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(54) Benævnelse: **EKSTRUDERINGSINDRETNING TIL RØRFORMEDE FLERLUMENPRODUKTER**

(56) Fremdragne publikationer:
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DESCRIPTION

[0001] The present invention relates to an extruder for making tubular articles with highly specific geometric / dimensional characteristics, such as for example a "multi-lumen" cross-section (i.e., defining multiple passage sections within a maximum perimeter), wherein the passing openings are arranged on multiple concentric crowns, and which may also have different macro- or microscopic dimensions both in terms of maximum external diameter and of overall number of internal passage openings (and also of angular distance between adjacent openings or again in terms of internal diameters of the individual passage openings themselves).

[0002] As is known, tubular products and micro-products with multi-lumen sections can be used in various fields, from medical applications to other engineering fields where considerable dimensional precision is required and where extremely strong structure and passage characteristics are required.

[0003] To date, the manufacture of extruded tubular products of particularly small dimensions or with particularly complex internal architectures must take into account the fact that the materials - usually polymeric - used in the manufacturing processes are used in extremely reduced amounts, and therefore during the passage in the forming head are extremely sensitive to thermal profiles as well as to all possible elements of environmental disturbance (turbulence in the flow of the material, thermal gradients, atmospheric and / or environmental elements around the forming head and so on).

[0004] The problems of very high sensitivity to the environmental / efflux parameters reflect in turn into problems of geometric and precision coherence of the extruded product (or micro-product), which may have internal walls that are not perfectly linear or with non-constant thicknesses and linearities, and in the most obvious cases it can even present occlusions or total collapses in the cross-section.

[0005] Examples of devices in this field can be found in documents JP H03 93523, EP 1 938 949, EP 2 138 201 and JP 2016 087971.

[0006] The present invention therefore intends to devise an extruder device which allows to overcome the aforementioned drawbacks, and in particular which allows to obtain multi-lumen tubular products with particularly small dimensions and / or with multi-coronal arrangement of the various passage openings, all with very high geometric / dimensional precision characteristics, with sufficiently high production rates and with high reliability and durability of the extrusion / forming plant. For the purposes of the present invention it should be specified that "multi-coronal arrangement" of the passage openings inside a section of an extruded product (or micro-product) means an arrangement of passage openings along two or more concentric circumferences with differentiated radii: these circumferences are obviously inscribed within a circumference of maximum radius defined by the outer surface of the

extruded product itself. A further object of the present invention is to provide a forming / extrusion device which can be advantageously integrated with other functional modules, for example a precision module and / or a localized temperature module, in order to guarantee further operating margins in terms of accuracy and reliability.

[0007] The mentioned technical task and the specified aims are substantially achieved by an extruder / micro-extruder device having the characteristics mentioned in one or more of the appended claims, and in any case disclosed hereinafter. Below is set forth the disclosure of a preferred but not exclusive embodiment of a device according to the invention, by way of example and not of limitation, of a device according to the invention, which is shown in the appended figures, wherein:

- figure 1 shows a partial cut through of the forming head according to the invention; and
- figures 2 and 3 show respectively two enlargements of the partial section illustrated in figure 1 from different angles.

[0008] With reference to the appended figures, the device according to the present invention basically comprises a main body 2 defining a passage cavity 2a and thus defining also an average outflow direction 2b: said main body 2 can be positioned at the end of an extrusion line, such that the passage cavity 2a is penetrable by an extrusion material.

[0009] The main body 2 defines in turn an input surface 3 (obtained on a first face of the main body 2), on which there is a plurality of entry areas afferent to the passage cavity 2a as well as an exit surface 4 (obtained on a second face of the main body, opposite to the first face) and defining a plurality of exit portions efferent from the passage cavity 2a and advantageously further comprising an expansion portion (4a) operatively associated with the exit surface (4) and adapted to mutually orient spontaneous expansive flows (or in currently used words in this technical field, the so-called expansive flows related to the "*die swell*" phenomenon) of the extrusion material through the exit surface (4) in reciprocal directions of mutual intersection.

