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(54) Title:  METHOD OF INCLUDING FEATURES IN AN ARTICLE MANUFACTURED FROM MARAGING STAINLESS STEEL

(57) Abstract:  A method for including a feature in an article manufactured from a maraging stainless steel comprises the steps of focusing an energy beam on the article at a temperature of at least 1000 °C in a nitrogen-free atmosphere. The beam generates intense energy and melts/vaporizes the maraging stainless steel and thus includes the feature along with austenitic edges. The article is cooled to a temperature of between 0 °C and -80 °C, in order to subject the austenitic edges to the isothermal martensitic transformation. The article is finally hardened at a temperature between 375 °C and 600 °C to cause particles in the edges to precipitate out from solution into martensitic structure. A centrifugal bowl comprises a base that can rotate about an axis of rotation. A filter sieve in the shape of a perforated peripheral side sieve wall extends from an open end to the base, and a plurality of vanes is disposed in a predominantly radial direction on the inner surface of the perforated peripheral side sieve wall.

FIG. 11a

FIG. 11b
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Method of including features in an article manufactured from maraging stainless steel

FIELD OF THE INVENTION

This invention relates to a method of including features in an article manufactured from a maraging stainless steel, and to uses of such a method.

BACKGROUND OF THE INVENTION

In case of a conventional martensitic chromium stainless steel, including features in an article by laser melting, by focusing an electron beam or the machining process of electrical discharge machining affects material properties of a heat affected zone in a negative way. The heat affected zone, located in-between the feature and an unaffected base material of the article, loses locally its corrosion resistance. This loss of corrosion resistance is caused by local precipitation of chromium carbides, which results in a depletion of the chromium content in the matrix to a level below the corrosion resistance threshold.

Precipitation-hardening stainless steel such as Sandvik Nanoflex™ steel is used for manufacturing of articles which are used in wet and corrosion prone environment. Laser melting of specific features on Sandvik Nanoflex™ parts and laser cutting of specific hole-patterns or other shapes in Sandvik Nanoflex™ parts like rotary shaving caps and cutters and other shaving and cutting elements is an interesting machining or shaping technique compared to other conventional or unconventional machining technologies. However, laser cutting and laser melting result a loss of hardness and strength in the heat affected zones of laser melted features, in the features and at the laser cut edges.

This loss is typically restored to a proper level by giving the article a hardening heat treatment as disclosed in EP 1216311. This document discloses a method for the manufacture of steel products and products thus produced, wherein steel is subjected to isothermal martensitic formation and precipitation hardening in a martensitic structure subsequent to soft annealing and shaping. The method steps include shaping followed by solution annealing between 1050 °C and 1200 °C, quenching from the solution annealing temperature with a quenching speed of at least 5 °C per second to a temperature below
500 °C, subjecting said steel to an isothermal martensitic transformation and subsequently hardening the steel at a temperature between 450 °C and 550 °C to precipitate particles in said martensitic structure.

Restoring the properties of the heat affected zone by such a hardening treatment will actually be a re-hardening heat treatment, because the articles are often already hardened to minimize burr formation during machining and grinding upfront in a manufacturing process. However such a full (re-)hardening heat treatment can cause significant distortion of the overall initial dimensional accuracy (straightness and flatness).

SUMMARY OF THE INVENTION

It is therefore advantageous to have a method for including a feature in an article without losing the dimensional accuracy of the article while restoring the hardness, strength and corrosion resistance of the heat affected zone.

A first aspect of the invention provides a method for including a feature in an article, wherein the article is manufactured from a maraging stainless steel, which method comprises the steps of:

- focusing an energy beam on the article at a temperature of at least 1000 °C in a nitrogen-free atmosphere, wherein the beam is configured for generating intense energy and for melting/vaporizing the maraging stainless steel in order to include the feature along with austenitic edges;
- cooling the article to a temperature between 0 °C and -80 °C in order to subject the austenitic edges to an isothermal martensitic transformation; and
- hardening at a temperature between 375 °C and 600 °C to cause particles in the edges to precipitate out from solution into martensitic structure.

The feature is created in the article by focusing an energy beam on the article in a nitrogen free atmosphere. Nitrogen is a strong austenite stabilizing element. Nanoflex™ should contain a maximum of 0.012 wt% nitrogen. Any additional pickup of nitrogen will block the transformation to martensite fully, leaving the material in the soft austenitic condition.

The energy beam can melt the material and can create smoothly rounded off tips. This beam can vaporize the material and can create slots or holes in the article. After the feature is included in the article, the article is cooled to ambient temperature.
Steel subjected to a sensitizing procedure alleviates thermo-mechanical stresses which would otherwise build up internally in the article. The reduced internal thermo-mechanical stresses enable the manufacture of the article with a very accurate size and which is stable in use.

Accordingly, a method for the manufacture of articles according to the invention is further characterized by subjecting the free cooled steel to an isothermal martensitic transformation by holding the steel at a temperature between 0°C and -80°C for at least one hour.

