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CORRELATION OF DIE CLEARANCE VALUE COMPUTED AND EXPERIMENTALLY DETERMINED DURING DRAWING OF TINNED SHEET.

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ABSTRACT

The aim of this study is calculation of die clearance from literature data followed by experimental verification on steel sheets. Steel sheet, thickness 0.24 mm. electroplated on both sides by tin with surface density 5.6/5.6 gm^{-2} was selected. For experiments the drawing die was developed on TU of Brno. The uniformity of wall thickness of cylindrical shells without flange was measured on lines oriented 0°, 45°, and 90° with respect to the drawing direction. The results could be utilized in press shops.

1. INTRODUCTION

Modern chipless technologies exhibit not only high productivity but high precision as well . The effectiveness and quality of this production is strongly influenced by optimization of technological parameters of the drawing of surface treated tinned sheets. Attention was concentrated on the size of die clearance. Design and technology parameters, especially dimensions of die clearance are very important area when drawing of thin sheets of tin coated steel are concerned. Although the technical side of drawing is generally mastered, there is no reliable reference material containing selected design and technology parameters for designers with respect to wide selection of new thin steel sheets coated by tin. Research done in the Institute of Technology of TU of Brno focussed on drawing of steel sheet, thickness 0.24 mm, electrolytically coated by tin, 5.6/5.6 gm-2. The test tool-die, made on TU of Brno was used for drawing of very thin sheets.

Fig. 1 Test die with shells

2. TESTED MATERIAL

For experiments steel sheet 0.24 mm thick coated from both sides by tin with surface density 5.6/5.6 gm^{-2} was selected. Tin coating is effectual protection against corrosion on condition that surface layer of tin remains continuous and uniform. Tin forms, under favorable conditions, dioxide SnO_2 and oxide SnO which excellently resist atmosphere and aqueous effects. Tin dioxide SnO_2 is tetragonal crystal lattice and it is necessary to take into account its brittleness. Tinned sheets are used in foodstuffs and chemical industries, and electrical engineering because they do not present sanitary threats and, on the other hand, display good soldering properties and chemical resistance [1, 2, 3].

Mechanical properties of the tin coated (density 5.6/5.6 gm^{-2}) sheet specimen with nominal thickness 0.24 mm were determined by tensile test in TIRA TEST 2300 machine [4]. Beam velocity was 5 mm/min, width of test specimen 12.5 ± 0.09 mm and other test parameters were in accordance with standard ČSN EN 10002-1, Appendix A, p. 16. Laboratory temperature was 20°C. Measured average value of tensile strength was R_m = 308 MPa, yield point in tension $R_{P0.2}$ = 181 MPa and elongation A_{80} = 26 %. Further, the value of technological test of denting according to Erichsen was determined - first crack appeared when indentation reached depth of 8.9 mm.

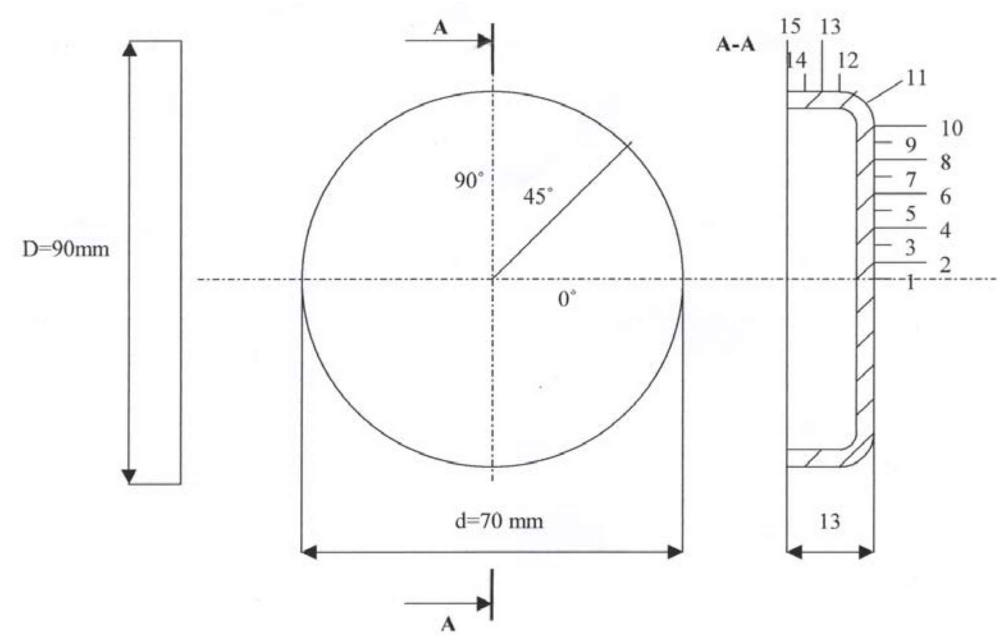
3. DIE CLEARANCE AND ITS DETERMINATION DURING DRAWING OF SHEET.

