meg, ahol a nyírófeszültséghez a szerszám-belsőnyomás érzékelő (10) által az ömledék belépésekor nála megállapított nyomás és az ömledéknek a szerszámfal-hőmérséklet érzékelőnél (11) való beérkezésekor fennálló nyomás nyomáskülönbségét (Δt), míg az áramlási sebesség megállapításához azt az időt (Δt) használjuk fel, amelyei az ömledék a szerszám-belsőnyomás érzékelőtől (10) a szerszámfal-hőmérséklet érzékelőig (11) igényel.

2. Eljárás egy fröccsöntő szerszámmal (1) rendelkező fröccsöntő gép (P) ellenőrzésére, dokumentálására és/vagy szabályozására, amely fröccsöntő gép fröccsöntő szerszámba egy ömledéket vezetünk be, ahol az ömledék viszkozitását a fröccsöntő szerszámban (1) közvetlenül a nyírófeszültség és a nyírósebesség mindenkorai hányadosai révén, nyomáskülönbségek (Δp), a szerszáműreg (1.1; 9; 17; 20) geometriája és az ömledék áramlási sebessége (Δt) alapján állapítjuk meg, *azzal jellemezve*, hogy a viszkozitást legalább egy, az ömledék áramlási útjában a szerszáműreg (17) környezetében elrendezett szerszámfal-hőmérséklet érzékelő (18) segítségével állapítjuk meg, és a mindenkorai nyírófeszültségek meghatározásához alapként a nyomáskülönbségeket (Δp) egy fröccsöntő fúvókában (6), a nyomáskülönbségeket (Δp) a fröccsöntő gép (P) hidraulikus rendszerében (7) és/vagy egy forrócsatorna-rendszerben vagy az ömledék befűtőcsöntési fázisa során közvetetten erőmérések útján határozzuk meg, amelyeket az ömledék szerszáműregbe való benyomására szolgáló gépegység-elemeknek kell végrehajtaniuk, és a nyírósebességek (Δt) meghatározásához a szerszáműregbe (17) való ömledékbelépés (19 beömlőnyílás) és a szerszámfal-hőmérséklet érzékelő (18) helyzete közötti távolságot (S17), illetve időt használjuk fel.

3. Fröccsöntő gép (P), amely olyan vezérlőeszközökkel rendelkezik, amelyek alkalmasak az 1. igénypont szerinti eljárás megvalósítására, és amely egy fröccsöntő szerszámmal (1) rendelkezik, amelybe egy ömledék van bevezetve, ahol az ömledék viszkozitása a fröccsöntő szerszámban (1) közvetlenül a nyírófeszültség és a nyírósebesség mindenkorai hányadosai révén, nyomáskülönbségek (Δp), a szerszáműreg (1.1; 9; 17; 20)

geometriája és az ömledék áramlási sebessége (Δt) alapján van megállapítva, ahol legalább egy szerszám-belsőnyomás érzékelő és egy szerszámfal-hőmérséklet érzékelő (10, 11, 18, 21, 22) van elrendezve, amelyek révén az ömledék szerszámüregbe (1.1, 9, 17, 20) való befröccsöntési fázisa során megállapítható nyomáskülönbségek és a szerszámüreg (1.1, 9, 17, 20) geometriája által a mindenkori hányadosok a viszkozitás számára a mindenkori nyírófeszültségekből és nyírósebességekből meghatározhatók.

4. A 3. igénypont szerinti fröccsöntő gép, ahol a szerszám-belsőnyomás érzékelő (10) a szerszámüregbe (9) való ömledékbelépés (19) közelében, míg a szerszámfal-hőmérséklet érzékelő (11) az ömledék áramlási útjának (S9) további szakaszában van elrendezve.

5. A 3. vagy 4. igénypont szerinti fröccsöntő gép, ahol a szerszámfal-hőmérséklet érzékelő (11) az ömledék áramlási útjának vége közelében van elrendezve.