The final aging process step will harden the article along with the isothermally transformed martensite edges formed in the laser-melted or laser cut features. The article is pre-aged upfront the manufacturing process to minimize burr formation during conventional machining processes. Subjecting the article twice to an aging treatment is not disadvantageous, as Nanofix™ steel is to a high degree not susceptible to over-aging. In this way the article will retain its as-received martensite content of cold rolling or original thermal hardening and also maintains its dimensional accuracy.

A method according to a preferred embodiment of the invention comprises the following steps:

a. focusing the energy beam on the article at a temperature of 1400°C to 1600°C for a period in a range of 10^{-7} seconds to ten seconds in the nitrogen-free atmosphere;

b. cooling the article to an ambient temperature in order to sensitize the austenitic edges and thereby initiating a following isothermal martensitic transformation;

c. subjecting the article to a further cooling at a temperature of between -30°C and -50°C for a period of at least an hour, in order to subject the austenitic edges to the isothermal martensitic transformation; and

d. hardening at a temperature between 450°C and 550°C for at least 3 minutes to cause particles in the edges to precipitate out from solution into martensitic structure.

As to step a of this embodiment, while a temperature of 1000°C will do, the lower the temperature is below 1400°C, the smaller the driving force for the eventual transformation from austenite to martensite. The upper boundary of the temperature range is more arbitrary, but heating above the steel melting point of 1600°C is not relevant to the present invention. This explains a preference for the range between 1400°C and 1600°C.
As to steps b and c of this embodiment, it is important to reach a temperature below 0 °C within a reasonable period of time so as not to jeopardize the effectiveness of the isothermal martensite transformation. While a martensite transformation still works at 0 °C or -80 °C (though slowly, and thus requiring a longer period at which the article is kept at that temperature), it works more efficiently in the temperature range between -30 °C and -50 °C, and preferably at -40 °C.

As to step d of this embodiment, while the hardening still works at 600 °C, it appears that above 550 °C, an excessive precipitation growth (over-aging) occurs to an increasing extent, which explains the preferred upper limit of 550 °C. As regards the lower limit, while the maximum strength is obtained at temperatures above 375 °C, at temperatures above 450 °C it takes less time to achieve the desired final hardness of 500 HV or more.

According to an embodiment of the invention, the energy beam is a laser beam or an electron beam.

According to another embodiment of the invention, the cooling of the article to the ambient temperature comprises the steps of:

a. free cooling the article from around 1600 °C to 1300 °C;

b. halting the cooling at a temperature between 1300 °C and 900 °C for at least 30 seconds in order to destabilize the austenitic edges and thereby optimizing initiation of a following isothermal martensitic transformation;

c. subjecting the article to a further cooling from 900 °C to 500 °C maintaining a cooling rate of at least -5 °C/s; and

d. subjecting the article to free cooling from 500 °C to ambient temperature;

The article is subjected to a free cooling from 1600 °C to 1300 °C. The word "free cooling" in the context of invention means natural cooling in a protective environment without a need for a specific rate of cooling. The advantage of the free cooling over a fast quenching is that the free cooling retains more dimensional accuracy of the article than the fast quenching. The free cooling is gentler to retain an original dimensional accuracy of the article.

The cooling temperature is halted between 1300 °C and 900 °C for at least 30 seconds. This is a sensitizing procedure and allows an initiation of the martensitic transformation to become optimal.
Later the article is subjected to a further cooling from 900 °C to 500 °C at the rate of at least -5 °C/s. This is approximately the cooling rate necessary to get the martensite transformation. Then the article is subjected to the free cooling till it reaches the ambient temperature.

According to an embodiment of the invention, the melting/vaporizing is carried out in presence of a protective noble gas. An important requirement is the nitrogen-free atmosphere during the laser melting or cutting process, which may be effected by fully shielding the articles with a protective inert noble gas, like for instance Argon gas, to prevent any nitrogen pickup from air into the Nanoflex™ steel.

According to a preferred embodiment of the invention, the feature includes pearls, holes, slots and/or the like. Laser melting of Sandvik Nanoflex™ parts creates pearls and laser cutting creates specific hole-patterns or other shapes in Sandvik Nanoflex™ parts like rotary shaving caps, cutters and other shaving and cutting elements.

A further object of an embodiment of the invention is to provide a method of manufacture of an article exhibiting a combination of superior strength, corrosion resistance and ductility. Such a method is further characterized in that the steel comprises chromium (Cr) in a weight percentage between 10 % and 20 %. Generally, martensitic steels with a low weight percentage of carbon, so-called maraging steels, may be with or without chromium. Corrosion resistant maraging steels comprise a weight percentage of chromium between 10.5 and 18 %. A particular type of maraging steel, which may be obtained by the method according to the invention, contains in weight percentage 10-20 % Cr, 7-10 % Ni, 3-6 % Mo, 0-9 % Co, 0.5-4 % Cu, 0.05-0.5 % Al, 0.4-1.4 % Ti and less than 0.03 % C and N.

According to a further embodiment of the invention, the above mentioned method is used for manufacturing a steel product having a homogenous hardness of at least 450 Hardness Vickers (HV).

