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A NEW DESIGN OF PRODUCT LABEL

Valerian ZAHARIA[1,*], George CONSTANTIN[2]

[1)] MS Student, Eng., Machines and Manufacturing Systems Department, University "Politehnica" of Bucharest, Bucharest, Romania
[2)] PhD, Prof., Machines and Manufacturing Systems Department, University "Politehnica" of Bucharest, Bucharest, Romania

Abstract: *In the first part of this study, a procedure of die-cutting the roll self adhesive labels and the worldwide situation of this procedure are presented. In the second part of this study, there is a description of the implementation steps of a special requirement type of self adhesive labels as opposed to the current procedures. It is about die-cutting a two-layer material that has significantly different degrees of compressibility on both sides. It is desired that only one of the layers to be penetrated by stamping. The article focuses on the main steps of the procedure, giving some guiding elements from the technological point of view. The article is accompanied by four annexes containing sketches of a magnetic rotary die cutting machine and pre-ordering sketches of a magnetic rotary die, and a draft order of such a die with the manufacturer's main requirements of flexible dies. For a better understanding there is a draft of a label produced by using this procedure at the end of the article.*

Key words**:** *labels, rotary die-cutting, flexible die, magnetic cylinder, blade, cutting edge angle.*

1. INTRODUCTION

The last 20-year development of using self adhesive labels has led to conceiving performant manufacturing technologies. One of them is the technology of die-cutting using a magnetic cylinder and a flexible die. This type of technology allows the use of the die cutting machine in synchronization with other printing machines, mainly flexographic ones. They can also be digital or offset. The technology is not generally very complicated but requires a high degree of precision (one thousandth of a millimeter) of the mechanic process involving the die components. The flexible die is in fact a board with the die cutting blades welded on its surface and it magnetically adheres to a cylinder in which the permanent magnets can be found. The magnetic cylinder, together with the die-cutter, tumble down on an anvil cylinder moving the label material setting bounds by die cutting. This study is a presentation of this die cutting process regardless of the applied adhesive and the execution of a new type of label with the help of two die cutting machines set in a line. The study also deals with the solving of problems that may occur because of the difference in compressibility of the material's two sides. The design of a flexible die is also taken into consideration together with its requirements depending on the material used for the label and on the die itself**.**

2. CURRENT STATE

Nowadays the worldwide majority of roll self adhesive labels are manufactured using rotary die cutting machines with magnetic cylinders and flexible dies on an additional cylinder called anvil. The self adhesive labels have been used in all fields. There is a wide market, from the ordinary shops to the top industries of car making etc. In Europe a system with a 0.480 mm gap between the magnetic cylinder and the anvil has been established whereas on the North American continent the system has a 0.483 mm gap between the two parts [1].

This system consisting of a magnetic cylinder, flexible die and anvil cylinder has been generally accepted and there is no label printer that does not consist of one or two magnetic rotary die cutting machines. The Omet-Italy company has announced the development of a more advanced technology, with magnetic cylinders "Monotwin" [2].

3. TECHNOLOGY USING A MAGNETIC CYLINDER AND A FLEXIBLE DIE

3.1. Label material

The label material is diverse and tailored to the requirements. It can be paper, plastic but it generally consists of a sandwich layer, the label itself with a layer of applied adhesive protected by a base, usually silicone paper. The two sides of the material have different compressibility. If the label material is paper, it is very compressible. Therefore, the height of the die cutting blades must be precisely calibrated so that they cut only the label material, leaving the more rigid base intact. The label material component layout is shown in Fig. 1.

The rotary cutting die must trim the outline of the label without piercing the board. The cut must be clean, it must firmly trim the outline and excess of material must be easily removed and it should not spread the adhesive between the label and the silicone board. A precise design of the die cutting unit allows the fulfillment of all these requirements. Figure 2 shows the two stages of the material cutting, at the beginning of the cutting and at the end of the process.

[*] Corresponding author: Institution address,
Tel.: 0040 21 402 9174
E-mail addresses: *zvalerian59@gmail.com* (V.Zaharia), *george.constantin@icmas.eu*(G. Constantin)

Fig. 1. Layout of the label material components (A – label; B – adhesive; C – silicone board).

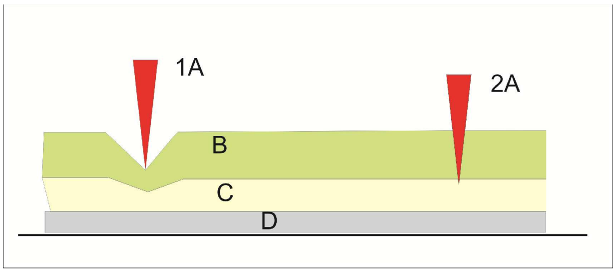


Fig. 2. Two stages of the material cutting (1A – die cutting blade at the beginning of cutting; B – label material; C – adhesive; D – board; 2A – die cutting blade after cutting).

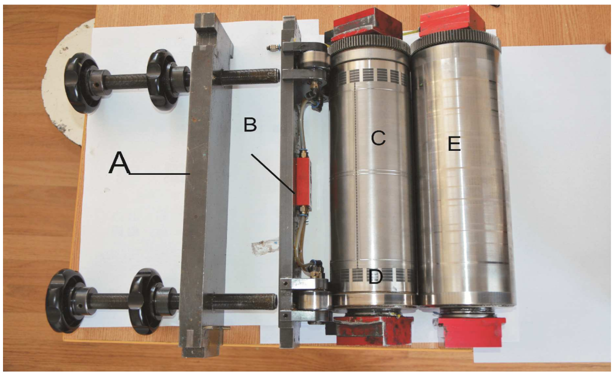


Fig. 3. Main components of the stamping unit: A – pressure screws; B – pressure rollers; C – flexible die; D – magnetic cylinder; E – anvil.

