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WASTE PRODUCTS MINIMIZATION IN SHEET CUTTING OUT PROCESS FOR TWIST-OFF TYPE COVERS PRODUCTION

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S u m m a r y

Innovative solutions of waste products minimization in the process of disks of tinned sheet cutting out by plastic working method are described in this article. Influence of various possibilities of allowances minimization in sheet cutting out process for Twist Off covers production have been analyzed in the work. The way cutting off the sheet delivered into the press and the sheet allowances between cut out surfaces have important meaning in the process. New solution of the shear edges shape for the sheet cutting off and blanking tool cutting edges new position making possible of the waste products minimization have been described in the work.

Key words: technological wastes, plastic processing.

Minimalizacja odpadów technologicznych podczas procesu wykrawania blachy dla wieczek typu Twist-Off

S t r e s z c z e n i e

W artykule przedstawiono innowacyjne rozwiązania minimalizacji odpadów technologicznych podczas wycinania krążków z blachy ocynowanej metodą obróbki plastycznej. Wykonano analizę wpływu różnych sposobów minimalizacji naddatków podczas wykrawania blachy dla wieczek Twist-Off. Istotne znaczenie podczas wycinania blach ma sposób rozkroju blachy dostarczanej do prasy oraz naddatki blachy między wykrawanymi krążkami. Opracowano nowe rozwiązanie kształtu krawędzi nożyc do rozkroju blachy oraz położenie krawędzi tnących wykrojnika, umożliwiające minimalizacje odpadów.

Słowa kluczowe: odpady technologiczne, obróbka plastyczna.

1. Introduction

The covers, commonly called by compact closure or screw cap name, serve for food products closing and storing in glass and plastic jars equipped in closing system similar to glass jars closing system. Twist-Off covers are suitable for all kind thermal processes: closing in the cold state and in the hot state, pasteurization and sterilization.

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For Twist-Off type covers production tinned sheets are used. The sheets are made in standard dimensions, accordingly to EN 10203/91 and EN 10202/01 standards. Circular surfaces cutting out can be made on presses with various working spaces and being usually smaller, than delivered metal sheet dimensions. This situation forces necessity of parting the sheets to smaller units – working strips meeting requirements of the blanking tool, press bench and press slide working space, and other necessary parameters, connected – for instance – with production automation.

Dies adapted to cutting and simultaneous the surface profiling we call blanking tools. Cutting process with blanking tool is similar to cutting with shears process. Punch and die are sort of cutting tool with closed profile, characterized by compact both together cutting edges. Cutting out [1] makes possible to obtain flat objects having or not having holes with various shapes.

Cutting out circular surfaces of the sheet for Twist-Off type covers production generates waste products in the form of blanking scraps. The magnitude of the sheet waste in cutting out on the press process depends on many factors and we can rank among others [2]:

- clearance between punch and cutting plate edge,
- kind of the material,
- the sheet thickness,
- the hole or cut out element quality requirements,
- the tool life expected,
- the gaps between cut out elements and also between cut out element and the sheet edge.

We can assume constant values of the sheet thickness and parted material kind. Aiming at the sheet waste in the covers cutting out process reducing the way of the sheet parting, cut out elements arrangement and the press construction solutions have been considered.

2. Cut out technology

Optimization analyze of the waste products obtained in the disks of the sheet cut out process for type Twist-Off covers production has been made on two LEN 40C presses with manual or mechanical feeding and on CEVOLANI 40B press with automatic feeding. The presses met criterion relating to power required and working space [3, 4]. The cutting process is based on separating of the disks with 107,2 mm diameter from the sheet strip with 0,18 x 298 x 652 mm dimensions; the disks cutting along closed line will make an object and the part on outside will make the waste (blanking scrap).

