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# Experimental and numerical investigation of the deep drawing process using a tractrix die – An industrial case study focused on stress and temperature analysis

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**ABSTRACT**

The deep drawing process of thick sheet metal for vessel production is carried out by applying a tractrix die with the absence of a blank holder, which has economic benefits for industrial production. The main aim of the paper is the development of a reliable numerical thermo-mechanical model of a silicon brass vessel manufactured by a deep drawing process in a tractrix die and a subsequent ironing process, which includes the previous assembly of the dies with reinforcing rings that creates the required prestresses. The testing of the mechanical properties of silicon brass CuZn24Si was carried out by a standard uniaxial tensile test, thus a flow curve was determined to describe the material behaviour. The initial temperatures of the environment, blank and tools were measured with an infrared thermal imager. A comprehensive finite element stress analysis of the deformable tools was carried out for the assembly phase of the dies, and for workpiece and tools in the deep drawing and ironing processes. The comparison of measured and numerically estimated temperatures had a good agreement, so the developed numerical model was confirmed and validated. This research study demonstrates how different process parameters can be investigated through a reliable and precise numerical model with complementary experimental research for the optimization of industrial technology.

**ARTICLE INFO**

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# Eksperimentalna in numerična raziskava procesa globokega vleka z uporabo matrice traktriks – Industrijska študija primera s poudarkom na analizi napetosti in temperature

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**POVZETEK**

Postopek globokega vleka debele pločevine za proizvodnjo posod se izvaja z uporabo matrice traktriks, pri čemer ni držala za surovec, kar ima ekonomske prednosti za industrijsko proizvodnjo. Glavni cilj članka je razvoj zanesljivega numeričnega termo-mehanskega modela posode iz silicijeve medenine, izdelane s postopkom globokega vleka v matrici traktriks in naknadnim postopkom likanja, ki vključuje predhodno montažo matric z ojačevalnimi obroči, ki ustvarjajo zahtevane prednapetosti. Testiranje mehanskih lastnosti silicijeve medenine CuZn24Si je bilo izvedeno s standardnim enoosnim nateznim testom, zato je bila določena tokovna krivulja, ki opisuje obnašanje materiala. Začetne temperature okolja, surovca in orodja so bile izmerjene z infrardečo termokamero. Izvedena je bila celovita analiza napetosti deformabilnih orodij s končnimi elementi za fazo montaže matric ter za obdelovance in orodja v postopkih globokega vleka in likanja. Primerjava izmerjenih in numerično ocenjenih temperatur se je dobro ujemala, zato je bil razviti numerični model preverjen in potrjen. Ta raziskava kaže, kako je mogoče z zanesljivim in natančnim numeričnim modelom z dopolnilnimi eksperimentalnimi raziskavami raziskati različne parametre procesa za optimizacijo industrijske tehnologije.

**PODATKI O ČLANKU**

*Ključne besede:*
Globoki vlek;
Matrica traktriks;
Ojačevalni obročki;
Metoda končnih elementov (MKE);
Eksperimentalno-numerični pristop;
Numerično modeliranje;
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