3.2. Die cutting unit

In Fig. 3, the main components of the stamping unit are found.

The pressure rollers (B) activated by the pressure screws (A), press down the magnetic cylinder (D) which rotates the flexible die (C). The cylinder leans on the anvil cylinder (E). The rotating motion between the cylinders is provided by the spiked wheels which can be found on each cylinder, at one end. The cutting material is forced to go through the two cylinders and the cutting die perforates only the label material. The cutting die blades stop in the adhesive area without piercing the silicone board as well. In Fig. 4 there is a drawing that shows the phenomenon of die cutting between the cylinders.

In Appendix 1 there is a drawing of a Kocher+Beck die cutting unit. The unit is marketed under the name of Arsoma 280 KS. The photos in this study are of this unit. In Fig. 4 one can notice that the variable element is the height of the blade (G). This one must be chosen so that, depending on the overall compressibility of the materials that the sandwich label is made of, it should stop exactly between the two sides of the label. This procedure is called partial piercing or *kiss cut*. When a complete

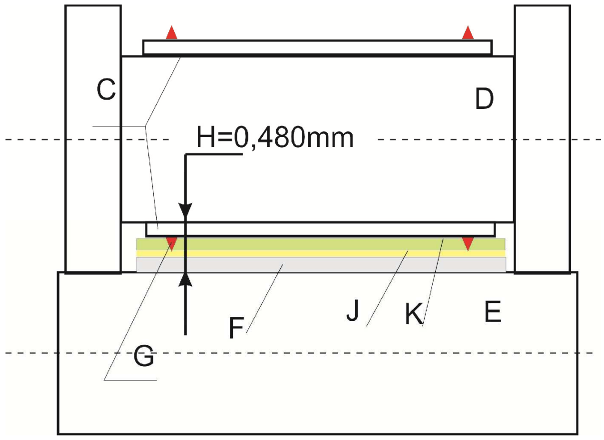


Fig. 4. Die cutting between the cylinders: C – flexible die; D – magnetic cylinder; E – anvil; F – the silicone board of the label; G – die cutting blades; H – gap between the cylinders; J – adhesive; K – material of the future label.

Fig. 5. Unfolded flexible die.

cutting of the material is desired, the height of the blade and the board is 0.480 mm and the cutting is called total cut. There are also materials consisting of more layers than the one shown in the Fig. 1 and the cutting die can be designed to cut through more layers. This procedure is called *Multi-level cutting*.

3.3. Flexible die

Figure 5 shows a flexible die unfolded for four labels in a roll. One can notice the die cutting blades that demarcate four labels for every turn of the magnetic cylinder. These blades rather set bounds to the material by crushing it than cut it, and the shape and angle of the blades are important in order to achieve that. The most important characteristic is the height of the blade. It varies depending on the board elasticity and the material of the future labels and also on the magnetic cylinder diameter that holds the flexible die.

A large diameter causes a wider penetration and vice versa for a small diameter. During the cutting of the material, there are four positions of the blade depending on how deep it penetrates – all of these being illustrated below.

The case in which the blade penetrates less deep and it does not completely cut the label material is presented in Fig. 6. The material excess cannot be removed from the label, the cutting outline being irregular and ragged. In Fig. 7 one can notice that the blade cuts the label

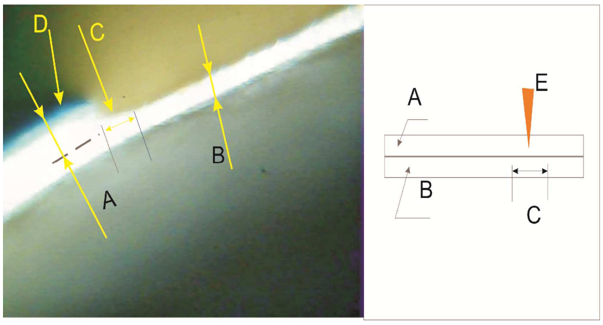


Fig. 6. Less deep penetration of the blade: A – label material; B – label board; C– action area of the blade; E – die cutting blade; D – layer of typography ink.

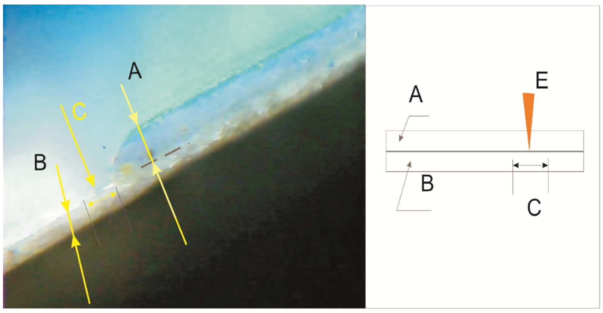


Fig. 7. Incomplete cutting: A – label material; B – label board; C – action area of the blade; E – die cutting blade.