LEN 40C eccentric press view one can see on 1a drawing and CEVOLANI 40B eccentric press view on 1b drawing.

a) b)

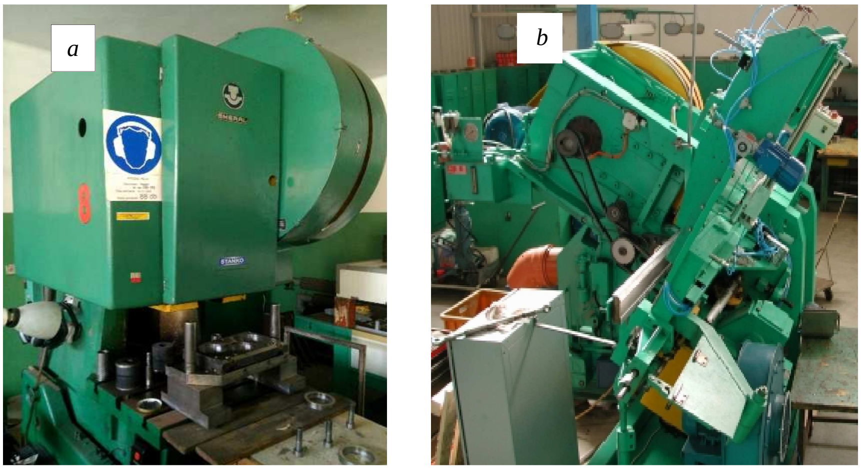

Fig. 1 Eccentric presses: a) LEN 40C, b) CEVOLANI 40B

3. The sheet parting and cut out elements arrangement

Tinned sheet is cut off from metallurgical coil to the sheet length in conformity with ordering requirements. The sheet parting to working strips is executed in relation to working space of the press the cut out will be made on.

Simplest way of the sheet cutting is based on gang slitter or guillotine use. The sheet parting in this way most often assumes a rectangle shape. Other way of the sheet parting to strips is parting with hairpin bends executed with the aid of shaping shears (Fig. 2). The contours of the shaping shears for the sheet parting can be designed in accordance with two cutting edge patterns: cutter arc contour (Fig. 2a) or hairpin bends contour (Fig. 2b).

a) b)

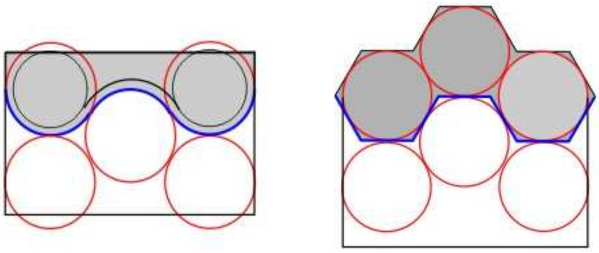

Fig. 2. Cutter cutting edge contour: a) arc contour, b) hairpin bends

The sheet parting depends on cut out surfaces shape and their arrangement on the sheet strip. Cut out elements position on the strip has to be determined with minimum spacing between them and between the elements and the strip edge maintaining. The spacing in the case of metal sheets used for Twist-Off type covers production most often run from 1 to 4 mm [5].There is also possibility to cut out without of spacing. The last way advantage is lower the material consumption, and disadvantage – worsening of the cut out element shape accuracy and burrs. In the sheet parting designing, and especially in designing of minimum spacing between cut out elements, feeder velocity and the way of operation are taken into account. On drawing 3 hypothetical view of the sheet parting and arrangement of cut out elements for Twist-Off covers surfaces are shown. Parting of the sheet from metal sheet T-Fix 930x710 mm has been made to 305,5 x 710,0 mm dimension by rectilinear cutting. Circular cut out fields arrangement takes into account required spacing between cut out elements and the sheet edge. Cut out and pressing process has been executed simultaneously in rowed device with eccentric press participation. The object (cut out element) is made in single cycle of the slide operation by concentrically arranged punches with unchanging the material position. Technological waste (blanking scrap) is moved manually or mechanically, and cut out element is moved with blanking scrap out of working zone.