[0010] In other words, the invention envisages making an extruder whose head has, along its axis of development, a portion of dimensions carefully shaped and calibrated so as to allow spontaneous reunion of the partial flows of material through the different passage openings: this reunion (or more accurately, the different local reunions radially distributed in the overall passage section) allows the creation of separation walls - by complementarity defining the passage openings of a multi-lumen extruded product - having thinnesses and mutual closeness ratios that would otherwise be impossible to define by directly imparting a forming through traditional passage openings (i.e. with such sizing that their cavities correspond identically to the "definitive" shape / section of the extruded product).

[0011] In order to further explain the present invention, reference should be made to the fact that usually a given shape / section made by extrusion derives from a passage opening which is exactly complementarily shaped to the desired shape / section: conversely, this invention

does not provide which are shaped exactly as definitive passage forms / sections that must be found in the finished extruded product, but teaches to realize the "voids" of the passage openings, also taking into account the typical dilatations of the polymer flows in the plastic state, occurring when the latter come out of structures with ducts having "bound" sections.

[0012] Going back now to the structural aspect of the invention, it can be seen in the accompanying exemplary figures that the expansion portion 4a is geometrically shaped according to a plurality of slots (4b) segmented and mutually arranged according to a matrix scheme: for example, such slots 4b can be shaped like an arc of circle or having a curved line, or still may be shaped according to substantially straight segments.

[0013] Thanks to the various possible combinations of the above-listed conformations, it is possible to obtain mutual intersections between spontaneous expansive flows (and therefore, as already mentioned above, it is possible to exploit the "*die swell*" phenomena) in a space defined by the expansion portion 4a in the absence of contact with walls of the expansion portion 4a itself.

[0014] Still at the level of realization possibilities, it should be noted that the expansion portion 4a can define, typically through a closed polygonal succession of slots (4b) shaped like an arc of circle or having a curved line, at least one coronal circumference having an average diameter smaller than a maximum diameter of a product achievable through the device 1: as a matter of facts, this section topology of the extruded product exploiting the present invention is rather critical to obtain with forming heads having a direct and two-way geometric correspondence between the surfaces of the extrusion openings and the shapes / sections of the extruded structures coming out of them.

[0015] If the topology of the extruded product is even more complex, the expansion portion 4a defines (for example, through a radial arrangement of slots 4b having substantially straight segments) at least one cross member radially arranged respect to at least a coronal circumference having an average diameter less than or equal to a maximum diameter of a product manufacturable through the device 1.

[0016] Still, it is possible according to the present invention that the passage cavity 2a is defined by a plurality of substantially parallel axial conduits, these axial conduits emerge at the central portions of the slots 4b defining the expansion portion 4a.

[0017] Conveniently and according to the requirements of the moment, the segmented slots 4b defining the expansion portion 4a can be geometrically interconnected at least in pairs in correspondence of the respective ends or can be geometrically separated, but placed in a mutual proximity relation, at least in pairs in correspondence of respective ends (so as to effectively exploit the *die swell* phenomena only where they are "locally" necessary in the overall section of the extruded product).

[0018] Also from the structural point of view, an guiding portion 3a may be present, which is

geometrically shaped according to a matrix scheme and is adapted to guide the extrusion material flows through the plurality of axial conduits defining the passage cavity 2a: in addition, where it is necessary the addition of "volumizing" material to define and keep stable the empty configuration of one or more passage openings in the extruded product, there may be appropriate insufflation means operatively active in the main body 2 and interposed between the axial conduits of the latter to enter a filler flow between the walls of the product manufacturable through the device 1 at least at the exit surface 4 (according to the technical implementation requirements, this filler flow can be of inert gas or air, or of an incompressible fluid or still of inert solid / granular fillers such as sand or sacrificial materials such as, for example, suitable polymers or aggregates which are then subjected to pyrolysis with relative elimination of the ashes... or more generally substances that can be chemically degraded and thus equally eliminated).