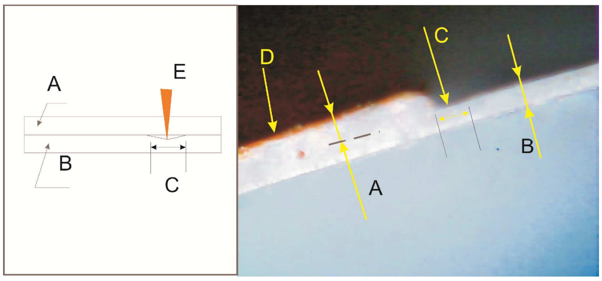


Fig. 8. Material penetration without detachment: A – label material; B – cutting surface; C – action area of the blade; E – die cutting blade; D – layer of the typography ink.

material and it stops exactly above the board without getting in contact with it. This process is correct but the blade will erode faster during the cutting and the operating time will be shorter. Ideally the blade should completely penetrate the label material and just gently press the board without piercing it, as shown in Fig. 8, C situation. In this case the blade height is the best, it has eroding resource and the lifespan is longer In Fig. 9, the height of the blade is greater than sheet thickness, the blade punching the cutting surface as well, damaging it. This is the case of a manufacturing defect as Fig. 6 shows, causing faulty products. Therefore, the blade height is significant and its size can be calculated using some samples with different sizes of the blade heights. Then visually and microscopically it determines the degree of penetration for an optimal choice of this value.

In Fig. 10 there is a flexible die assembled on a magnetic cylinder manufactured with two sizes of the die cutting blade height of 440 microns and 432 microns. The gap between these two should be 8 μm. Out of the 840 μm that form the gap between the anvil and the

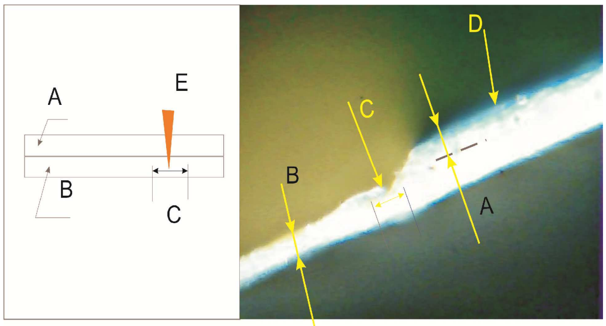


Fig. 9. Blade height greater than sheet thickness: A – label material; B – cutting surface; C – action area of the blade; E – die cutting blade; D – layer of typography ink.

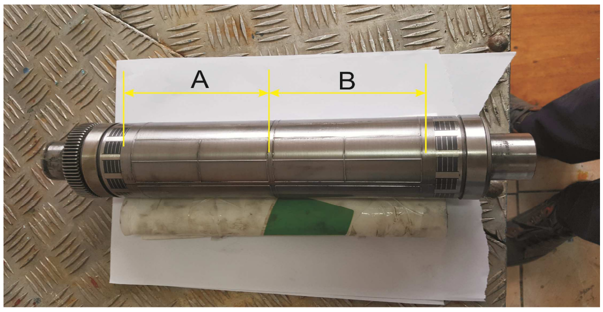


Fig. 10. Two sizes of the die cutting blade: A – die cutting blades with a height of 440 μm; B – die cutting blades with a height of 432 μm.

magnetic cylinder there is a space of 40 μm so the material is forced to go through while being cut. Using an extra surface with a low elasticity and a 10 μm thickness, multi-layered underneath the cutting surface, the material can be forced to be pierced by the blade, in layers of 10, 20 or 30 with a total penetration of 40 microns. After many trials, some heights have been calculated (Table 1) for a label material made of semi-gloss paper with a 60 μm thickness and a standard 56 μm thickness silicone cutting surface so that the desired label (with double-sided penetration) could be obtained. Using this method, one can determine the proper height of the blade for any type of material and its cutting surface. From Table 1 it becomes obvious that a 440 μm height of the blade is needed for a normal cut of the material and it is in connection with a 445 μm blade for die cutting the other side of the material.

This height is higher because the label paper is in this case the holder and the blade has to compensate for the higher paper elasticity difference compared to the silicone support.

Not only the right size of the blade is important, but also its shape which is influenced by the material of the future self adhesive label. In Fig. 11, two types of blades that work with different angles depending on the material that is used are presented.

Table 1

Calculation of blade heights

Material base	Cutting surface thickness	Height of the blade
Silicone paper	0.060 mm	0.440 mm
Semi-gloss paper	0.054 mm	0.443 mm

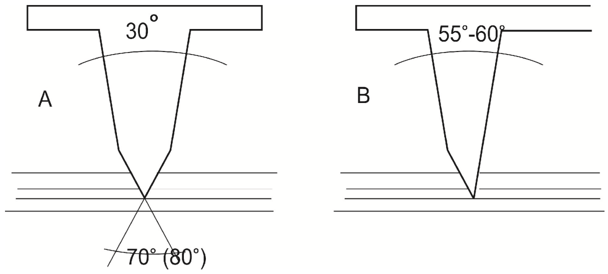


Fig. 11. A symmetrical blade B asymmetrical blade.

The symmetrical blade with an angle of 80 degree is used for materials made of paper and the 70 degree angle is used for polyethylene, polypropylene or PVC foil. A lower degree of the angle is used for polyester foil. The asymmetrical blade is used for thick materials with a thick layer of adhesive. The tips of these blades must be laser-forged and they can have hardness from 50 HRC to 67 HRC. Treating these cutting edge surfaces with different types of substances (e.g. teflon) capable of reducing friction will expand the cutting die lifetime. The friction coefficient will be lowered from 0.3–0.4 (not treated) to 0.1–0.02 (treated). By reducing friction between blade and material the blade wear decreases. The cutting dies cannot be sharpened, they are disposable.

3.4. Assembling the die cutting unit into the printing device

The die cutting unit is assembled into the printing device after the printing and drying units have been set and same work speed is used as for the whole printing device. An excess material removal unit is also added to this device. In Fig. 12 a die cutting unit is incorporated into a printing technological flow.