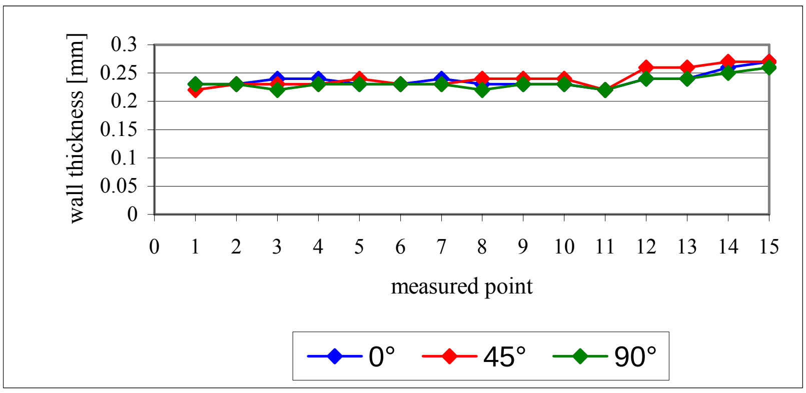
Relations used for die clearance calculation vary in technical publications (Tab.1)

Authors	Mathematical relation	For thickness=0,24mm, D=90mm Two side Sn coating 5,6g/5,6g/m² Initial solution	Test in TU Brno
TSCHÄTSCH H.	$w = s * \sqrt{\frac{D}{d}}$	$w = 0,24 * \sqrt{\frac{90}{70,08}} = 0,281\text{mm}$	
OEHLER	$w = s + k * \sqrt{s}$	$w = 0,24 + 0,07 * \sqrt{0,24}$ $w = 0,274\text{mm}$	
HELLWIG,W.	$u_{zl} = s + 0,20 * \sqrt{s}$	$u_{zl} = 0,24 + 0,20 * \sqrt{0,24}$ $u_{zl} = 0,338\text{mm}$	
ZUBCOV,M.J.	$z = t_{max} + c * t$	$z = 0,24 + 0,2 * 0,24$ $z = 0,288\text{mm}$	Optimal die clearance $t_m = t_{max} + 0,01$ [mm] $t_m = 0,24 + 0,01$ $t_m = 0,25\text{mm}$
ROMANOVSKIJ	$z = \frac{d_m - d_n}{2} =$ $z = s_{max} + n * s$	$z = 0,24 + 0,2 * 0,24$ $z = 0,288\text{mm}$	
ŠOFMAN,L.A	$z = t * (1 + 0,05 * \sqrt{\frac{10}{t}})$	$z = 0,24 * (1 + 0,05 * \sqrt{\frac{10}{0,24}})$ $z = 0,317\text{mm}$	
VDI Richtlinie 3175	$u_{z\max} = s * \sqrt{\beta}$	$u_{z\max} = 0,24 * \sqrt{1,28}$ $u_{z\max} = 0,271\text{mm}$	
22 73 01	$t_m = (1,2 \div 1,3) * s_0$ $t_m = (1,1 \div 1,2) * s_0$	$t_m = (1,2 * 0,24) = 0,288\text{mm}$ $t_m = (1,3 * 0,24) = 0,312\text{mm}$ $t_m = (1,1 * 0,24) = 0,264\text{mm}$ $t_m = (1,2 * 0,24) = 0,288\text{mm}$	
SRP,K. aj.	$z = s + 0,07 * \sqrt{10 * s} - \text{steel}$ $z = s + 0,04 * \sqrt{10 * s} - \text{non-metal}$ $z = s + 0,02 * \sqrt{10 * s} - \text{aluminium}$	$z = 0,24 + 0,07 * \sqrt{10 * 0,24} = 0,348\text{mm}$ $z = 0,24 + 0,04 * \sqrt{10 * 0,24} = 0,301\text{mm}$ $z = 0,24 + 0,02 * \sqrt{10 * 0,24} = 0,271\text{mm}$	

Tab. 1 Die clearance width t_m (relations used for calculation from selected authors and standard for drawing)

