

The present invention relates to a drying process for increasing the filling capacity of tobacco material.

Flow-drying cut tobacco by technologically sophisticated means, in which the tobacco material intended for drying is dried in a stream of hot drying gas, involves achieving a combination of objectives in the process which are contradictory in part and thus the best solution technologically is to aim at achieving an optimum of the relevant target functions. These differing functions may be grouped together into three groups relating to the product and process characteristics. The group of the physical product properties substantially covers the target functions of a good tobacco filling capacity for a relatively low cigarette draw resistance and a low degradation, resulting in stable cigarette ends. The chemosensorial properties of the product form the second group, the optimum of which is characterized by high aroma retention, low influence on components and satisfactory smoke flavour. The third group required for optimum procedure is that of a minimum energy consumption and minimum exhaust gas emissions from the point of view of environmental protection.

The individual target functions of the three different objective groups are governed substantially by the process parameters set forth in the following Table, i.e. the moisture content of the tobacco before and after drying, the local heat-transfer and mass-transfer coefficients between the surface of the tobacco and the surrounding drying gas during the treatment, and the specific heat of the drying gas.

Table

Product property Process parameters	Tobacco filling capacity draw resistance cig. end stability	Smoke flavour, components, aroma retention	Minimum energy consumption, low emissions
Tobacco moisture prior to drying	max. possible approx. 40 % for cut lamina, on wet-weight basis	cut moisture preferred; i.e. 18-20 % for cut lamina on wet-weight basis	min. possible difference in moi- sture
Tobacco moisture after drying	min. possible	min. 12 % (cig. moisture)	min. possible exhaust air temp.
Local heat- and mass-transfer coefficients	max. possible during treatment	min. possible during treatment	
Specific heat of drying gas	max. possible, e.g. high water vapour content	min. water vapour content to avoid steam distillation	high water vapour content

Optimum physical product properties are achieved by a relatively high tobacco moisture content prior to drying; as a guide 40%, on a wet-weight basis, should be regarded as an upper limit in practice; furthermore a relatively low tobacco moisture content after drying, maximum possible local heat-transfer and mass-transfer coefficients during the treatment and as high as possible a specific heat of the drying gas, which can for example be achieved by a high water vapour content. By contrast, optimum chemosensorial product properties require the moisture content of the tobacco before drying to correspond substantially to that of usual cut tobacco of about 18% to 20% on a wet-weight basis, and the moisture content of the tobacco after drying is not to be less than that as usual in the cigarette, i.e. about 12%, again on a wet-weight basis. The local heat-transfer and mass-transfer should be kept as low as possible during drying; likewise to avoid steam distillation, the water vapour content in the drying gas should also be kept as low as possible. The required process characteristics to minimise environmental pollution are represented by maintaining the temperature of the exhaust air as low as possible and the difference in the moisture content of the tobacco material before and after drying as low as possible as well as ensuring a water vapour content in the drying gas.

From DE 34 41 649 A1 a process is known for reducing the moisture content of expanded tobacco, whereby the expanded tobacco is dried in a dryer by hot gas at a temperature within a range of about 340°C to about 510°C. The residence time within one or more series-connected dryers is dimensioned so that a tobacco product is obtained having a moisture content of about 3% to about 16% with respect to the weight at the dryer output. In particular, the temperature of the drying gas is kept constant within the dryer at about 510°C.

DE 31 47 846 A1 teaches a process for improving the filling capacity of tobacco material by expanding the moist tobacco material by pressure reduction and subsequent drying to the moisture content required in processing, the tobacco material having a moisture content of 15% to 80% thereby being dried to a moisture content of 2% to 16% in each case with respect to the moist tobacco material. The

temperature of the drying gas is between 50°C and 1000°C and preferably is above 100°C. An expansion apparatus is arranged upstream of a drying section and either separated from said drying section or connected thereto to form a unit. Due to the tobacco material to be dried having an extremely short residence time in the expansion apparatus, the drying within the expansion apparatus itself can be ignored.