According to a still further embodiment of the invention, the article is a cap of an electric rotary shaver. It can be a cutter of an electric rotary shaver. During hair trimming, teeth that cut the hair are in direct contact with human skin. For enhancement of the skin comfort it is beneficial to provide the teeth of the guard and the cutter with smoothly rounded off tips. An efficient method to realize this is laser melting of the tips of the trimmer teeth such that rounded pearls are formed in the front tip of the teeth. This method is suitable for many types of steel and stainless steel.
The article can be a cutter, a knife or a spring in a domestic appliance. The article may be a medical or a dental instrument. The article may also be a diaphragm plate spring in a fluid valve. In general, the article can be any domestic appliance where there is direct contact between the skin and the steel.

The present invention will now be explained in greater detail with reference to the figures, in which similar parts are indicated by the same reference signs.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates loss of hardness in a laser melted pearl;
Fig. 2a illustrates several laser melted pearls in row on front of trimmer teeth;
Fig. 2b illustrates an exploded view of a laser melted pearl of Fig. 2a;
Fig. 3a illustrates front view of several laser melted pearls in row of trimmer teeth;
Fig. 3b illustrates an exploded front view of a laser melted pearl of Fig. 3a;
Fig. 4 illustrates a shaving cap with patterns of holes and slots; and
Fig. 5 illustrates cross section of two laser cut holes showing austenitic edges at an original martensitic article.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto. Any reference signs in the claims shall not be construed as limiting the scope. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. Where the term "comprising" is used in the present description and claims, it does not exclude other elements or steps. Where an indefinite or definite article is used when referring to a singular noun e.g. "a" or "an", "the", this includes a plural of that noun unless something else is specifically stated.

Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.
Moreover, the terms top, bottom, over and the like in the description and the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other orientations than described or illustrated herein.

Fig. 1 is a graph plotted with hardness on y-axis and position on x-axis. The position in the graph is defined as the distance in mm between a feature included in an article and rest of the body of the article.

Fig. 2a illustrates an article 100 including laser melted pearls 110. Fig. 2b is an exploded view of the pearl 110. Fig. 3a is a front view of the article 100 including the pearls and Fig. 3b is an exploded front view of the pearl 110.

Fig. 4 illustrates an article 100 which is a shaving cap including features in the form of holes 120 and slots 130.

Fig. 5 illustrates austenitic edges 150 formed while including a feature in the article 100 with rest of the body 140 of the article 100.

It is evident from Fig. 1 that the hardness is lost in the included feature and in its vicinity. The hardness in the feature is around 300 to 330 Hardness Vickers (HV) whereas the hardness 1mm away from the feature is around 600 HV. Laser cutting and laser melting result in a loss of hardness and strength in the heat affected zones of laser melted features and at the laser cut edges. This loss is caused by the back-transformation of the martensite into austenite and local precipitation of alloying elements, which results in a depletion of the content of alloying elements in the matrix. This loss is typically restored to a proper level by giving the article a hardening heat treatment.

An example of laser melting of tip of an article is explained here in detail. The article is a hair trimmer. The laser melted tips of teeth of the hair trimmer are shown in Figs. 2a, 2b, 3a and 3b. A typical hair trimmer has two cutting elements, a guard and a cutter. The guard and the cutter run in direct mechanical contact with each other. Both the guard and the cutter consist of a series of cutting teeth placed aligned in a row on a linear body. Hair is cut between flanges of the teeth of the cutter and of the guard. The trimmer cutters and guards are typically made out of cold rolled Nanoflex™ strip material with a hardness of about 300 - 400 HV. The strip or cut off pre-shapes are first aged at 500 °C for 10 minutes to harden the material to about 500-600 HV. The higher hardness makes the material more brittle and minimizes burr formation during machining and grinding in the manufacturing process. During hair trimming, teeth that cut the hair are in direct contact with human skin. For
enhancement of the skin comfort it is beneficial to provide the teeth of the guard and the cutter with smoothly rounded off tips. An efficient method to realize this is laser melting of the tips of the trimmer teeth such that rounded pearls are formed in the front tip of the teeth.

The tips are melted by focusing a laser beam on the tips of the teeth of the cutter and the guard at a temperature of 1500 °C for a period in a range of 10^7 seconds to ten seconds in a nitrogen free atmosphere. The pearls are formed with austenitic edges. The trimmer is then free cooled from around 1500 °C to 1300 °C. The cooling is halted at a temperature between 1300 °C and 900 °C for at least 30 seconds in order to destabilize the austenitic edges and thereby optimizing initiation of a following isothermal martensitic transformation. Then the trimmer is subjected to a further cooling from 900°C to 500 °C maintaining a cooling rate of at least -5 °C /s. This is approximately the cooling rate necessary to get the martensite transformation. This is rather a low cooling speed as compared to quenching. Quenching in metallurgy is associated with cooling speeds of -30 °C/s and higher up to -100°C/s or -150 °C/s. The trimmer is then subjected to free cooling from 500 °C to ambient temperature. This cooling sensitizes the austenitic edges and thereby initiates a following isothermal martensitic transformation.

