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Analysis of die Shape Influence on Al-Cu Bimetal Charge Yield during Extrusion Process

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In the work an analysis of backward Al-Cu bimetallic rod extrusion process from the value of charge yield in final product was done. The range of research included FEM modeling of the process with programm Forge 2008®. For the chosen parameters of the process, simulation investigations for range of die and punch angle from α=30° to α=70° in the room temperature and extrusion speed v = 10 mm/s were carried out. On the base of the research the character of bimetal flow and values of nose crop and tail crop were obtained. Such investigations allowed to choose an optimal shape of the dies. Moreover the analysis of strain, stress and velocity of bimetal in all cases from the research range was realized to obtain the detailed analysis of metal flow into the deformation zone.

Keywords: FINITE ELEMENT METHOD, BIMETALLIC ROD, EXTRUSION, NOSE CROP, TAIL CROP, DIE, DEFORMATION ZONE

1. Introduction

In the extrusion process like in other processes of metal forming a very important economical parameter is a productivity of the process. The productivity is strict connected with charge yield on which the significant influence has an amount of the technological discard.

During the extrusion process in the conical die exists two different type of discards: a nose crop and a tail crop. Moreover in the process of simultaneous extrusion of different materials which flows in non-uniform way like copper and aluminum, the length of discards (both tail crop and nose crop) increases and the charge yield is decreasing.

The length of the tail crop and nose crop was measured for all shape die variants (half angles of conical die α=30÷70°) during the numerical analysis of bimetal flow.

The characteristic place of measurement was showed in **Figure 1**. The length of tail crop could be measured directly because this is the same values as the length of plastic deformation zone (conical die zone). To obtain the length of the nose crop the process of extrusion should be operated until the steady state (the particular layers of the bimetal are flowing almost uniformly through the calibration zone [1]).

2. Aim of the work

The numerical research were conducted to analyze the backward extrusion process of bimetal round rods from the discard forming point of view. The bimetal billet was consisted from copper sleeve (CW004A) and aluminum core (1050A). The modeling was conducted for following parameters of the extrusion process: the initial diameter of bimetal charge was 22 mm and extrusion ratio equal 5, range of die angles: α=30÷70° (**Figure 1a**), percentage fraction of sleeve was 15%, ram speed v = 10 mm/s, all the variants of modeling were done in the condition of cold deformation. The main aim of the work it was establishing the optimal half die angle for the extrusion process.

3. Analysis of discard forming

In the **Figure 2** all the analyzed variants of die shape with lengths of discards were presented. Along with increasing the angle of slope of extrusion die, the length of the nose crop is decreasing. Such tendency is more visible for cases until α = 50º, for higher values of angles (α = 60º and 70º) the decreasing the nose crop is less intense (**Figure 3**).

The character of the phenomena is strictly connected with the friction forces which appears on the surface of moving die. It could be stated that the longer zone of plastic deformation, the influence of friction forces on the nose crop is more intense. And the smaller differences between flow velocities of particular layers on the cross-section of the bimetal caused by smaller values of the resistance of plastic flow of outer layer of bimetal resulted insignificant decrease of the length of the nose crop for cases where α = 50º, 60º i 70º.