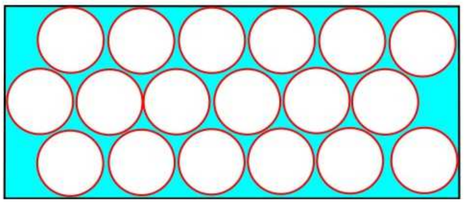

Fig. 3 The parted strip and cut out elements arrangement for linear cutting view

The sheet technological waste, taking into consideration the disk diameter (Ø 107,2), is in this case 26,2 % [4].

Cut out elements arrangement for the sheet parting with hairpin bends is shown on drawing 4. Cut out way has been maintained similar, as in a/m method, i.e. with participation of simultaneous rowed device with manual feeding.

In comparison with drawing 3 the sheet technological waste, taking into consideration the disk diameter, is clearly smaller (Fig. 4).

Exemplary calculations of the waste magnitude have been made in accordance with literature recommendations [6], on the assumption that cut out disks spacing is minimal.

At manual feeding [6] technological allowances *a* and *b* are red from tables and multiplied by conversion factor K_r; for this example the factor is:

$$a \cdot K_r = 2{,}4 \cdot 0{,}8 = 1{,}92 \text{ mm}, \tag{1}$$

and cut out elements spacing:

$$b \cdot K_r = 2{,}0 \cdot 0{,}8 = 1{,}6 \text{ mm}. \tag{2}$$

In factory producing Twist-Off covers on LEN 40C press with lower drive and mechanical feeder electromagnetically aided experimentally have been determined sufficient allowances a = 1,2 mm and b = 1,2 mm [4]. On the sheet strip fore-part and end (for safety reasons) one can use the greater allowance, b = 1,6 mm.

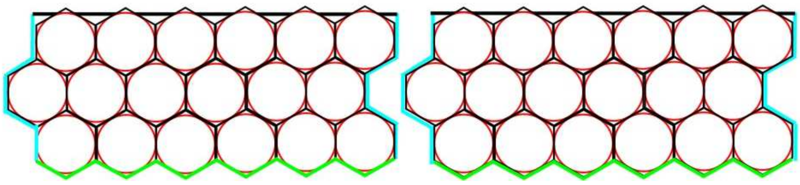

Fig. 4. The parted strip and cut out elements arrangement for cutting with hairpin bends view [7]

In circular elements cutting out process from the sheet or sheet strips with rowed cutting system – in accordance with Institute of Plastic Working in Poznań recommendations [6, 7] – it has been found, that optimum yield can be obtained at cutting out 2 – 7 rows of circular elements.

In process determination of cut out elements position in the sheet strip minimum spacing between cut out elements and between them and the strip edge should be maintained.

For rowed cutting out of circular elements [5] the strip width (excluding hairpin bends) is determined by formula:

$$B = D + 2t + 0{,}87\,(D + p)(k - 1), \tag{3}$$

and the sheet utilization factor for the case is:

$$\eta = \frac{\pi D^2 k}{4(D+d)\left[(D+2t+0{,}87(D+p)(k-1)\right]} \cdot 100\,, \tag{4}$$

where: B – the strip width, η – the material utilization factor, k – rows' number, t – allowance between cut out element and the strip edge, p – distance between neighbouring cut out elements.

From that – after substituting the values in 3 and 4 formulas – we obtain in conformity: B = 298,22 mm and η = 83,55 %. And so for this case technological waste is 16,45 %.

At investigation of cut out elements arrangement in the sheet strip it is also necessary to consider cut out effectiveness. One should avoid or minimize punches free movements number. It is important in mass production [4]. On 5 and 6 drawing cut out elements arrangement for the sheet parting with hairpin bends. Cutting out way has been maintained, similar, as in previous method, but with the sheet automatic feeding with two incomplete free movements (Fig. 5) and without free movement (Fig. 6).