The trimmer is subjected to a further cooling at a temperature between -30 °C and -50 °C for a period of at least an hour. This isothermally transforms the austenitic edges to martensitic edges. Finally the trimmer along with the laser melted pearls is hardened at a temperature between 450 °C and 550 °C for at least 3 minutes to cause particles in the edges to precipitate out from solution into martensitic structure. The final aging treatment hardens the pearls to a level of 500 HV or higher.

Figs. 4 and 5 demonstrate another example where the article is a shaving cap. The shaving caps are generally stamped out of soft annealed Nanoflex™ strip material with a thickness of 0.45 mm. The stamped caps are hardened up to a hardness of 450 - 550 HV according to the heat treatment as described in EP1216311. After hardening, the face of a shaving area and an inside running groove are machined until a membrane with a thickness of 50 - 70 µm in the shaving area remains. In this membrane a pattern of holes and slots is cut with laser as shown in Fig. 4. After laser cutting the laser cut edges are transformed to soft austenitic edges wherever the temperature exceeded 900 °C. Yet the rest of the body of the shaving cap remains martensitic as shown in Fig. 5.

The shaving cap is cooled in a similar way as explained in the above example. After cooling down from laser cutting in a nitrogen free atmosphere, the shaving cap is placed in a cooling system for 24 hours at -40 °C. In an isothermal martensite transformation
process, a martensite content of about 70% will be reached in the edges. The hardness of the edges is at this stage about 300 HV to 330 HV. A final aging treatment does harden the isothermal martensite in the edges from this level up to a hardness level of 500 HV or higher.

During laser melting and laser cutting, the articles are fully shielded with a protective inert Argon gas to prevent any nitrogen pickup from air into the Nanoflex™ steel. Nitrogen is a strong austenite stabilizing element. Nanoflex™ should contain a maximum of 0.012 wt% nitrogen. Any additional pickup of nitrogen will block the transformation to martensite fully, leaving the material in the soft austenitic condition.

A final ageing treatment is needed for both laser melted and laser cut articles. This is generally a re-hardening step. However, Nanoflex™ is to a high extent not susceptible to over-ageing. Therefore the additional ageing will not negatively affect the previously aged article either metallurgically or dimensionally. Thus a homogeneous hardness of 500 HV or higher can be reached in the article including the pearls and the area around the holes and slots.

It is to be understood that although preferred embodiments, specific constructions and configurations have been discussed herein according to the present invention, various changes or modifications in form and detail may be made without departing from the scope of this invention as defined by the independent claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage.
LIQUID EXTRACTOR

FIELD OF THE INVENTION:
The subject matter relates to a device for extracting liquid from solids such as the centrifugal bowl arrangement of a juicer.

BACKGROUND OF THE INVENTION:
WO20051 10173 discloses a double action sieve for juice extractors. The disclosed double action sieve comprises a cone with a steeper angle put onto the base cone. Such a juicer has a limited juice output.

SUMMARY OF THE INVENTION:
It is an object of the invention to provide a centrifugal bowl arrangement that can increase the liquid output. It is a further object of the invention to provide a method to improve the liquid output.

The object of the invention is realized by providing a centrifugal bowl comprising a base that can rotate about an axis of rotation. A filter sieve in the shape of a perforated peripheral side sieve wall extends from an open end to the base and a plurality of vanes is disposed in a predominantly radial direction on the inner surface of the perforated peripheral side sieve wall. The disclosed centrifugal bowl increases the separation efficiency by positively applying the rotational speed, which in turn increases the liquid output.

In an embodiment of the invention, the shape of the vanes is triangular and more or less fills the space between a feeding tube and the perforated peripheral side sieve wall. The shape of the vane is selected based on the directions of the perforated peripheral sieve wall and the feeding tube. The triangular shape of the vanes improves catching efficiency.

In a further embodiment of the invention, the number of vanes is six. There is a relation between the number of vanes, the size of the vanes, the vertical dispersion behavior and the catching efficiency. The inventors have found that six vanes results in good catching efficiency thereby increasing the juicer output.

In a still further embodiment of the invention, the vanes are disposed such that there is no leakage between the perforated peripheral side sieve wall and the vane. This

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ensures that solids are retained within the centrifugal bowl. This minimizes the loss due to leakage and increases the liquid output.

In a still further embodiment of the invention, the base is dome shaped having cutting teeth disposed on the inner side of the domed construction. The domed construction generates a vertically more dispersed pattern of pulp and juice mixture and hence increases the juice output.

According to the further object of the invention, a method of improving the juice output of a juicer is disclosed. The juicer has a centrifugal bowl with a base that can rotate about an axis of rotation. A filter sieve in the shape of a perforated peripheral side sieve wall extends from an open end to the base. The method of improving the liquid output comprises the step of preventing the slippage of both fluid and solids in the tangential direction.

In an embodiment of the method, preventing the slippage of both fluid and solids in the tangential direction comprises the step of providing a plurality of vanes in a predominantly radial direction on the inner surface of the perforated peripheral side sieve wall. The vanes give rise to a coriolis effect, wherein a particle moving in rotating frame of reference experiences the coriolis force acting perpendicular to the direction of motion and to the axis of rotation. The vanes increase the centrifugal forces thereby enhancing the juice output.