Moreover, the formulas for die clearance calculation in the case of coated thin sheet drawing are scarce. That is why the optimizing experimentally die clearance was attempted at Institute of Technology TU of Brno. Sheet 0.24 mm thick with two sides tin coated with surface density 5.6/5.6 gm^{-2} was selected for experiments. Best results as far as the surface quality, dimension and shape accuracy are concerned were obtained with rondel, diameter D = 90 mm, sheet thickness t = 0.24 mm and die clearance t_m = 0.25 mm. Thickness variations of selected shell are shown in Fig. 2. The comparison of t_m values obtained by different relations published in literature shows certain variations of t_m. For example according to Hellwig die clearance for the first draw is t_m = 0.338 mm, from directive 3175 VDI it follows, for draw degree K = 1.35 and rondel size D = 90 mm, $t_{m\ max}$ = 0.271 mm [5, 6]. Czech technical literature and ČSN standards concerning drawing recommend die clearance as 1.1 to 1.3 multiple of sheet thickness, which means in our case the value from interval 0.264 to 0.312 mm.





	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
0°	0,23	0,23	0,24	0,24	0,23	0,23	0,24	0,23	0,23	0,23	0,22	0,24	0,24	0,26	0,27
45°	0,22	0,23	0,23	0,23	0,24	0,23	0,23	0,24	0,24	0,24	0,22	0,26	0,26	0,27	0,27
90°	0,23	0,23	0,22	0,23	0,23	0,23	0,23	0,22	0,23	0,23	0,22	0,24	0,24	0,25	0,26

The variations of wall thickness (nominal thickness 0,24 mm)

Steel sheet electroplated on both sides by Sn 5,6 g/m^2, STONE FINISH,CA T61, lubricant DRAWSOL WDC9