A further process for increasing the volume of shredded stems by impregnation with an impregnating agent containing at least water with subsequent heating of the impregnated shredded stems by a steamed drying gas is known from DE 30 37 885 A1. The drying gas has a temperature of about 105°C to about 250°C. The shredded stem particles are transported by means of a pneumatic transport system through an expansion zone and a drying zone where they are held for at least roughly 10 seconds and dried to a final moisture content of at least 12.5% by weight. The speed at which the shredded stems are transported is preferably reduced in the vertical direction in a cross-sectional widening of the drying zone so that only the shredded stems which have been dried to a specific degree are further transported.

In a process known from DE 32 46 513 A1 for drying and loosening cut tobacco the tobacco is introduced into a conduit, through which a stream of gas containing steam and air is conducted at a velocity of more than 30 m/sec at a temperature in the range of approx. 260°C to 370°C. The conduit comprises an elongated tube having a first and second section in tandem array, the first section having a smaller cross-sectional area than the second so that the pressure in this region decreases when the gas passes therethrough. Within the conduit the tobacco is continuously accelerated, but without attaining the velocity of the gas stream.

Prior art processes for improving the filling capacity of tobacco material partly involve the tobacco being impregnated with a vaporizable liquid or a liquified gas, for example, water, CO₂, organic solvents, Freon and the like, the impregnating agent subsequently being vaporized or sublimed. This process has the drawback, however, that although it furnishes an expanded product having improved filling

capacity, the tobacco structure generated is not particularly stable. On the contrary, cigarettes having these products have been observed to hot collapse, meaning the collapse of the tobacco structure during smoking.

DE-PS 31 30 778 discloses a process for increasing the filling capacity of tobacco material by a so-called shock treatment in which suitably conditioned tobacco material is dried in a high-velocity stream of hot gas within a very short time, namely in less than 1 second. Due to this shock-like treatment, the surface of the tobacco dries within an extremely short time and forms a shell of sorts supporting the tobacco which is still moist within. Although satisfactory physical product properties can be achieved with this process, the chemosensory and economical/ecological aspects are largely ignored.

It is, therefore, an object of the invention to provide a process of the type according to the preamble in which the disadvantages of prior art are eliminated, thereby improving in particular the physical and chemosensory properties of tobacco material used in filling cigarettes, and in a particularly preferred embodiment of the invention, thereby maintaining pollution of the environment resulting from such a process at a minimum.

This object is achieved by the subject matter of claim 1.

Further advantageous embodiments of the present invention are disclosed by the features of the subsidiary claims.

The advantages achieved by the process according to the invention are based on the fact that within a drying section in which the tobacco material is conducted for drying in a stream of hot gas, the coefficients of local heat-transfer and material-transfer of pretreated, i.e. cut and moistened tobacco material, continually decrease from very high values at the beginning of the drying section to comparatively low values at the downstream end of the drying section, in flowing therethrough. As a

result, as in the aforementioned shock treatment, the surface of individual tobacco cuttings is fixed very rapidly so that a shell serving as a sort of "corset" for the still moist tobacco material is formed. In the further course of the drying procedure the convection between the surface of the tobacco and the hot gas surrounding it is reduced by retarding the flow velocity of the hot gas and of the tobacco material, however, as a result of which the local heat-transfer and mass-transfer coefficient between the tobacco material and the hot gas is reduced. Governing the procedure in this way ensures, on the one hand, that the initially dried and fixed surface of the tobacco fibre volume enlarged in the moistening process remains dry in the course of the further drying although moisture from the fibre interior continuously diffuses to the fixed surface and, on the other, that the drying is not intensive enough for the tobacco material to be overheated and undesirably affected as regards flavour.