In the upper part of the Fig. 12 one can notice the excess material being rolled for waste removal. The printing device speed must be synchronised to the die cutting unit speed. The flexographic process is usually applied for printing labels in a roll. In this case, a turn of the printing roll determines a turn of the magnetic cylinder together with the flexible die, or a multiple of the printing role length. A turn of the printing roll generally corresponds to a turn of the flexible die. As a conclusion, the unfolded length of the printing roll is equal to the length of the flexible die. Different types of magnetic cylinders are required for different lengths of the printing roll. The printing length matches the rolling diameter. The

Fig. 12. The die cutting unit in a printing device.

Table. 2

Printing lengths and the corresponding number of teeth

Printing length [mm]	Number of teeth
346.075	109
298.450	94
275.225	87
247.650	78

Circular Pitch formula is used for making the rolling wheels of the cylinder heads. The following formula determines the number of teeth for the magnetic cylinder.

$$N = \frac{L}{3{,}175}, \qquad (1)$$

where N stands for the number of teeth for the magnetic cylinder and L is the length of the printing tool of the printing device.

Considering the fact that the working tolerance of this kind of cutting die is quite strict, one cannot use a wide range of cylinders. If the number of teeth is reduced, a phenomenon of inflection becomes apparent and the die cutting can no longer take place. The number of teeth cannot either be diminished too much as the magnetic cylinder becomes too large and size problems would occur. For the Arsoma 280KS device (280 being the maximum working width of the device) the minimum number of teeth is 64 and the maximum is 144. In Table 2 there are some examples of printing lengths and the corresponding number of teeth.

The magnetic cutting dies have an extensive working lifespan, going up to 1–1.5 million rotations, but they are very sensitive to repeated interchanges. Mounting and removing of a unit, which are relatively easy procedures, shorten the cutting die lifespan to 5–10% because the shape of the blade is sensitive to the deformations that may occur during the mounting process. The cutting die is also very sensitive to corrosion and its storage has to be made with great care. The manufacturer recommends the storage in low humidity places and an anticorrosive oil W44 treatment.

4. LABEL PRODUCING

4.1. Requirement

A label consisting of two areas is desired:

- a fixed area that cannot be easily removed and that can represent the product authenticity;
- the second area should be easily removed from the rest of the label, as a flyer, and if it is possible this area should be made up of more identical sections on which code bars would be printed.

These codes can be easily integrated into the computer system to get information about the packet, the parcel, but they should be placed in a different area than the product. Here is an example. The product data can be processed in the office but the product itself is in a separate warehouse and just by scanning the detached section one can issue the parcel delivery notice. The label is 110 mm in size, the same size as the maximum printing width of the direct thermal printing device of the beneficiary. The fixed section has a 110 × 70 mm data area. For the detachable area, a minimum 20 × 55 mm surface is needed and at least three sections are required. The labels will be delivered in rolls. The core inner diameter is 76.2 mm and the maximum roll diameter is 200 mm, the labels are made of semigloss paper with a permanent adhesive that can be stored in negative temperatures during wintertime and in temperatures of more than 30ºC during summertime.

4.2. Achieving the goals

The requirements can be smartly fulfilled without using multilevel label material. One can use a sandwich material consisting of a base, the label material and the adhesive. The upper side of the material is die cut and the label itself is being defined. A second die cutting unit defines the base itself on the down side of the material, on the board side, just next to the detachable area. The detachable area keeps a base on the back and when it sticks to the product, it does not allow a permanent adhesion of this area. In Figs 13 and 14 the areas are shown and the way they get detached on the two sides of the material

In Fig. 13 there are demarcations on the label for the fixed areas (A), for the detachable area consisting of 3 detachable labels (B) and for the die cutting on the back (a dashed line D that will stay on the label). The D part was detached so that the three parts of the flyer area could be noticed

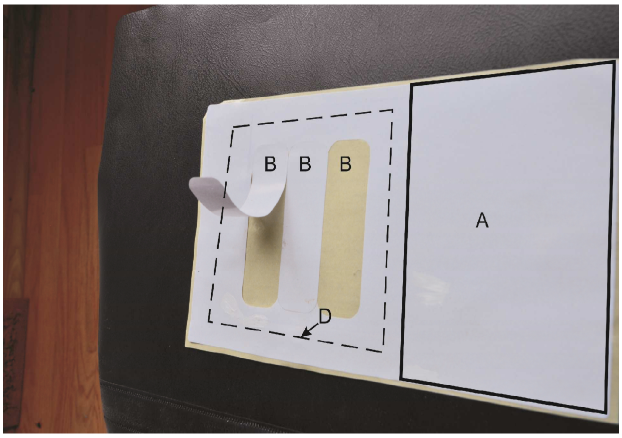


Fig. 13. Label demarcations: A – fixed area; B – detachable areas; D – protection base demarcation.

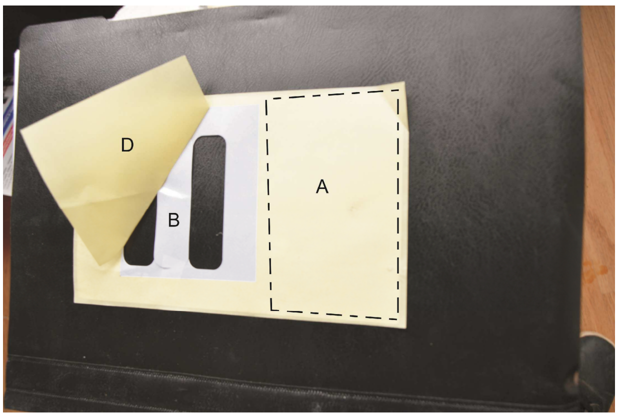


Fig. 14. The back side of the label: A – fixed area; B – detachable areas; D – protection base.