[0019] The invention achieves several advantages.

[0020] Firstly, thanks to the peculiar constructive architecture of the forming head, it is possible to operate with very high precision, defining a wide variety of passage openings arranged on multi-coronal radial schemes and with extremely thin walls and having a very high level of planarity (on the radial walls) or having a very high level of constancy of curvature (on the circumferential walls).

[0021] At the same time, the peculiar mode of cooperation of the various ducts of the device ensures optimal post-extrusion control of the product, which is maintained in a sufficiently stable form at least for the time during which the polymeric material is subjected to chemical-physical stabilization: in other words, the optimal mutual arrangement of the passages of the extrusion material and of those dedicated to the "filler flow" allow to maintain accuracy of processing and, with the appropriate modifications, a wide variety of conformations.

[0022] Moreover, the versatility of the present invention must be seen in two equally advantageous and possibly combinable aspects: one aspect is linked to the possibility of obtaining very complex multi-lumen internal architectures (and with passage openings of different shapes, not necessarily polygonal but also, for example, perfectly circular or in any case curvilinear) and the another aspect is that of obtaining multi-lumen tubes with "single-crown" arrangement but with extremely small dimensions.

[0023] Finally, it should be noted that the present invention allows to maintain low production costs of the device and also allows to obtain a high operating life: this makes possible an industrial process being highly efficient and having very rapid amortization, thus generating a further reduction of costs and a consequent increase in profitability.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

- JPH0393523B [0005]
- EP1938949A [0005]
- EP2138201A [0005]
- JP2016087971A [0005]

Patentkrav

1. Ekstruderingsindretning til rørformede flerlumenprodukter med flerkrans-anordning, omfattende:

- et hovedlegeme (2) som definerer et gennemgangshulrum (2a) og en gennemsnitlig udstrømningsretning (2b), idet nævnte hovedlegeme (2) kan positioneres ved enden af en ekstruderingslinje, idet nævnte gennemgangshulrum kan gennemtrænges af et ekstruderingsmateriale;
- en indgangsoverflade (3) dannet på en første side af hovedlegemet (2) og som definerer en flerhed af indgangsområder tilførende til nævnte gennemgangshulrum (2a); og
- en udgangsoverflade (4) dannet på en anden side af hovedlegemet, modsat nævnte første side, og som definerer en flerhed af udgangsområder udadførende fra nævnte gennemgangshulrum (2a),

kendetegnet ved, at:

den yderligere omfatter et ekspansionsafsnit (4a) funktionelt forbundet med udgangsoverfladen (4) og indrettet til indbyrdes at orientere spontane ekspansionsstrømme af nævnte ekstruderingsmateriale grundet matricekvældning, gennem udgangsoverfladen (4) i gensidige retninger med gensidigt skæringspunkt; og

- nævnte ekspansionsafsnit (4a) definerer en anordning af gennemgangsåbninger indrettet langs mindst to koncentriske kransomkredse med respektive differentierede radiusser, idet nævnte mindst to koncentriske kransomkredse definerer to respektive gennemsnitlige diametre, som er mindre end en maksimal diameter af et produkt, som er opnåeligt med indretningen (1).

2. Indretning ifølge krav 1, hvor nævnte ekspansionsafsnit (4a) er geometrisk udformet for at danne en flerhed af slidser (4b) segmenteret og gensidigt indrettet ifølge et matrixsystem, idet nævnte slidser (4b) omfatter et forudbestemt antal slidser (4b) udformet som en bue eller med en buet linje og et forudbestemt antal slidser (4b) med i alt væsentligt lige segmenter, idet de gensidige skæringspunkter af nævnte spontane ekspansionsstrømme grundet matricekvældning er i et område defineret af ekspansionsafsnittet (4a) i fravær af

kontakt med væggene af ekspansionsafsnittet (4a).

3. Indretning ifølge kravene 1 eller 2, hvor ekspansionsafsnittet (4a) definerer nævnte mindst to koncentriske kransomkredse gennem en lukket polygonal rækkefølge af slidser (4b) udformet som en bue af cirkler eller med en buet linje.

