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DEVICE FOR EMBOSSING A FOIL, APPLICATION OF THE DEVICE,
METHOD FOR ITS MANUFACTURE, AND METHOD FOR THE OPERATION OF
THE DEVICE

Background of the Invention

The present invention refers to a device for embossing a foil, the device comprising a pair of rollers which are provided with toothings of the same kind and which are coupled to a drive and capable of being driven in common, the rollers being capable of being pressed against each other in a resilient manner, and to a method for the operation of a device for embossing a foil which comprises a pair of rollers having toothings of the same kind which engage in each other in operation. A device of this kind is described in detail in US Patent No. 5,007,271. This known embossing device was based upon the problem of achieving both a high quality of the embossing and in particular a mutual synchronization of the embossing rollers in spite of the relatively fine toothings of the latter while only one of the rollers is driven and in turn drives the other roller. It had been found that these requirements were difficult to fulfill if the two rollers were equally provided with hardened teeth in order to ensure acceptable lifetimes of the rollers.

In order to fulfill the requirement of the mutual synchronization of the embossing rollers, the rollers were mutually aligned in such a manner that the circumferential rows of teeth of both rollers lie in the same plane, so that the flanks of the teeth in the meshing area of the two rollers contact one another and a forced driving of the idle roller by the driven roller results.

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07 MAY 1999

The mentioned disposition resp. the mutual alignment of the embossing rollers has been practical as long as the embossed foils, especially packing foils, were mainly aluminum foils. Recently, however, paper foils are increasingly used or even prescribed. These foils are substantially stiffer than aluminum foils, and it has been found that the known embossing rollers are no longer adapted to the requirements.

Summary of the Invention

It is the object of the invention to provide a device which fulfills the new requirements, i.e. which allows an optimal embossing of any kind of foils. This object is attained by a device for embossing a foil wherein said device comprises a mode of operation in which the rollers are moveable relative to each other and mutually displaceable in positions of determined engagement of the roller toothings in order to allow a self-stabilizing operation. The dependent claims describe particular characteristics of an exemplary embodiment.

The invention further refers to an application of the device of the invention for the embossing of foils which are mainly composed of paper, and to a method for the manufacture of the embossing rollers wherein the toothing is exposed to an erosion subsequent to its shaping.

As mentioned, the determined mutual position of engagement of the roller toothings which is intended according to the invention not only ensures a stable mutual driving and a synchronization of the roller rotation but also an optimal embossing independently of the materials to be embossed. Therefore, the invention further refers to a method for the operation of a device for the purpose of embossing a foil wherein in continuous stationary operation, the rollers are

operated in a mutual position in which each tooth in the contact area of each roller is enclosed at least approximately symmetrically between four teeth of the other roller.

Brief Description of the Drawings

The invention will be explained in more detail hereinafter with reference to a preferred embodiment.

- FIG. 1 shows a schematic representation of the toothings of an embossing roller in a developed view;
- FIGS. 2 and 3 show a position of engagement of the toothings of the embossing rollers when the device is started;
- FIGS. 4 and 5 show the stable position of engagement of the toothings of the embossing rollers;
- FIG. 6 illustrates the influence of a led through foil on the self-stabilization of the mutual roller positions;
- FIG. 7 schematically shows the stabilized mutual position of the roller toothings according to the invention; and
- FIG. 8 shows a corresponding illustration in a stable mutual position of the rollers.

Detailed Description of the Invention

For the fundamental structure of the embossing device, reference will be made to the above-mentioned US Patent No. 5,007,271. A foil band is passed between two toothed embossing rollers of which one is fixedly supported and driven while the other one is freely rotatably journaled on an axle and pressed against the driven roller with an adjustable pressure by spring force or by pneumatic or other means.

Both embossing rollers are provided with a superficial toothing of the same kind which is schematically shown in Fig. 1 in a developed view, and which comprises pyramidal teeth which are arranged in rows extending in the circumferential direction and perpendicularly thereto in the axial direction. As mentioned, Fig. 1 is a schematic representation, i.e. the pyramidal teeth are illustrated as if they had the precise geometrical shape of a pyramid with an acute point, which was indeed the case in the mentioned embodiment of the prior art.