6. Fröccsöntő gép (P), amely olyan vezérlőeszközökkel rendelkezik, amelyek alkalmasak a 2. igénypont szerinti eljárás megvalósítására és amely egy fröccsöntő szerszámmal (1) rendelkezik, amelybe egy ömledék van bevezetve, ahol az ömledék viszkozitását a fröccsöntő szerszámban (1) közvetlenül a nyírófeszültség és a nyírósebesség mindenkori hányadosai révén, nyomáskülönbségek (Δp), a szerszámüreg (1.1; 9; 17; 20) geometriája és az ömledék áramlási sebessége (Δt) alapján állapítjuk meg, ahol egy szerszámüreghez (17) legalább egy, az ömledékbelépéstől (19) bizonyos távolságra (S17) a szerszámüreg falán elrendezett szerszámfal-hőmérséklet érzékelő (18), míg a fröccsöntő gép (P) fröccsöntő fúvókájához (6) és/vagy a fröccsöntő gép (P) hidraulikus rendszeréhez (7) és/vagy egy forrócsatornához egy nyomásérzékelő van hozzárendelve.

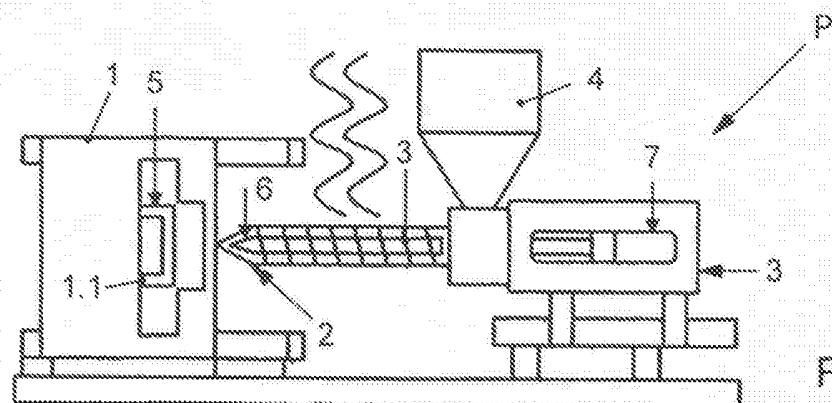


Fig. 1

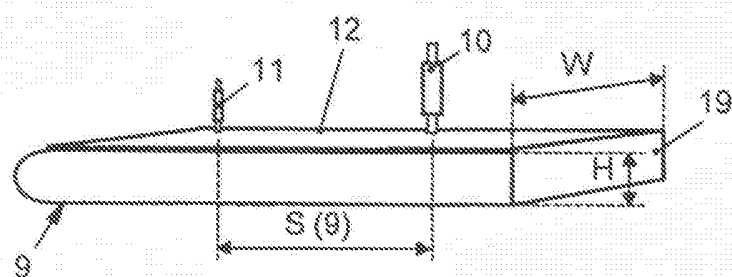


Fig. 2

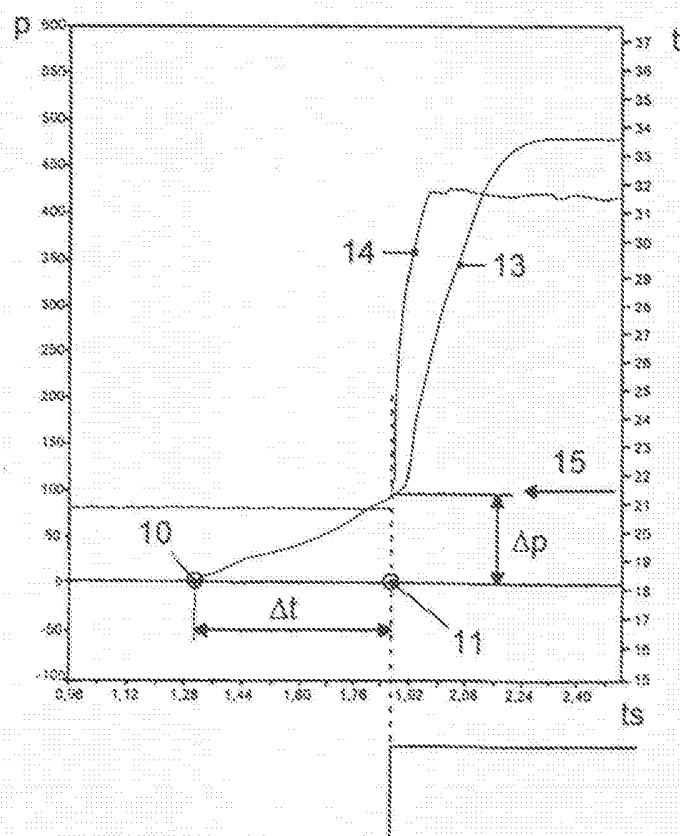


Fig. 3

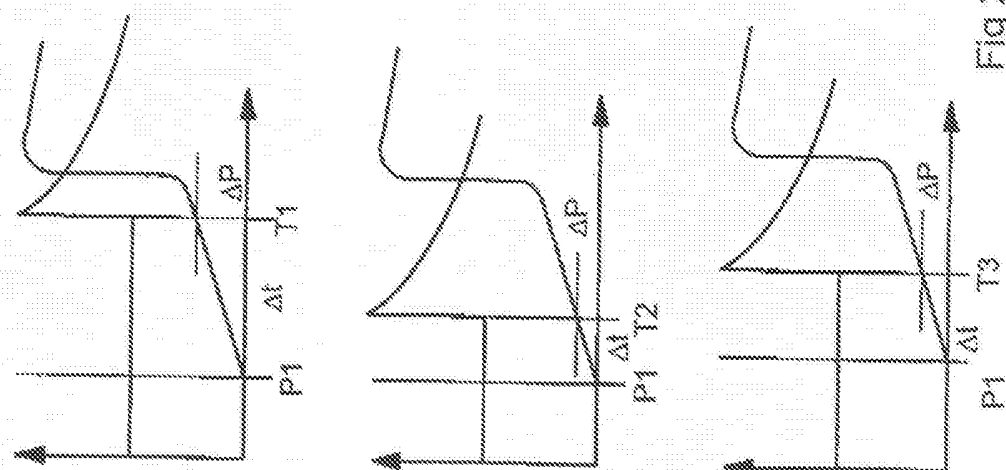
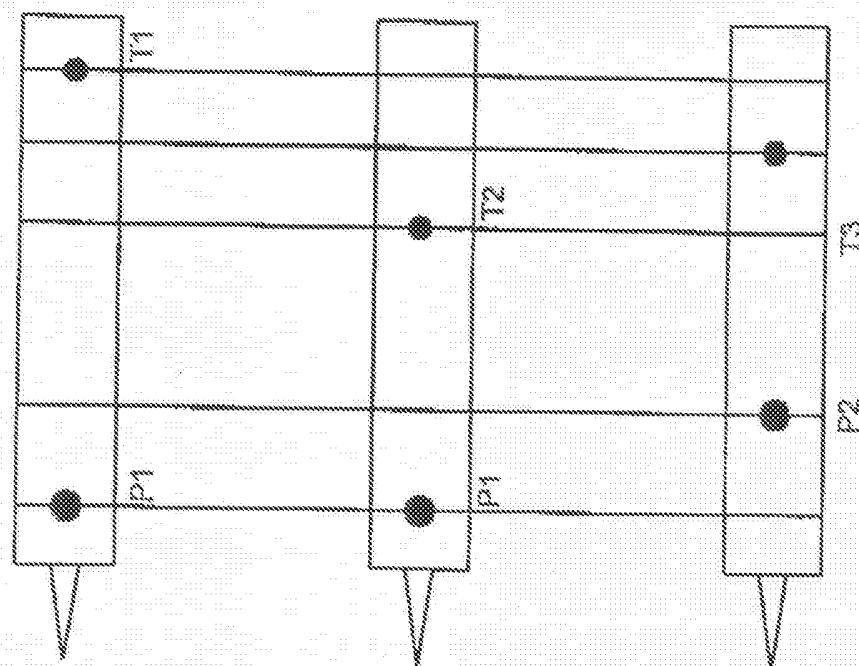


Fig 2a



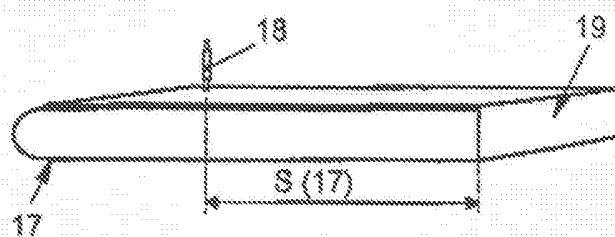


Fig. 4