4. Indretning ifølge kravene 1 eller 2, hvor ekspansionsafsnittet (4a) definerer nævnte mindst to kransomkredse gennem en radial anordning af slidser (4b) med i alt væsentligt lige segmenter, idet mindst et tværelement er indrettet radialt i forhold til mindst en af nævnte kransomkredse med en gennemsnitlig diameter, som er mindre end eller lig med en maksimal diameter af et produkt, som kan fremstilles med indretningen (1).

5. Indretning ifølge et hvilket som helst af de foregående krav, hvor gennemgangshulrummet (2a) er defineret af en flerhed af i alt væsentligt parallelle aksiale ledninger, idet nævnte aksiale ledninger fremstår ved midterste afsnit af slidserne (4b), som definerer ekspansionsafsnittet (4a).

6. Indretning ifølge et hvilket som helst af de foregående krav, hvor de segmenterede slidser (4b), som definerer ekspansionsafsnittet (4a), er geometrisk indbyrdes forbundet, i det mindste parvist, ved respektive ender.

7. Indretning ifølge et hvilket som helst af de foregående krav, hvor de segmenterede slidser (4b), som definerer ekspansionsafsnittet (4a), er geometrisk adskilt, men indrettet i et gensidigt nærhedsforhold, i det mindste parvist, ved respektive ender.

8. Indretning ifølge et hvilket som helst af de foregående krav, hvor der også er et føringsafsnit (3a) geometrisk udformet ifølge et matrixmønster, og indrettet til at føre ekstruderingsmaterialestrømme gennem nævnte flerhed af aksiale ledninger, som definerer gennemgangshulrummet (2a).

9. Indretning ifølge et hvilket som helst af de foregående krav, hvor der også er indblæsningsorganer, som er funktionelt aktive i hovedlegemet (2) og anbragt mellem de aksiale ledninger af sidstnævnte for at indføre en fyldstofstrøm mellem

væggene af produktet, som kan fremstilles med indretningen (1), i det mindste ved udgangsoverfladen (4).

10. Indretning ifølge krav 9, hvor nævnte indblæsningsorganer er indrettet til at fremføre et flydende fyldstofmateriale, fortrinsvis i den gasformige form, eller et fyldstofmateriale i den faste form, som kan udledes fortrinsvis ved pyrolyse eller kemisk nedbrydning, idet nævnte fyldstofmateriale definerer nævnte fyldstofstrøm.