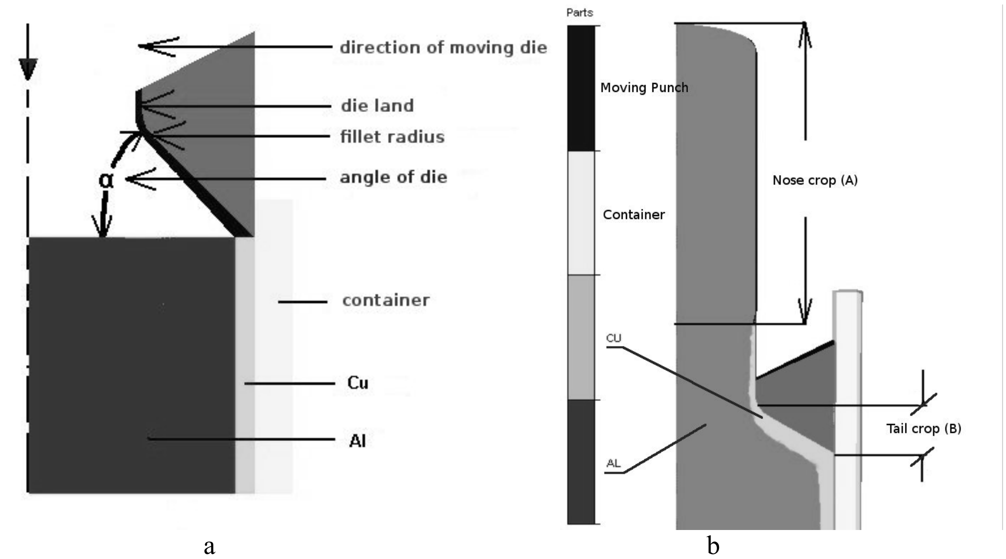

Figure 1. Model of backward extruded Al-Cu bimetal before the process (*a*) and after with characteristic values of discards (*b*)

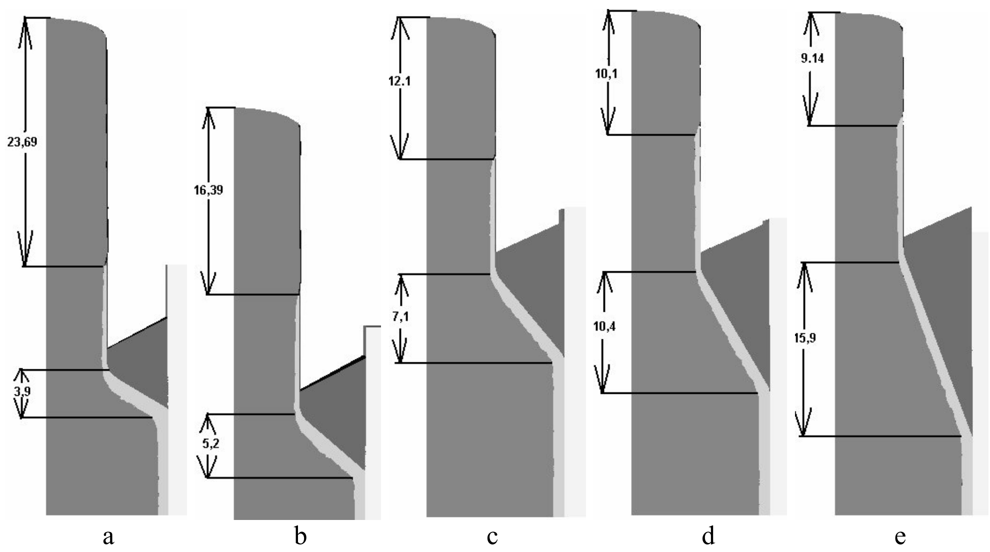

Figure 2. Length of discards for particular variants of extrusion process: *a* – α = 30º; *b* – α = 40º; *c* – α = 50º; *d* – α = 60º; *e* – α = 70º