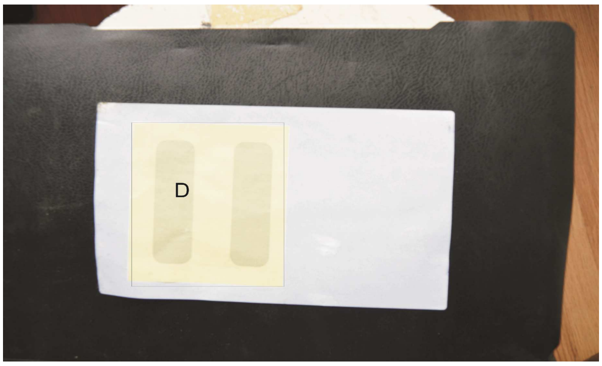


Fig. 15. Label ready for getting stuck on a product.

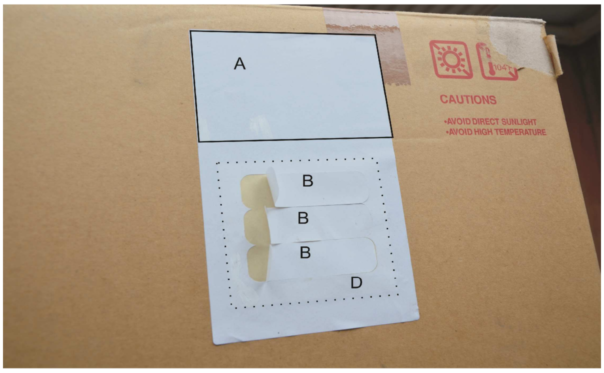


Fig. 16. Label is stuck on a product: A – fixed or permanent area; B – flyer area; D – protection area.

In Fig. 15 the rear side of the label is shown, ready to be stuck on a container or a product. On the back, one can notice the defined area D that helps the flyer part sections not to adhere to the labeled surface. Therefore the flyer parts can be detached. In Fig. 16, the label is stuck on a product and for a better understanding the flyer parts are slightly detached.

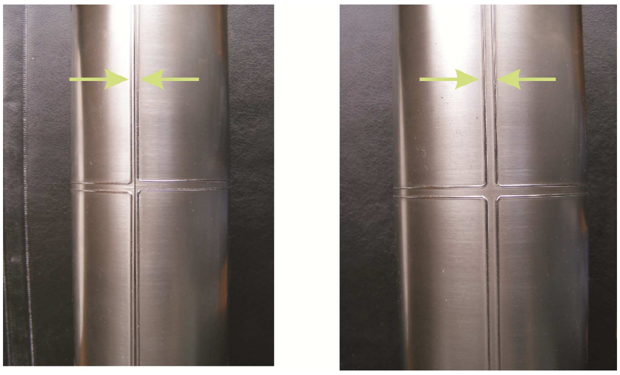
The fixed part A is permanently stuck on the product. The flyer parts B can be easily detached because there is a base D (marked by a dashed line) underneath them. There is a buffer zone, between the fixed part and the flyer part, which ensures the adherence of the non-adhesive base. This buffer zone is needed otherwise this type of label cannot be made. In fact this is the only disadvantage of this solution. The buffer zone makes the label surface about 20 mm bigger on every side of the flying parts, resulting into a longer label than the ordinary one.

4.3. Size-setting of the label

The beneficiary asks for a 110 mm width of the label. Its length is determined by summing up the component parts along the label. They are: the 70 mm fixed area, 3 mobile parts with a 20 mm width each (meaning 60 mm altogether) and 2 buffer zones of 20 mm each. A label is about 170 mm long. Its size is 170 × 110 mm. Two millimeters can be missed out of the buffer zone so that there is a complete number of labels on a cylinder

4.4. Size-setting of the cutting die

For making a label, two die cutting units are required on a printing device. One unit will cut the upper side and the other will cut the back of the label. Therefore, two die



a b

Fig. 17. Cutting die connection to the magnetic cylinder in the gap area: *a* – gap for connecting the cutting die; *b* – gap inside the cutting die.

cutting units have to be made. The smallest size for a die cutting unit is with 64 teeth or 203.275 mm length. The label being shorter, the 170 mm should be multiplied by 2. In Table 2 the proper cylinder would be the one with 109 teeth and a 346.075 mm printing length. Two labels are joined and two gap areas of 4 mm are added for a proper optical reading of the thermal printer. The gap defines the space between two successive labels that are usually in a roll. For the self adhesive labels this gap is not taken by a label and it is used as an artifice for connecting the rotary cutting die.

In Annex 3, the two overlaid die cutting units are shown as they leave a print on both sides of the label. The cutting die is connected to the magnetic cylinder in the gap area for a continuity of the cutting. This process is shown in Fig. 17. In Fig. 17,*a*, the flexible die connection is presented as opposed to Fig. 17,*b* where a gap position inside the cutting die is shown. This means that the gap is divided in two parts on both edges of the cutting die and there is a small extra distance in the joining area for the oscillator gear while tumbling down the material. The height of the blade can be found in Table 1 and the proper size for a label with paper base is 0.440 mm and the size of the paper base (which is one of the most used bases) is 0.056 mm. The height for back side cutting is slightly different because the base is silicone paper. This one is less compressible and much thinner. For the second die cutting the roles are switched and the upper side of the label becomes the base. It works differently and it has a high degree of compressibility. It is very common that some samples of materials are sent to the cutting die manufacturer for proper sizing. The height in this situation is 0.443 mm (Table 1).