DRAWINGS

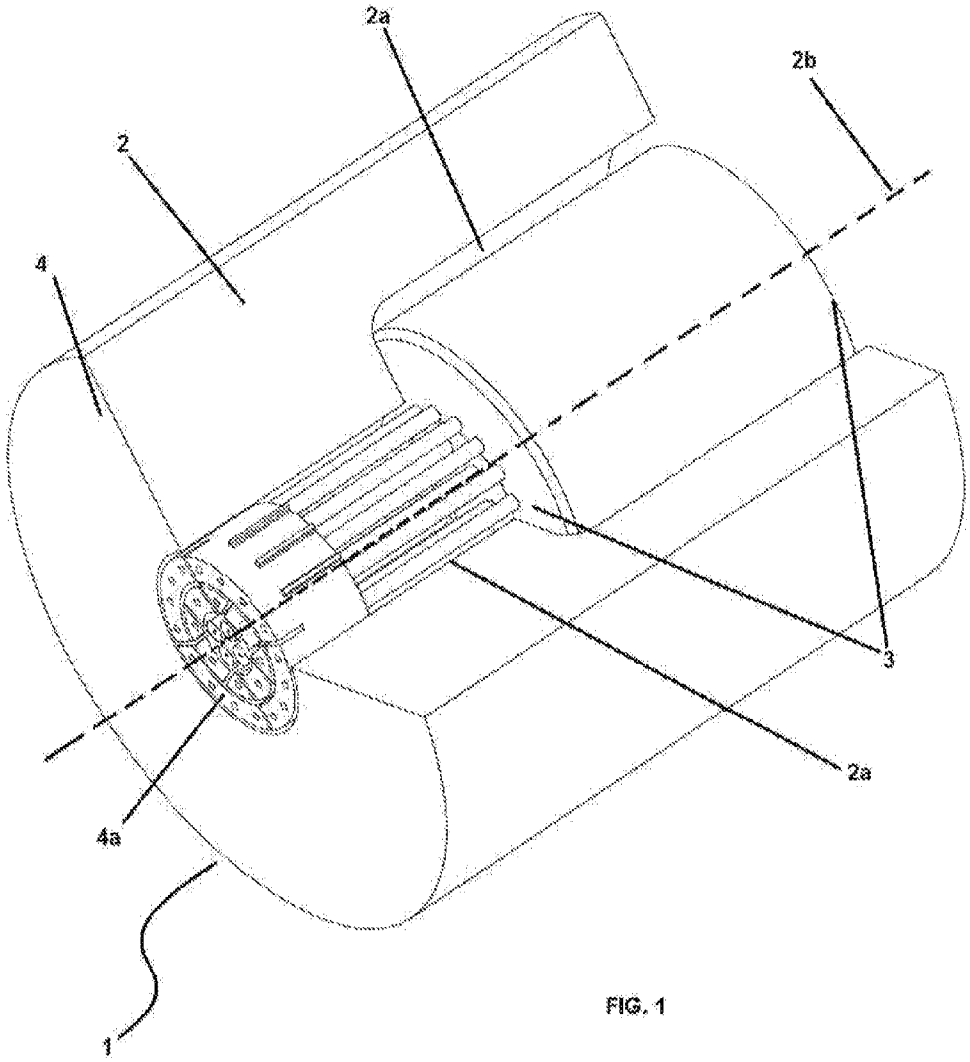

FIG. 1