According to a novel feature, the points of the teeth are now flattened according to FIGS. 2 to 5, i.e. the teeth are shortened by an amount ΔA (FIG. 3) which in practice is equal to at least 2%, preferably 5 to 25% of the theoretical geometrical tooth height. Furthermore, the edges of the pyramidal teeth resp. of the truncated pyramids are cut, which may e.g. be achieved by a generally erosive finishing treatment subsequent to the machining of the toothing, e.g. by an etching or a galvanic erosion which mainly affects the edges.

Another difference with respect to the known embodiment, where the mutual axial position of the embossing rollers was

predetermined, is that the rollers are mutually displaceable with a relative axial play of at least half a tooth pitch, preferably of three quarters of a tooth pitch, in order to allow a mutual displacement to a stable position, as will be explained below.

When the embossing rollers are first joined and pressed against each other with an inserted foil band and set in motion as the device is started, it is highly probable that in the contact area of the rollers, the relative tooth position according to FIGs. 2 and 3 results. FIG. 2 shows the relative tooth position in the circumferential direction, and FIG. 3 shows the relative tooth position in the axial direction. According to FIG. 3, the flanks of the teeth contact each other, thus resulting in a mutual working height E_{H1} .

Since the embossing rollers are in rotation, they tend to a mutual axial displacement, and if the teeth of the two rollers cease to run on the respective tooth flanks, the rollers resp. their toothings will interpenetrate deeper, thus resulting in a smaller working height E_{H2} . This relative position of the teeth is illustrated in FIGs. 4 and 5, where FIG. 4 again shows the relative tooth position in the circumferential direction and FIG. 5 shows the relative tooth position in the axial direction. It appears that the teeth are now mutually engaged in such a manner that each tooth is symmetrically enclosed between four teeth of the other roller, i.e. that the teeth contact each other along their edges, and since the edges of the teeth are cut and their points are flattened, the toothings will settle or catch in a deeper position of engagement which is stable and from which they do not depart, as experience shows. The toothings thus stabilize themselves dynamically in a certain position. As shown in FIG. 6, this self-stabilizing effect

is reinforced by the foil passed between the embossing rollers.

In any position of engagement of the two embossing rolls, the embossed material is forced around structural edges K1, K2. This produces a paper tension which generates the forces F1 and F2 on the idle roller, thereby contributing to a displacement of this embossing roller from the instable position according to FIG. 6 to the stable position of maximum penetration according to FIGs. 4 and 5. As mentioned, a considerable force is required in order to displace the rollers out of the mutually stabilized position of maximum penetration in the axial or in the circumferential direction. A safe and stable driving of the idle roller with a constant mutual tooth position in the corresponding range of engagement is therefore ensured. At the same time, an optimal embossing, especially also of paper foils, is ensured. In the initial position of engagement, the teeth could also mutually contact the flanks in the axial direction, in which case the stable position of engagement would be attained by a relative displacement in the circumferential direction.

FIGs. 7 and 8 schematically show a comparison of the embossing process in the position of the invention (FIG. 7) and in the conventional tooth position (FIG. 8). In both figures, the points of the teeth of one roller are indicated by triangles and those of the other roller by circles. The dotted lines are the relevant breaking lines, and it appears that the embossing length in the tooth position of the invention is substantially longer than in the conventional tooth position while the foil nerves are not only folded free of tension but also in symmetrical diagonal directions additionally.

For a reliable operation, however, certain minimal conditions must be fulfilled as well. Thus, in the embossing procedure of the invention according to FIG. 7, the metallized paper can provide a dynamic compensation of a certain pitch error ΔT of the two embossing rollers due to its elasticity. In other words, an embossing according to the invention is no longer possible if the pitch difference ΔT is greater than a certain self-centering factor. In any case, the embossing pattern will deteriorate if the self-centering resp. -synchronization is not ensured. The terms of the following relationships are

T_1 = radial pitch of the first roller
 T_2 = radial pitch of the second roller
 ΔT = pitch difference
 T_{HT} = theoretical radial pitch (nominal pitch)
 S_{ZF} = self-centering factor
 E_F = empirically determined factor = 98.75.

$$S_{ZF} = \frac{T_{HT}}{E_F} \quad \Delta T = T_1 - T_2 \quad S_{ZF} \geq |\Delta T|$$

In a numerical example, this means:

T_1 = 0.402
 T_2 = 0.399
 T_{HT} = 0.400
 ΔT = $0.402 - 0.399 = 0.003$
 S_{ZF} = $\frac{0.400}{98.75} = 0.00405$

$$0.00405 \geq 0.003,$$

which means that the self-centering effect is ensured. The preceding dimensions are all in mm.