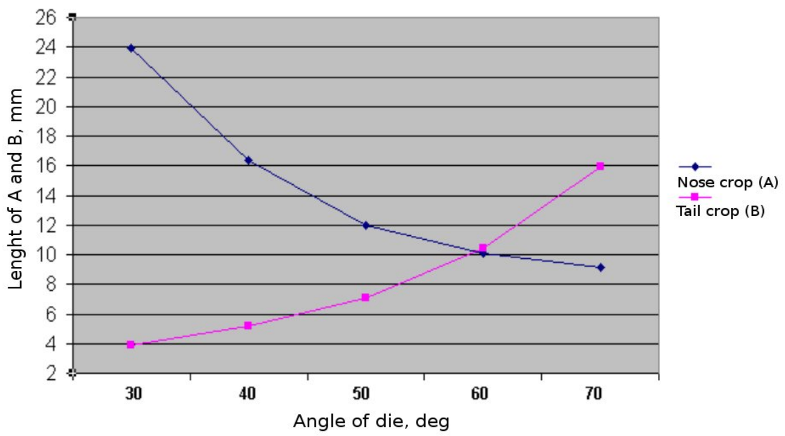

Figure 3. Relation between die angle and length of the discards

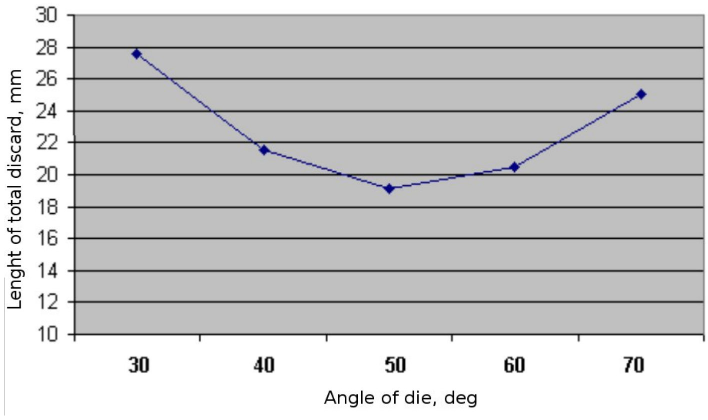

Figure 4. Total discards for investigated die angles

The charge yield and the length of total discard is composed also of the tail crop which is increasing along with increasing the angle of die surface (α) [2].

Total values of the discard was presented in **Figure 4**. The character of the curve allow to establish a local maximum for extrusion process of bimetal rod with 15 % fraction of copper layer which is located for the angle α=50º.

4. Conclusions

On the base of the analysis of numerical research it could be stated that:

1. High nonuniformity of bimetal flow during extrusion process for composition: hard sleeve and soft core (bimetal Al-Cu) is increased along with decreasing of die angle.
2. During bimetal layers flow in non-steady stage of extrusion process it is created the part of extrusion which would be treated as a nose crop. And higher resistance to flow in the outer layer exists the longer nose crop is created.
3. The amount of the discards depends on bimetal composition, for Al-Cu (type of flow B [3]) the main part of the discards is forming during non steady stage of extrusion process and the proper extrusion is forming during steady stage of the process and it can be assumed that this part of product perform conditions according to standards for bimetals [4].
4. On the base of the numerical analysis of particular layer flow the optimal angle of the die was chosen. The angle α = 50º allows to obtain the smallest amount of discards and the biggest charge yield for final product.

References

1. Berski, H. Dyja, A. Maranda, J. Nowaczewski, G. Banaszek,: *Analysis of quality of bimetallic rod after extrusion process. Journal of Materials Processing Technology*, volume: 177, 2006, pp. 582-586.

2. Lucki B, *Optimal shape of die for extrusion process of Al-Cu bimetal rods*, Czestochowa 2009, (non-published).

3. Laue K., Stenger H.: *Extrusion*. Ohio 1981. American Society for Metals, Metal Parks.

4. *ASTM B 566 copper clad aluminum wire.*

Анализ влияния формы матрицы на выход годного в процессе прессования биметаллических алюминий-медных прутков

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В работе проведен анализ процесса обратного прессования Al-Cu биметаллического прутка с точки зрения выхода годного. Исследования проводились при помощи программы Forge 2008 ®, основанной на методе конечных элементов. Моделирование проводилось при следующих параметрах процесса: угол матрицы в диапазоне от α=30° до α=70°; комнатная температура; скорость перемещения пресс-штемпеля v = 10 мм/с. В результате моделирования был получены данные о характере течения биметалла, длине переднего монометаллического конца и объеме пресс-остатка. Проведенные исследования позволили определить оптимальную геометрию матрицы. Также был проведен анализ распределения деформаций, напряжений и полей скоростей течения биметалла во всех точках эксперимента, что позволило установить характер течения металла в обжимной части пластической зоны. Ключевые слова: метод конечных элементов, биметаллическая труба, прессование, передний конец, пресс-остаток, матрица, очаг деформации.