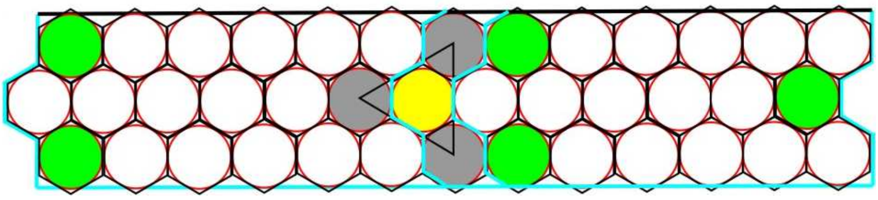

Fig. 5. Example of the sheet parting with two incomplete free movements

The sheet parting shown includes two incomplete working cycles: the first – with one cut out element and the last – with two cut out elements. Such parting causes lowering the production effectiveness.

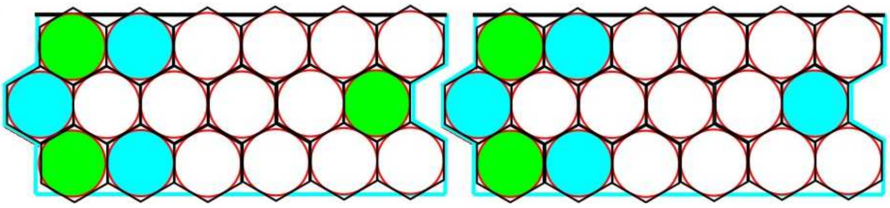

Fig. 6. Example of the sheet parting without free movement

The sheet parting difference, in accordance with 5 and 6 drawings, lies in that in the case of second parting (Fig. 6) the yield was higher by 16,7 % [4].

The material savings can be obtained by proper cut out elements arrangement in the sheet rowed strips. In the case of the elements with disk shape utilization degree increases together with rows number increase.

Technological waste magnitude is dependent on allowances on side intervals and between cut out elements. Such the sheet parting example is shown on drawing 7.

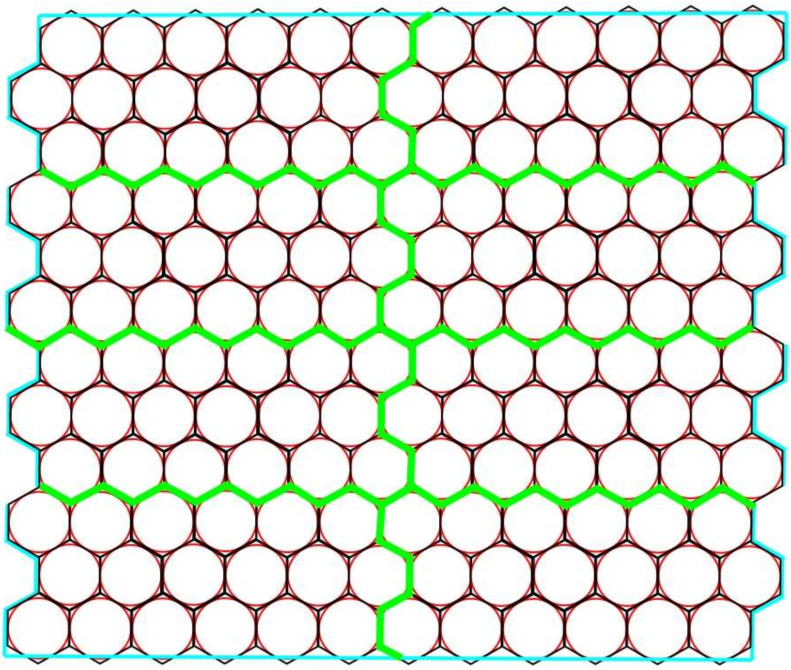

Fig. 7. Example of the sheet parting at shape cutting with working strips indication

4. Recapitulation

The results of the solutions described in this article have been implemented in STANKO company. In comparison the sheet cutting along straight line the sheet yield (77,1 %) is by 11,7 % worse, than in the strips shaped cutting method.

Shown method of the sheets parting is executed on guillotine-duster; the last one has additional function of the sheet smearing on the way of hot grease sprinkling and the sheet parting owing to use of separate die blocks with sintered carbide inserts.

Production process execution has been worked out basing on material yield factor (88,8 %); the factor high value increases the product competitiveness on the market.

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