BRIEF DESCRIPTION OF THE DRAWINGS:

The above-mentioned aspects, features and advantages will be further described, by way of example only, with reference to the accompanying drawings, in which the same reference numerals indicate identical or similar parts, and in which:

Fig. 1 illustrates an exemplary juicer in a partially cut view;

Fig. 2 illustrates an exemplary centrifugal bowl arrangement for the juicer illustrated in Fig. 1;

Fig. 3 and Fig. 4 schematically illustrate general geometry of a path a particle takes in the rotating centrifugal bowl;

Fig. 5 schematically illustrates a time-place diagram;

Fig. 6 schematically illustrates the catching efficiency;

Fig. 7 schematically illustrates the variation of angle alpha with respect to the radius;

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Fig. 8 and Fig. 9 schematically illustrate the critical velocity above which particles can escape;

Fig. 10 schematically illustrate the fraction of particles caught and the fraction of particles escaped; and.

Fig. 11a and Fig. 11b illustrate an exemplary centrifugal bowl arrangement according to the present subject matter.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring now to Fig. 1, a juicer arrangement 1 is generally provided in the form of a motor driven domestic appliance capable of extracting the juice from fruits (orange, lemon, grapefruit), especially citrus fruits, and delivering the juice into a vessel positioned adjacent the main body of the appliance e.g. Juice jug.

A housing 101 accommodates a motor 102 with a driving shaft 103 that can drive a centrifugal bowl 105.

The centrifugal bowl 105 has a frusto-conical shape (cf. Fig. 2) and consists of:

i) a base 3 that can be mounted on the driving shaft 103 to rotate about an axis of rotation. Cutting teeth are disposed on the inner side of the base, thus forming a grating disk. The diameter of the base is smaller than or equal to the diameter of the open end.

ii) a filter sieve 105 comprising the sieve 151 and the sieve support 152. The filter sieve 105 is in the form of a perforated peripheral side sieve wall extending from the open end to the base. The base 3 and the filter sieve 105 are supported by the holder 104. The holder 104 is arranged in the juicer on the driving shaft 103 so that the centrifugal bowl comprising both the base 3 and the filter sieve 105 can be rotated.

In operation, the base 3 (i.e. the grating disk) grates vegetables and/or fruit, and the juice and the pulp are thrown against the filter sieve 105. The juice drips through the filter sieve 105 and is collected by the juice collector 107, from which it is drained via a spout 108, for example, into a glass/vessel positioned under the juice spout e.g. Juice Jug. The pulp is ejected over the upper edge of the filter sieve 105 and is collected in a pulp container 106.

The housing 101 with motor 102, driving shaft 103, centrifugal bowl, filter sieve 105, juice collector 107 and pulp container 106 is covered by a lid 109. The lid 109 has an inlet piece 2 for feeding fruit, vegetables, etc. into the juicer, i.e. putting them on to the base (i.e. the grating disk). In the example illustrated in Fig. 1, the inlet piece 2 has the form
of a feeding tube, the inner opening 203 of which is positioned just over the base (i.e. the grating disk) in order to form an interstice with the base. The inlet piece 2 is dimensioned in such a way that it has a slightly smaller inner radius than the base (i.e. grating disk) of the centrifugal bowl.

Juicers have a certain juice output (i.e. juice per unit weight). The juice output here refers to the ability to retrieve a fraction of juice of all the juice that can be extracted from a certain fruit.

The juice extraction comprises two steps. In a first step, the fruit is grated and in a second step the juice is extracted from the grated material which is normally a mixture of juice and pulp.

The working principle of the disclosed centrifugal bowl is based on the following:

1. Coriolis effect
2. Catching effect
3. Pumping of air effect

When fruit or vegetables are introduced into the juicer via the inlet piece 2, for example, by means of a pusher to be introduced into the inlet piece for pushing the fruit or vegetables and to be guided by the protrusion 202, the fruit or vegetable is held by the pusher and the side wall 201 of the inlet piece 2 so as to be grated into bits and pieces (i.e. a mixture of pulp and juice is formed by the grating disk). The bits and pieces are then caused to pass through the interstice by centrifugal forces.

In operation, the mixture of juice and pulp is free to fly from the slit between the feeding tube and the fast spinning base forming a vertically dispersed pattern of the particles (i.e. bits and pieces) containing the juice-pulp mixture. The vertically dispersed pattern of the particles is subject to the centrifugal forces that are generated by the rotating centrifugal bowl. The higher the centrifugal force the better it is.

The vertically dispersed pattern of the flying particles is subject to these centrifugal forces. Due to these centrifugal forces, the flying particles are caught on the perforated peripheral side sieve wall. The juice is separated from the flying particles that are caught on the perforated peripheral side sieve wall (i.e. separating the juice from the pulp-juice mixture). It is noted here that a fraction of the flying particles are caught on the perforated peripheral side sieve wall and some fraction of the flying particles escape without being caught on the perforated peripheral side sieve wall. Due to the decrease in the amount of flying particles being caught on the perforated peripheral side sieve wall, the amount of
juice that can be separated from the pulp-juice mixture reduces thereby reducing the overall juice output of the juicer. Generally, the separation efficiency has to be high. The separation efficiency here refers to the efficiency of separating the juice from the pulp-juice mixture. When the separation efficiency is high, the amount of juice entering into the perforated peripheral side sieve wall can increase. This in turn can increase the juice output.