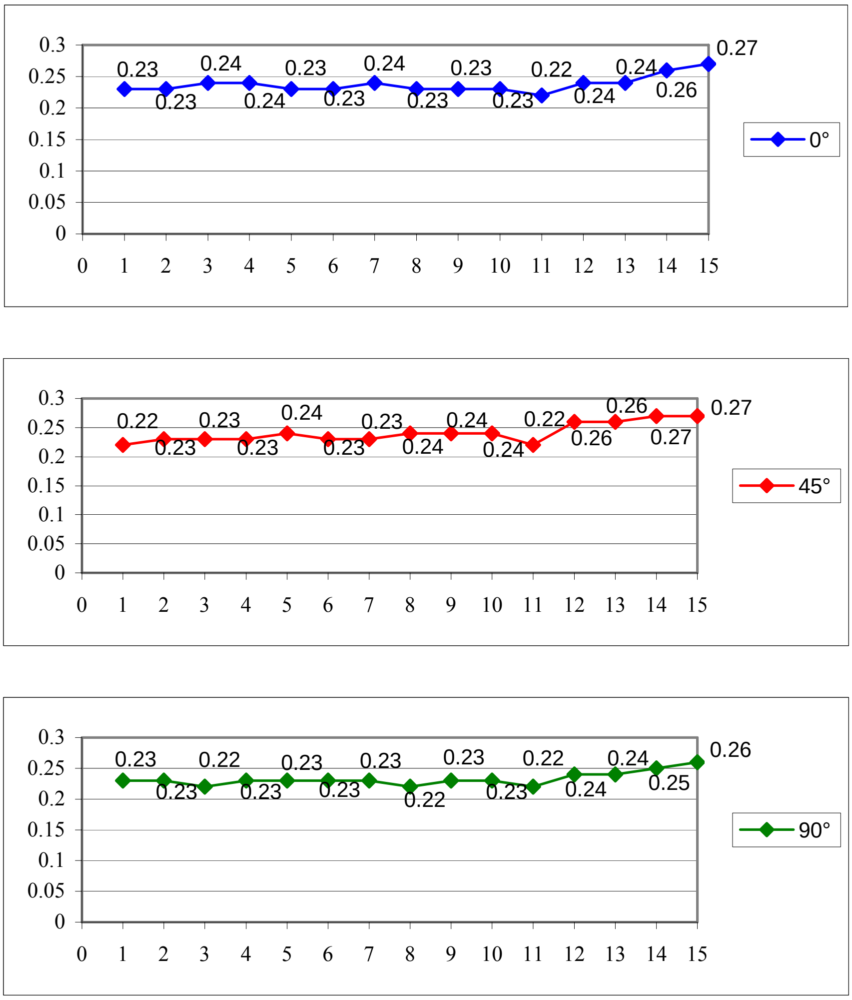


Fig. 2 The variations of wall thickness

4. TRIBOLOGICAL ASPECTS OF COATED SHEETS DRAWING

During drawing, and especially deep drawing, the surface properties of examined very thin sheet coated by tin are changing due to the plastic deformation of basic material. Thus the volume of lubricant trapped on the sheet surface defined by ratio of open and closed cavities in the material vary. This causes the change of friction coefficient during drawing. Further, final surface after drawing determines the brilliancy of covering varnish, e. g. on industrially produced components. It is necessary to develop model for each particular dimension of very thin sheet covered by Sn used in mass production e.g. in foodstuff industry. The variation of surface structures is difficult to describe using present two-dimensional parameters. It seems necessary to determine physical parameters of tribological processes accompanying drawing technology and evaluate three-dimensional parameters for description of tinned sheets surface. Each type of forming operation requires specific properties of lubricant. Market offers wide spectrum of lubricants and their choice should be consulted with specialist and experimentally verified for each specific case of employed forming technology [7,8,9,10,11]. For experiments performed at TU of Brno lubricant DRAWSOL WDC 9 was used, degree of draw was K = 1.28 and drawing was done in press CTC 5.

5. CONCLUSIONS

The aim of experiments performed at Institute of Technology , TU of Brno, was to verify optimal size of die clearance for cylindrical shell without flange produced from steel sheet with gauge 0.24 mm, coated from both sides by tin with planar density 5.6/5.6 gm^{-2}. The die clearance was determined by calculation using relations found in technical publications and verified experimentally. Special drawing tool was designed and manufactured at Institute of Technology. Experimental results proved:

from rondel diameter interval D = 85 to 115 mm, and sheet gauge 0.24 mm, best results with respect to the surface quality, shape and dimension accuracy, were obtained for cylindrical shell without flange made from rondel D = 90 mm, die clearance was t_m = 0.25 mm and degree of draw K = 1.28,

functional shells were produced using drawing punch d = 70.08 mm with lubricant DRAWSOL WDC 9 applied uniformly on the surface of rondel sheet which is in contact with drawing die,

initial pressure of downholder, as obtained by optimization, was p_p = 1.32 MPa,

functional test shell, produced with above listed parameters, was made by single draw,

the size of experimentally determined optimal die clearance t_m = 0.25 for tested sheet gauge 0.24 mm with tin coating 5.6/5.6 gm^{-2} is less than that obtained by calculations based on technical literature; maximum difference attains 35 %.

Note:

This contribution contains results of MSM 262100003 studied at Institute of Technology, FME, TU of Brno.

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PROBLEMATIKA ZAZORA ALATA U PROCESIMA DUBOKOG IZVLAČENJA TANKIH LIMOVA SA PREVLAKAMA

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REZIME

U ovom radu je razmotrena problematika zazora kod alata za duboko izvlačenje tankih limova, i to teoretskim i eksperimentalnim putem. Specijalni alat za duboko izvlačenje konstruisan je i izrađen na institutu Univerziteta Brno. Izvlačen je čelični lim debljine 0.24 mm, na koji je specijalnim postupkom naneta prevlaka sa obe strane. Nakon eksperimenta merena je ravnomernost debljine zida i to pod različitim uglovima (0^o, 45^o i 90^o) u odnosu na pravac izvlačenja.

Mehaničke osobine lima pre deformisanja određene su eksperimentom zatezanja na TIRA TEST 2300 mašini.

Pored eksperimentalnih istraživanja problem zazora kod alata za duboko izvlačenje razmatran je i teoretski na bazi literaturnih podataka. Pri tome se konstatuje da postoji vrlo mali broj literaturnih izvora koji se bave zazorom kod dubokog izvlačenja lima sa prevlakama.

Na bazi sopstvenih eksperimentalnih rezultata i teoretskih podloga iz literature, verifikovana je optimalna veličina zazora kod dubokog izvlačenja cilindričnih komada bez venca, materijal debljine 0,24 mm. Za eksperimente su korišćene rondele prečnika D = 85 – 115 mm. Najbolji rezultati sa stanovišta kvaliteta površine, tačnosti oblika i dimenzija dobijeni su za slučaj dubokog izvlačenja iz rondele prečnika D = 90 mm i za zazor alata od 0,25 mm.

U procesu dubokog izvlačenja tankih limova sa prevlakama spoljna površina se menja i u tribološkom smislu, tj. menja se odnos tzv. "otvorenih" džepova na površini lima u kojima se nalazi sredstvo za podmazivanje. Koeficijent trenja se menja u toku procesa.

Za podmazivanje u eksperimentalnim istraživanjima je korišćeno sredstvo DRAWSOL WDC9 koje je ravnomerno naneseno na površinu lima. Inicijalni pritisak držača lima bio je p=1,32 Mpa.