According to the invention, governing the process is also dictated by specifying the maximum velocity and maximum temperature of the drying gas at the end of the drying section, specifying such process parameters according to the invention at the outlet end needing to be viewed in close relationship with the values of the same parameters at the inlet end of the drying section. These pairs of values of the parameters governing the process at the inlet and outlet ends of the drying section are the result of having optimized implementation of drying the tobacco whilst satisfying the objective functions of the physical and chemosensorial properties of the product and as regards energy savings which in turn helps in reducing environmental pollution. The process according to the invention is distinguished by specifying pairs of values in the form of minimum and maximum values at the start and end of the drying procedure, whereas the processes known from prior art remain very vague in this respect and, in particular, fail to specify such process parameters essential to certain points within the drying apparatus.

Furthermore, a rapid drop in the temperature of the drying gas is achievable due to the mass-ratio of drying gas and tobacco material being relatively low and the resulting large area of heat-transfer and material-transfer, thus further counteracting

overheating the tobacco. The energy consumed by drying can be kept small because the amount of drying gas to be heated is comparatively small and, as will be further explained, the resulting low temperature of the drying gas at the end of the drying process reduces the energy consumption to a minimum. Expediently, this mass-ratio of drying gas to tobacco is set to values between 1 and 3.

In one means of controlling the process according to the invention the local heat-transfer coefficient at the start of drying is between 800 and 1000 J/sm²K and at the end of the drying process between 120 and 180 J/sm²K. As a further essential parameter of the process the local mass-transfer coefficient is preferably 1 to 2 m/s at the start and 0.15 to 0.25 m/s at the end of drying.

Yet a further parameter influencing the local heat-transfer and mass-transfer coefficients is the velocity of the hot gas in flowing through the drying section which is retarded from a value between 30 and 100 m/s, preferably between 40 and 100 m/s, to not more than 15 m/s, preferably to a value between 8 and 15 m/s.

In addition to the comparatively high proportion of tobacco in the combined stream of drying gas and tobacco material, as evident from a glance at the energy balance, a low temperature of the drying gas after drying also contributes towards keeping the energy consumption low. Neglecting the loss of energy to the environment and the heat in evaporating the tobacco contents, energy is mainly required to evaporate the water contained in the tobacco material. The thermal efficiency serving to characterize the efficiency of drying can be represented by the formula

$$\text{thermal efficiency} = \frac{\text{evaporated amount of water} * \text{heat of evaporation}}{\text{energy supplied}}$$

From the energy balance, the energy supplied is:

$$mc_p T_{out} + \Delta m_w h_w$$

where:

- m : exhaust gas amount
 c_p : mean specific thermal capacity of the exhaust gas from 0°C to T_{out}
 T_{out} : temperature of the drying gas at the end of drying
 Δm_w : evaporated water amount
 h_w : heat of evaporation at 0°C ,

so that the thermal efficiency is given by:

$$\eta_{th} = \frac{\Delta m_w h_w}{mc_p T_{out} + \Delta m_w h_w}$$

It is clear from this simple estimate that the thermal efficiency is the better the lower the exhaust air amount and temperature. According to the invention the exhaust air temperature is to be set to less than 130°C , preferably 100°C to 130°C . By the process according to the invention efficiencies can thus be achieved of up to 85%, certainly not less than 80%.

To reduce the amount of exhaust gas and/or the energy consumption, the major proportion of the drying gas separated from the dried tobacco in a separating apparatus, for example a tangential separator or a cyclone, is heated to advantage via a directly or indirectly heated hot gas generator and recycled for further drying. To minimize pollution of the environment by exhaust gas emissions the remaining minor proportion of the drying gas with the evaporated tobacco components dispersed therein is processed according to the invention environmentally compatible in a biological exhaust gas scrubber, the investment and operating costs of which rise more or less in direct proportion to the amount of exhaust gas to be scrubbed.

Further features of the invention and the advantages achievable thereby will be apparent from the description of a preferred example embodiment and the drawing, in which:

Figure 1 is a schematic illustration of a drying apparatus suitable for carrying out the process according to the invention.

Via a supply conduit 2 cut tobacco material is introduced into a moistening means 4 to which water is supplied via a feeder 6.