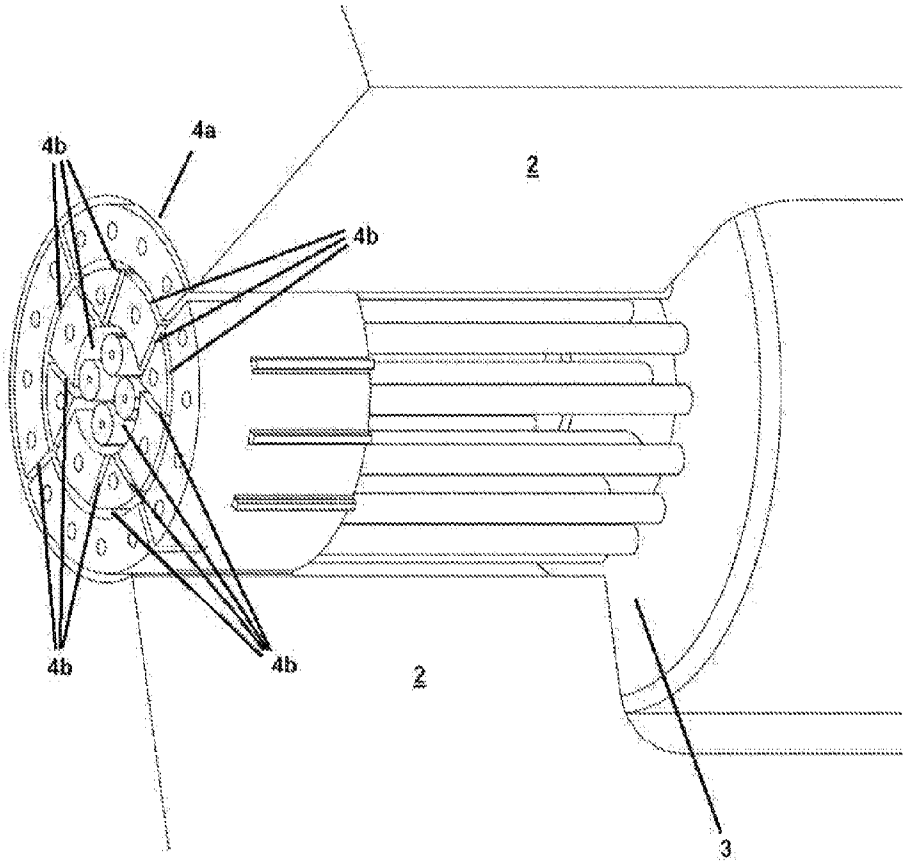

FIG. 2

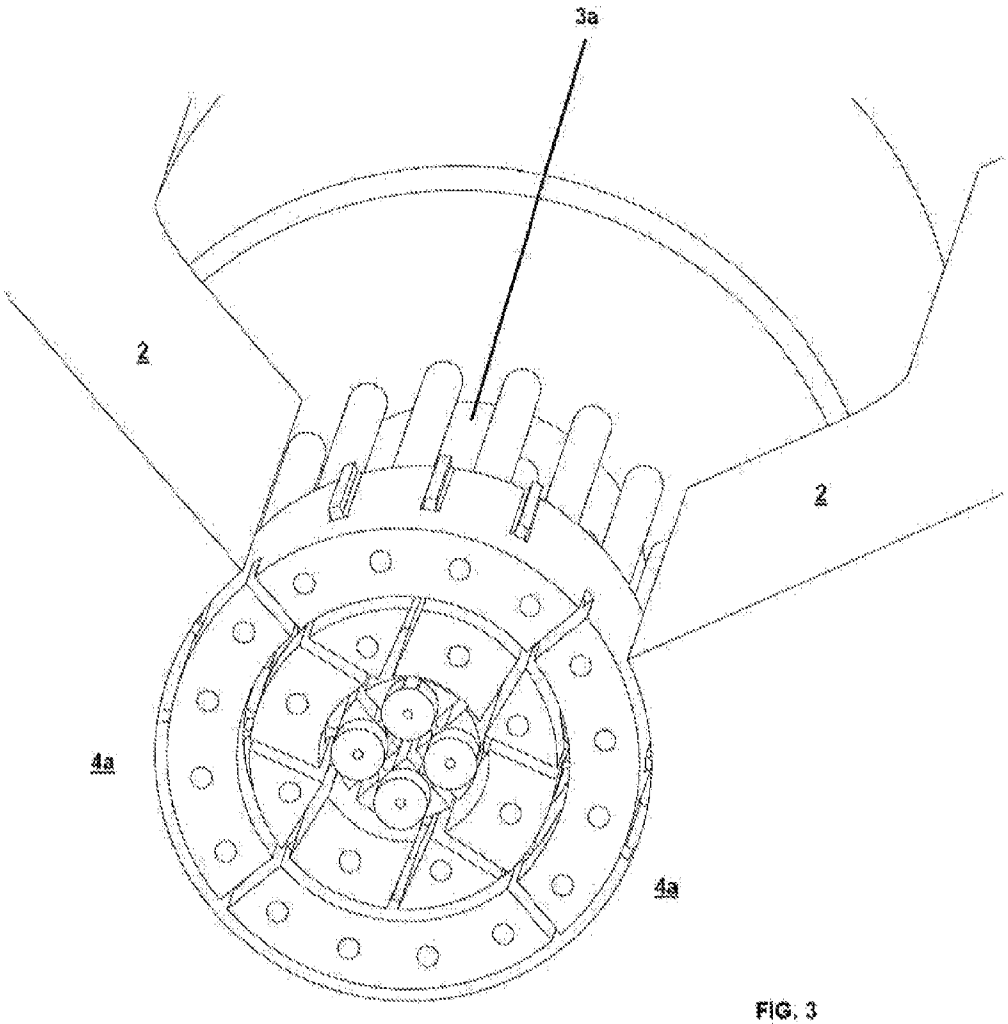

FIG. 3