4.5. Proper positioning of the die cutting units

For this type of label, two die cutting units are positioned, one beside the other, having the same working speed. There is only a difference in the order of positioning the magnetic cylinders and the anvil, underneath the pressure rollers. For the first unit, the anvil is assembled. Then the magnetic cylinder together with the flexible die for the upper side of the label is added and then the pressure rollers are assembled. For the second unit, the magnetic cylinder together with the flexible die for the back of the label is assembled first and only then the anvil and the pressure rollers.

5. CONCLUSIONS

The procedure achieves the task and allows the making of a relatively cheap label with no need of special equipment. Putting it into practice may lead to some technical problems as a die cutting unit is used in a completely new way and the proper height of the flexible die cutting blade is required. This study should also deal with the way the cutting material functions under the pressure of the flexible die cutting blade. As long as the data is scarce and there is no related bibliography, in the future this study will also include some research data and the design of some pressure curves for different types of material and for different heights of the flexible die cutting blade. This research is necessary not only for this study but also for future situations that may lead to new products.

AKNOWLEDGEMENTS: To the Kocher+Beck company for the data provided about the Arsoma 280KS die cutting unit with a magnetic cylinder.

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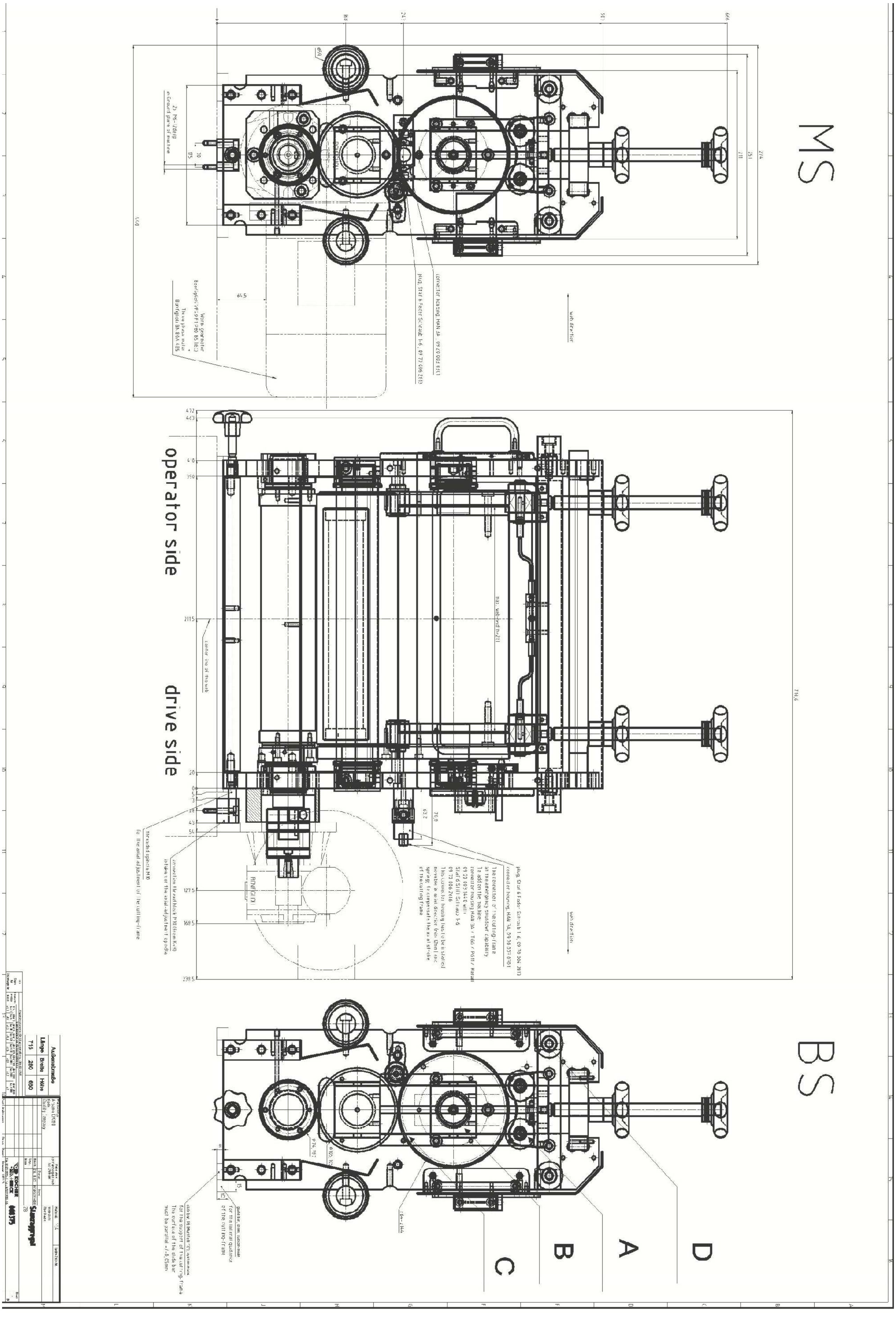
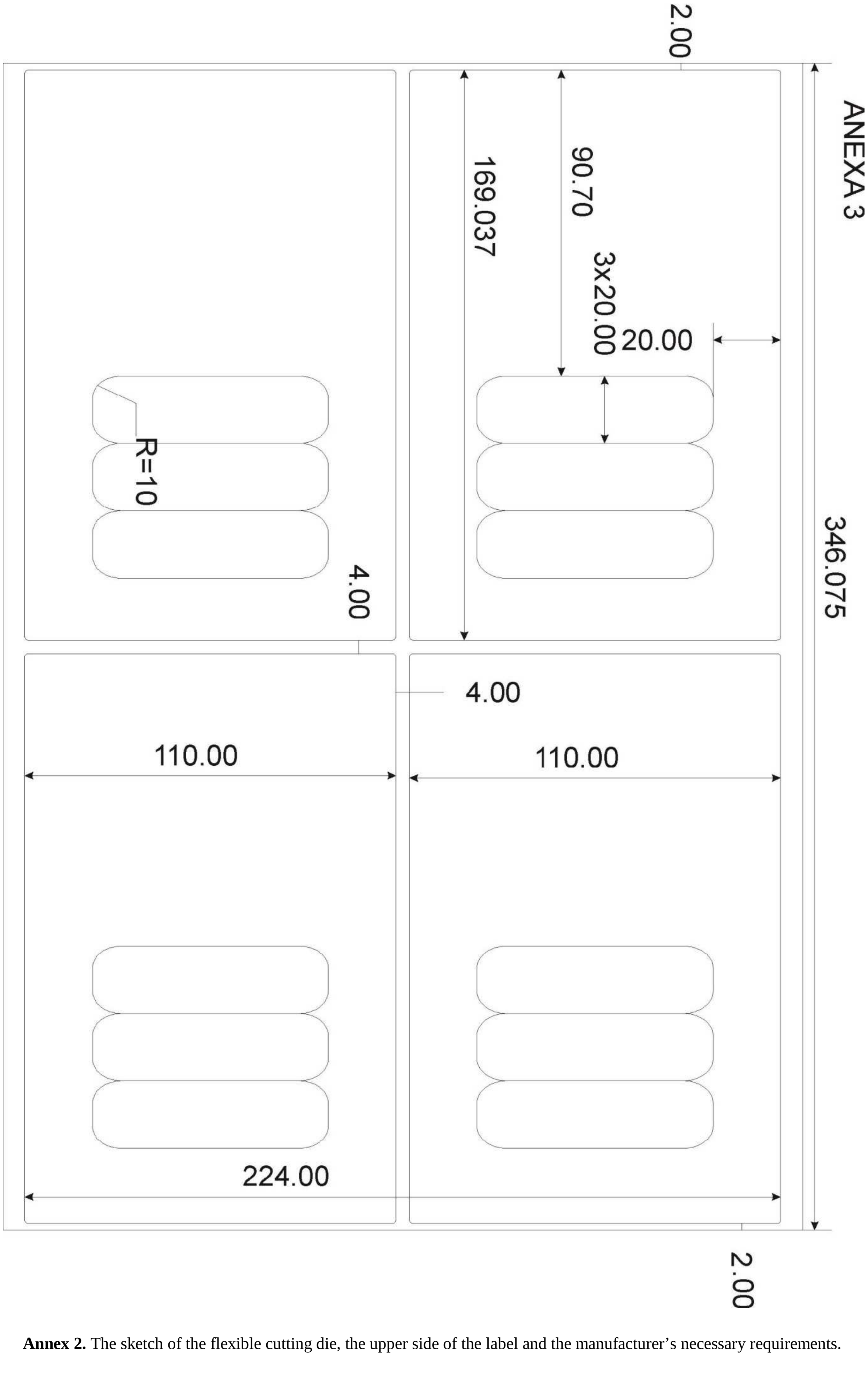
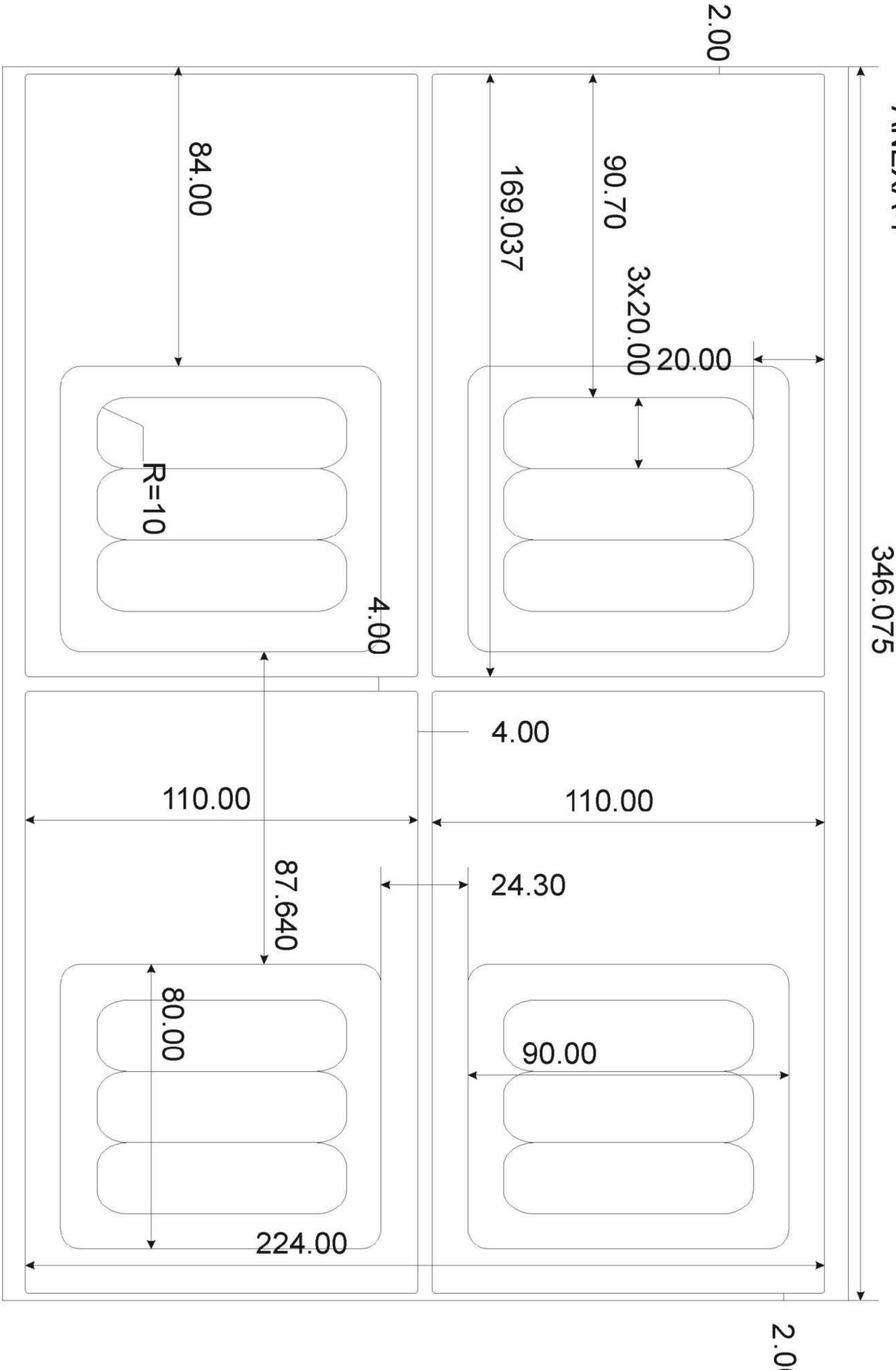