In operation, the centrifugal bowl rotates. The shredded flying particles are transported along the perforated peripheral side sieve wall. The mesh (small holes on the filter sieve) separates the juice and the fruit fibers. The juice flows through the sieve holes into the juice collector 107. Through the spout the juice flows directly into the juice jug.

Further, the solid fibers will spin out directly into the pulp container 106.

The juicers continue to drip when the juicing process has finished. There can be some pulp-juice mixture left out on the perforated peripheral side sieve wall which has not been separated well. This pulp-juice mixture can have some amount of juice still left out. Generally, the gravitational force pulls out all the remaining juice. Alternately, air can be pumped that can blow the juice completely out of the filter sieve and the juice collector into the Juice Jug.

The inventors have found that it is highly unlikely that the rotational speed of the perforated peripheral side sieve wall is truly imposed on the flying particles. Due to this, some percentage of the particles can slip out and may not be caught on the perforated peripheral side sieve wall.

The disclosed centrifugal bowl makes use of the above mentioned effects, namely:
- the coriolis effect wherein the amount of centrifugal forces acting on the flying particles is increased;
- the catching effect wherein the amount of flying particles that are caught on the peripheral side sieve wall is increased; and
- the pumping of air effect wherein sufficient air is pumped to ensure that the remaining juice left out on the filter sieve and the juice collector is blown completely out into the Juice Jug.

The centrifugal forces are increased by adding vanes on the inner surface of the perforated peripheral side sieve wall. The term vane here refers to a flat surface that rotates and pushes against air or liquid. The vanes give rise to a coriolis effect. The coriolis forces increases the centrifugal forces acting on the flying particles.

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Further, the disclosed centrifugal bowl positively applies the rotational speed on the pulp-juice mixture. This prevents or decreases slippage of the pulp-juice mixture in the rotational direction. This can increase the juice output.

Further, the radial vanes provide sufficient force to blow the juice from the perforated peripheral side sieve wall to the outlet, so as to prevent dripping. The radial vanes also provide additional forces to press the juice (liquid) out of the pulp-juice mixture which can increase the separation efficiency.

Further, the catching effect of vanes is an effective approach to counter spray the pulp-juice mixture in the vertical direction. The vanes can enhance the catching efficiency which in turn can increase the juice output considerably. The catching efficiency here refers to the percentage of the flying particles that are caught on the perforated peripheral side sieve wall. An analysis of the effect of vanes is described below.

Geometrically, every particle path (i.e. in the rotating centrifugal bowl) can be fully described by a starting radius \( r \), and going tangentially. The radius \( r \) can be considerably smaller compared to the radius of a feeding tube when there is a large (apparent) radial component in the velocity. This is illustrated in Fig. 3, wherein \( r \) is the trajectory, \( R_1 \) is the start vane and \( R_2 \) is the end vane, \( v \) is the angle of vane-entrance, which is influenced by \( r \).

The path that the pulp and juice mixture takes between the slit and landing on the filter sieve and its effect on the separation efficiency is important and can be characterized with several parameters namely

\[ V: \text{velocity;} \]
\[ R: \text{radius;} \]
\[ a: \text{angle between the horizontal plane and the trajectory.} \]

Along the trajectory of the particle, a co-ordinate \( x \) is defined, as illustrated in Fig. 4. From Fig. 4, it can be seen that:

\[ x(O) = r \times \tan \theta \]
\[ \phi(t) = \alpha t \]
\[ x = \sqrt{R^2 - r^2} \]

A time-place diagram for occurrences on the \( x \) co-ordinate is illustrated in Fig. 5. The horizontal axis represents the time and the vertical axis represents where on the \( x \) co-ordinate the vanes intersect this co-ordinate.

In an embodiment, the proposed design has 6 vanes, meaning that every 60 degrees a new vane will pass through (cf. Fig. 1a, 1b). There is a relation between the
number of vanes, the size of the vanes, the vertical dispersion behavior and the desired
catching efficiency. For the exemplary juicer illustrated in Fig. 1, six vanes work well. In
some embodiments, 27 vanes (smaller in size) can be used which also works well and
increase the catching efficiency. The horizontal line (cf. Fig. 5) represents the distance along
the trajectory which coincides with the vane at its greatest radius. It is noted here that the
size of the vanes, the shape of the vanes are chosen such that it results in good catching
efficiency. Further, a radial rib construction acts as a radial flow pump. It pumps air. This
air flow has sufficient force to blow the juice from the juice collector to the outlet.

A particle will fly along the trajectory coordinate too, and its path in the time-
place diagram will be a straight line. It will have a slope that is indicative of its speed.
Furthermore, particles can emanate from the feeding tube at random moments, so a particular
particle with a certain speed can cross the horizontal line at any place, but will still have a
specific slope, depending on its speed.

So, particles with velocity > 64mm/110 deg will be able to escape. All
particles with a lower speed will be trapped by the vanes.