The described preferred embodiment offers simplicity, reliability, long lifetimes of the rollers, a high quality of the embossing independently of the foil material, and simple operation. In this embodiment, it is advantageous to use the described tooth shape which allows the dynamic displacement into the preferred stable mutual position of the toothings. Alternative embodiments are also possible, however.

The rollers may be provided with teeth of different heights or of the same height, i.e. the pitches have to correspond, of course, but the amount of flattening may vary. Preferably, in the case of different heights of the teeth, the idle, i.e. the undriven roller is provided with the lower teeth. It will be exposed to a slightly greater wear, but it is easier to exchange than the driven roller.

The rollers may also comprise means for a preliminary or coarse orientation, e.g. coarse toothings at the edges resp. on the sides of the rollers which engage in each other at the start and provide a coarse orientation of the rollers, thus contributing to a correct engagement and the subsequent transfer of the rollers to their stable positions. These orienting means have to have enough play in order to allow a free mutual displacement of the rollers to the stable position.

It is also possible to lock the mutual roller positions as soon as the stable position of engagement is attained and thus to exclude any risk that the rollers might jump from a stable position to a different one. For example, as soon as the stable position is attained, the axial position of the idle roller might be locked by clamping the axially displaceable roller axle, and a previously uncoupled play-free gear could be connected between the two rollers.

Ultimately, the rollers could also be mutually positioned by play-free gears or in such a disposition that a mutual engagement in the sense of the invention is predetermined from the start.

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Claims

1. A device for embossing a foil, the device comprising a pair of rollers which are provided with toothings of the same kind and which are coupled to a drive and capable of being driven in common, the rollers being capable of being pressed against each other in a resilient manner, wherein said device comprises a mode of operation in which the rollers are moveable relative to each other and mutually displaceable in positions of determined engagement of the roller toothings in order to allow a self-stabilizing operation.
2. The device of claim 1, one roller of which is capable of being driven while the other one is freely rotatable and capable of being driven by the engagement of the roller toothings, wherein said rollers are axially displaceable relative to each other, said freely rotatable roller being preferably arranged with axial play.
3. The device of claim 1, wherein in the stable mutual position, said rollers interpenetrate with maximum penetration depth.
4. The device of claim 1, wherein in the stable mutual position, each tooth of each roller is symmetrically enclosed between four teeth of the opposite roller.
5. The device of claim 1, wherein said rollers comprise pyramidal teeth whose points are flattened.
6. The device of claim 5, wherein the edges of said teeth are cut.

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7. The device of claim 5, wherein said flattening amounts to at least 2% and is preferably comprised between 5 and 25% of the tooth height.

8. The device of claim 1, wherein said rollers comprise teeth of different heights, the freely rotatable roller preferably comprising the lower teeth.

9. The device of claim 1, wherein means for a preliminary mutual orientation of said rollers are provided which are engaged when the rollers are joined or which act as a gear allowing a certain play between the two rollers.

10. The device of claim 1, comprising means allowing to cancel the mutual mobility of said rollers when said determined mutual position of engagement is attained, e.g. by canceling the mutual axial play or by engaging a gear connected between the rollers.

11. An application of the device of claim 1 for the embossing of foils which are mainly composed of paper.

12. A method for the manufacture of the rollers of the device of claim 1, wherein said toothing is exposed to an erosion subsequent to its shaping.

13. The method of claim 12, wherein said erosion is effected by etching, galvanic erosion, or the like.

14. A method for the operation of a device for the purpose of embossing a foil by means of a pair of embossing rollers provided with toothings of the same kind which engage in each other in operation, wherein in continuous stationary operation, the rollers are operated in a mutual position in which each tooth in the contact area of each roller is

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enclosed at least approximately symmetrically between four teeth of the other roller.

15. The method of claim 14, wherein said rollers are set into rotation at least during start-up and brought together in order to obtain a determined, stable mutual position of engagement of the rollers in which they remain in continuous operation.

16. The method of claim 15, wherein after having attained said stable position of engagement, said rollers are locked in this mutual position by canceling their mutual play in the axial and/or in the circumferential direction.

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