The moistening means 4 may, for example, be formed by a moistening cylinder or a moistening tunnel. In the moistening means 4 the tobacco material is brought to a moisture content of 18% to 40% on a wet-weight basis. The resulting swelling process causes the volume of tobacco material to increase. The result of this moistening treatment may be additionally further improved by means of steam 5. Thereafter the moistened tobacco material is conveyed via a gas-tight lock 8 into a pneumatic drying section 12. The drying section 12 consists substantially of two vertical interconnected sections 10, 14. At the inlet point 9 of the drying section 12 the tobacco material is introduced into a stream of drying gas which flows from the top to the bottom through the drying section 12 shown vertically upright in the apparatus illustrated. Apart from the process explained here in which the tobacco material and the drying gas are in down flow, such a drying section 12 may fundamentally have any desired orientation.

At the inlet point 9 the temperature of the drying gas previously heated in the hot gas generator 20 is 200°C to 600°C and its flow velocity is 40 to 100 m/s. At the inlet point 9 the drying gas has a water vapour content of 20 to 90 mass percent and the mass-ratio of the drying gas to the tobacco material here is between 1 and 3, these values equating as follows:

$$\frac{\text{mass flow of tobacco material}}{\text{mass flow of hot gas}} \times 100 = \text{mass percent}$$

At this point an extremely high local heat-transfer and mass-transfer very quickly takes place between the drying gas and the moistened tobacco material, due to the high velocity of the drying gas relative to that of the tobacco material in conjunction with the high drying gas temperature and its water vapour content, producing a heat-transfer coefficient a of approx. 800 to 1,200 J/sm²K and a mass-transfer coefficient b of approx. 1 to 2 m/s. This high heat-transfer and mass-transfer results in superficial drying and fixing of tobacco fibre volume swollen in the moistening process. In the further course of the process, drying is then controlled so that, on the one hand, the tobacco surface remains dry to prevent softening of the fixed surface due to subsequent diffusion of water from within the fibre, whilst on the other, drying is not too intensive to prevent any overheating and its attendant negative effect on the flavour of the tobacco. To prevent this happening, the tobacco material is accelerated in the short first portion 10 of the drying section 12, which may be configured as a simple length of tube, to more or less the velocity of the drying gas, leading or trailing merely by the sinking rate of the tobacco particles. Due to the decreasing velocity of the drying gas relative to that of the tobacco material, heat-transfer and mass-transfer during acceleration is continually diminished. In the subsequent second portion 14 of the drying section 12 the drying gas, and in common therewith the tobacco material, is retarded, thus resulting in the convection at the surface of the tobacco being further reduced. During retardation the relative velocity and thus the heat-transfer and mass-transfer between the tobacco material and the hot gas continuously decreases with progressive drying. For this purpose portion 14 of the drying section 12 has a cross-sectional area at its downstream end which is three to five times larger than the cross-sectional area of portion 10 and thus at the downstream end of portion 14 a local heat-transfer coefficient $a = 120$ to 180 J/sm²K and a local mass-transfer coefficient $b = 0.15$ to 0.25 m/s, as well as a tobacco moisture content of 12% to 15% on a wet-weight basis, a drying temperature of 100°C to 130°C and a drying gas velocity of 8 to 15 m/s materialize.

Furthermore, the reduction of the local heat-transfer and mass-transfer coefficients within the drying section 12 is promoted by the low mass-ratio of 1 to 3 of drying gas to tobacco material and as a consequence by the large heat-transfer and mass-transfer area.

To increase the steam content of the drying gas, steam 27 may be additionally introduced into the cycle of the drying gas via a shutoff valve 31, although this can be avoided by carefully sealing off the circuit from any infiltrating air.

The dried tobacco material is then separated from the drying gas via a separating means 16, for example a cyclone or a tangential separator, and discharged from the drying apparatus 1 via a further gas-tight lock.

The drying gas separated from the tobacco material in the separating means 16 is led through a fan 22, a conduit 38, 42, 44 to the hot gas generator 20 and heated to the original drying gas temperature of 200°C to 600°C. This hot gas generator 20 may be heated optionally directly or indirectly so that the stream of drying gas returned via conduit 44 can be both directly mixed with additional hot drying gas and heated in direct heat exchange by a suitable heating medium, whereby hot drying gas may also be employed as such a heating medium.