Assuming that the juicer runs at 100 rotations per second, the velocity
becomes:

\[ V = (64 * 1(T^3))/((110/(360*0.01))) = 2 \text{W sec} \]

Representing this velocity as critical velocity \( V_c \), then it follows

\[ V_c = \sqrt{n} \frac{R^2 - r^2}{t} \]

Where

- \( n \): represents the number of equidistant vanes
- \( t \): represents the rotational frequency

If particles are going faster than this critical speed, there will be a fraction of
the particles caught. For a particular particle this depends on the time and velocity on the x-
axis. This translates into straight line with a certain slope (= velocity) and start on the time
axis (= timing). When the line crosses a vane, it will be caught, when it does not, it will be
missed. This is illustrated schematically in Fig. 6 (based on the calculated results) depicting
the efficiency at various values of \( a \).

In an embodiment, the vanes are triangular in shape and more or less fill the
space between the feeding tube (2) and the perforated peripheral side sieve wall. The
triangular shape is chosen based on the directions of the perforated peripheral sieve wall and
the vertical feeding tube. In order to catch the particles most efficiently, the vanes have to be
close to the feeding tube and have to be connected to the perforated peripheral side sieve wall. The top side (3rd side of the triangle) can be chosen straight but can have any contour, thus generating different geometrical shapes compared to a triangle. The triangular vanes impose the angular velocity of the filter sieve upon the flying particles (i.e. the pulp and juice mixture). An unexpected effect is that the vanes also intercept the particles with a trajectory having an angle $\alpha$ greater than zero. When such a particle is trapped, it will cling to the vane and will glide radially with $\alpha = 0$ to the filter sieve, where the separation process will take place. A few geometrical considerations can be made on this such as when particles will be trapped and when they will be missed. Referring now to Fig. 7, when the angle $\alpha$ increases the apparent radius $R_2$ decreases, this is because the trajectory crosses the topside of the triangular vanes.

Referring now to Fig. 8, with given $r$ and $R_2$ there exists a certain velocity $v_c$, the critical velocity, above which particles can escape. This velocity depends also on the number of vanes. When one assumes that the maximum velocity equals the tangential velocity at radius $r$, then one can also calculate number of vanes, $R_2$ combinations.

$$v_c = \sqrt{R^2 - r^2/16}$$

Assume

$$v_c = wr$$

which implies

$$wr = \sqrt{R^2 - r^2}$$

$$2\pi r = \sqrt{R^2 - r^2} n$$

$$2\pi = \sqrt{(R/r)^2 - 1} n$$

$$(2\pi/n)^2 = (R/r)^2 - 1$$

$$R = r\sqrt{1 + (2\pi ln)}$$

Referring now to Fig. 9 and Fig. 10, when the velocity is higher than the critical velocity, a certain fraction can escape. This fraction can be estimated for a given $v, r$ and geometry. It is assumed that there is equal chance of particles leaving at a particular angle.

$$v_c < v < v_e: \text{ partly caught}$$
The fraction caught \( fc \) can be calculated from sketched geometry.

\[
v_c : \text{speed when other side of vane is hit} \\
v_c = \omega cl \frac{d(rtan(wt))}{dt} = w \cdot r \cdot \cos^2 \omega \cdot t \\
= \omega \cdot r \text{ at } t = 0
\]

In operation, the radial vanes provide sufficient force to blow the juice from the centrifugal filter sieve to the outlet, so as to prevent dripping and to provide additional forces to press the liquid out of the pulp.

Referring now to Fig. 11a and Fig. 11b, in an embodiment, the vanes are radially disposed on the inner surface of the peripheral side sieve wall and should not leak between the filter sieve and the vanes. This ensures that the entire pulp juice mixture is retained in the centrifugal bowl and minimizes the loss of pulp juice mixture due to leakage. Further, the juice output is increased.

Many other vane constructions are possible depending on the balance between the slip and centrifugal force that one wants. In an embodiment, the base 3 (i.e. the grating disk) is domed in construction having cutting teeth disposed on the inner side of the domed construction. The domed construction generates a vertically more dispersed pattern of pulp and juice mixture which can increase the juice output.

The disclosed centrifugal bowl prevents slippage of both fluid and pulp in the tangential direction. The disclosed centrifugal bowl arrangement increases the catching efficiency and separation efficiency which in turn increases the juice output. Further, the disclosed centrifugal bowl is simple in construction when compared to the double action sieve disclosed in WO20051 10173, since there is no need to glue the sieves and balance the sieves since there is only one sieve.

In summary, the juice output of continuous centrifugal juicers can be increased by adding radial vanes on the inner surface of the perforated peripheral side sieve wall which is simple in construction.

The disclosed centrifugal bowl can be used in all devices where a fluid is to be exposed to a centrifugal force to force separation and transport over the filter sieve. It is also suitable for juice extractors that use the principle of centrifugal juicing. Although the disclosed centrifugal bowl is applicable to juicers, it may be applied to any food processing apparatus which extracts liquid from solids such as compacters, coffee machines, and foam generators. Further, many devices have internal fluid passages. Blowing through these

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passages is an effective means to make it dry again. In such cases, the disclosed centrifugal bowl can also be used e.g. in Perfect draft, Senseo, and kitchen appliances.