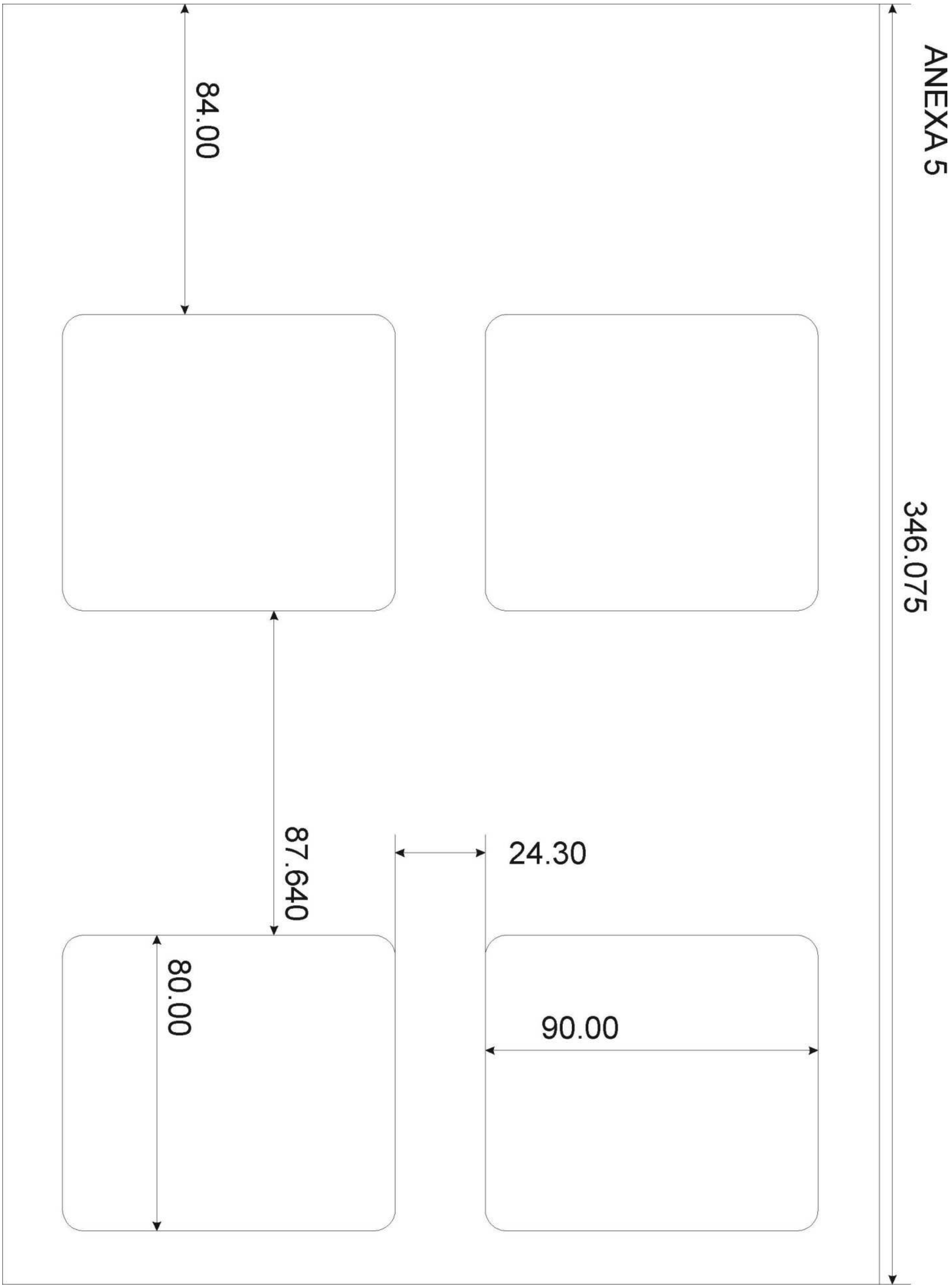
Annex 1. Arsoma 280 KS rotary die cutting unit. Manufacturer: Kocher+Beck Germany.



Annex 2. The sketch of the flexible cutting die, the upper side of the label and the manufacturer's necessary requirements.



Annex 3. The sketch of the flexible die cutting on both sides. A check-up of the two cutting dies centre is required.



Annex 4. The drawing of the flexible die needed for the back of the label used as a base. The manufacturer's required sizes for the flexible die.