At the location 36 a minor proportion of the drying gas, namely its exhaust gas proportion, is forwarded by a fan 24 via an exhaust gas conduit 29 and a control valve 30 to a scrubber 28, and subsequently to a biological emission control apparatus 29.



Patent Claims

1. A drying process for increasing the filling capacity of tobacco material in which
 - a) the cut and moistened tobacco material is conveyed in a drying gas flow, dried within a tubular drying section (12) and thereafter separated from the drying gas,
 - b) the drying gas at a feed means (9) into said drying section (12) has a temperature of at least 200°C and a flow velocity of at least 30 m/s and
 - c) the flow velocity of the drying gas is reduced in said drying section (12)

characterized in

- d) that the flow velocity of the drying gas at said feed means (9) is at the most 100 m/s;
 - e) that to reduce the local heat-transfer coefficient and the local mass-transfer coefficient between the surface of the tobacco material and the surrounding drying gas with the reduction of the flow velocity of the drying gas the flow velocity of the tobacco material in said drying section (12) is also reduced;
 - f) that the flow velocity of the drying gas at the end of said drying section (12) is at the most 15 m/s; and
 - g) that the drying gas at the end of said drying section (12) has a temperature of at the most 130°C.
2. The process as set forth in claim 1, characterized in that the local heat-transfer coefficient at the start of the drying is 800 to 1000 J/sm²K and at the end of the drying is 120 to 180 J/sm²K.
3. The process as set forth in any of the claims 1 or 2, characterized in that the local mass-transfer coefficient at the start of the

drying is 1 to 2 m/s and at the end of the drying is 0.15 to 0.25 m/s.

4. The process as set forth in any of the claims 1 to 3, characterized in that the ratio of the masses of drying gas to tobacco material during the drying is 1 to 3.
5. The process as set forth in any of the claims 1 to 4, characterized in that the drying gas has at the end of said drying section (12) a flow velocity of at least 8 m/s.
6. The process as set forth in any of the claims 1 to 5, characterized in that the retardation of the flow velocity of the mixture of drying gas and tobacco material is effected by cross-sectional widening and/or temperature reduction.
7. The process as set forth in any of the claims 1 to 6, characterized in that the reduction of the local heat-transfer coefficient and of the local mass-transfer coefficient takes place in less than 1 second.
8. The process as set forth in any of the claims 1 to 7, characterized in that, at the start of drying, the drying gas has a water vapor content of 20 to 90 mass percent.
9. The process as set forth in any of the claims 1 to 8, characterized in that water vapor is supplied to the drying gas.
10. The process as set forth in any of the claims 1 to 9, characterized in that at the start of said drying section (12) the drying gas has a temperature of at the most 600°C and at the end of said drying section (12) has a temperature of at least 100°C.



11. The process as set forth in any of the claims 1 to 10, characterized in that the tobacco at the start of the drying has a moisture content of 18% to 40% and the dried tobacco content has a moisture content of 12% to 15%, in each case with respect to the moist tobacco material.
12. The process as set forth in any of the claims 1 to 11, characterized in that the thermal efficiency of the drying is at least 80%.
13. The process as set forth in any of the claims 1 to 12, characterized in that the mixture of drying gas and tobacco material is separated after the drying and a major proportion of the drying gas is returned to the drying operation, and preferably a minor proportion of the drying gas is purified in a biological exhaust purification apparatus.
14. The process as set forth in any of the claims 1 to 13, characterized in that the drying gas to be supplied to the drying operation is heated to its operating temperature in a hot gas generator which is heatable selectively directly or indirectly.
15. The process as set forth in any of the preceding claims, characterized in that to reduce the flow velocity of the drying gas a tubular drying section (12) for conducting the mixture of drying gas and tobacco material is employed, having at its downstream end (14) a cross-sectional area which is 3 to 5 times larger than the cross-sectional area at the upstream end (9) of said drying section (12).