While the subject matter has been illustrated in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the subject matter is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art of practicing the claimed subject matter, from a study of the drawings, the disclosure and the appended claims. Use of the verb "comprise" and its conjugates does not exclude the presence of elements other than those stated in a claim or in the description. Use of the indefinite article "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps. A single unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. The figures and description are to be regarded as illustrative only and do not limit the subject matter. Any reference sign in the claims should not be construed as limiting the scope.
CLAIMS:

1. A method for including a feature in an article, wherein the article is manufactured from a maraging stainless steel, which method comprises the steps of:
   focusing an energy beam on the article at a temperature of at least 1000 °C in a nitrogen-free atmosphere, wherein the beam is configured for generating intense energy and for melting/vaporizing the maraging stainless steel in order to include the feature along with austenitic edges;
   cooling the article to a temperature between 0 °C and -80 °C in order to subject the austenitic edges to an isothermal martensitic transformation; and
   hardening at a temperature between 375 °C and 600 °C to cause particles in the edges to precipitate out from solution into martensitic structure.

2. A method as claimed in claim 1, comprising the steps of:
   a. focusing the energy beam on the article at a temperature of 1400 °C to 1600 °C for a period in a range of 10⁻⁷ seconds to ten seconds in the nitrogen-free atmosphere;
   b. cooling the article to an ambient temperature in order to sensitize the austenitic edges and thereby initiating a following isothermal martensitic transformation;
   c. subjecting the article to a further cooling at a temperature of between -30 °C and -50 °C for a period of at least an hour, in order to subject the austenitic edges to the isothermal martensitic transformation; and
   d. hardening at a temperature between 450 °C and 550 °C for at least 3 minutes to cause particles in the edges to precipitate out from solution into martensitic structure.

3. The method of claim 1, wherein the energy beam is a laser beam or an electron beam.

4. The method of claim 2, wherein the cooling of the article to the ambient temperature comprises the steps of:
   a. free cooling the article from around 1600 °C to 1300 °C;
b. halting the cooling at a temperature between 1300 and 900 °C for at least 30 seconds in order to destabilize the austenitic edges and thereby optimizing initiation of a following isothermal martensitic transformation;

c. subjecting the article to a further cooling from 900 °C to 500 °C maintaining a cooling rate of at least -5 °C/s; and

d. subjecting the article to free cooling from 500 °C to ambient temperature;

5. The method of claim 1, wherein the melting/vaporizing is carried out in presence of a protective noble gas.

6. The method of claim 1, wherein the feature includes pearls, holes or slots.

7. The method according to claim 1, wherein the steel comprises chromium in a weight percentage between 10 and 20.

8. Use of the method of claim 1 for manufacturing an article having a homogenous hardness of at least 450 HV.

9. Use according to claim 8, wherein the article is a cap of an electric rotary shaver.

10. Use according to claim 8, wherein the article is a cutter of an electric rotary shaver.

11. Use according to claim 8, wherein the article is a cutter in a domestic appliance.

12. Use according to claim 8, wherein the article is a knife in a domestic appliance.

13. Use according to claim 8, wherein the article is a spring in a domestic appliance.
14. Use according to claim 8, wherein the article is a medical or dental instrument.

15. Use according to claim 8, wherein the article is a diaphragm plate spring in a fluid valve.
CLAIMS:

1. A centrifugal bowl (105) comprising:
   a base (3) that can rotate about an axis of rotation; and
   a filter sieve in the shape of a perforated peripheral side sieve wall (151)
   extending from an open end to the base and wherein a plurality of vanes (155a..155f) is
   disposed in a predominantly radial direction on the inner surface of the perforated peripheral
   side sieve wall (151).

2. The centrifugal bowl as claimed in claim 1, wherein the shape of the vanes is
   triangular and more or less fills the space between a feeding tube (2) and the perforated
   peripheral side sieve wall (151).

3. The centrifugal bowl as claimed in claim 1, wherein the number of vanes is
   six (155a, 155b, 155c, 155d, 155e, 155f).

4. The centrifugal bowl as claimed in claim 1, wherein the plurality of vanes is
   disposed such that there is no leakage between the perforated peripheral side sieve wall (151)
   and the vane.

5. The centrifugal bowl as claimed in claim 1, wherein the base (3) is dome
   shaped having cutting teeth disposed on the inner side of the dome.

6. A juicer comprising the centrifugal bowl as claimed in any one of the
   preceding claims.

7. A method of improving the juice output of a juicer, the juicer having a
   centrifugal bowl with a base that can rotate about an axis of rotation and a filter sieve in the
   shape of a perforated peripheral side sieve wall extending from an open end to the base,
   wherein the method of improving the juice output comprises the step of preventing the
   slippage of both fluid and solids in the tangential direction.

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8. The method as claimed in claim 7, wherein preventing the slippage of both fluid and solids in the tangential direction comprises the step of providing a plurality of vanes in a predominantly radial direction on the inner surface of the perforated peripheral side sieve wall.
FIG. 3a

FIG. 3b
FIG. 6

FIG. 7

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\[ V_c < V < V_e \]