Optimising a specific tool for electrical terminals crimping process

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Abstract

The continuous need for increasing productivity leads to the use of increasingly sophisticated equipment, enabling new approach techniques of manufacturing processes, higher speeds and greater accuracy in the final product. However, almost all of the equipment require appropriate tools, which effectively take advantage of their available potential. Engineering has an extremely important role in this matter since it will have to develop the tools regarding the satisfaction of a large number of requirements. This work was developed around a real need, having been stipulated the requirements needed by the customer, being the tool design elaborated around these same requirements. A tool optimisation was undertaken still at the preliminary draft stage, the materials have been carefully selected and the budgeting was also presented, as well as a plan for the operation and maintenance of the tool.

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Keywords: Focused tools; Engineering; Mechanical design; Materials selection; Budgeting; Payback; FMEA.

Nomenclature

<table>
<thead>
<tr>
<th>Slightness</th>
<th>Relation between height and radius of rotation of the base</th>
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<tr>
<td>Kanban</td>
<td>Semi-finished product (intermediate stock)</td>
</tr>
<tr>
<td>Microconstituent</td>
<td>Constituent at microscopic level</td>
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</tbody>
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Micro-cut: Cut done in the crimping zone of the terminal in order to check its quality.
Microstructure: Constituents arrangement at microscopic level.
Recrystallization: Change in grain size and in microconstituents.

1. Introduction

Mould, die and punch industries are, for several decades, a very prestigious industry in Portugal, and this work is developed in this context, with quite a lot of multinational companies based in this country working for the automotive industry. The quality demand, the technology competence and industrial competitiveness, allow this kind of tools to be developed and/or manufactured in Portugal, fulfilling even the most rigorous customers’ requirements.

The main purpose of this work is to project a specific tool for electrical terminal crimping process directed to the automotive industry that should obey to the customer needs, using the most suitable materials and with reduced cost. This work comprises two main aspects: first, the analysis of the technical and scientific progresses related to this matter; second, the development of the project itself, following this methodology: (a) Gathering of data needed for this project; (b) Analysis of the customer requirements; (c) Identification of the problem and elaboration of a plan on how to overcome difficulties; (d) Benchmarking of possible solutions in identical tools; (e) Execution of the project; (f) Solution of materials and thermal treatments to each component; (g) Elaboration of the tool assembly plan, instructions for use and maintenance.

Cutting and forming have too much importance in modern technology, since these manufacturing processes allow complex shapes, improving as well the material characteristics by a more compact structure, which increases some properties like mechanical strength and toughness [1-4]. Cutting is a process that has none or few effects in the mechanical properties, allowing a good dimensional precision and finishing at low cost with high production rates. Depending on the clearance between the punch and die, the sheet material and the tool wearing, it will result in more or less burr, which is the main quality standard [5, 6]. Clearance is the most important feature: if it is too big it will result in too much burr, if it is too small it will result in a faster wear of the cutting edge [7, 8]. Oehler (1993) states that the clearance used between the punch and dies must be [9]:

\[ f/2 = 0.005 \cdot e \cdot \sqrt{R_c} \quad (p/t < 3 \text{ mm}) \]  
\[ f/2 = (0.010 \cdot e - 0.015) \cdot \sqrt{R_c} \quad (p/t \geq 3 \text{ mm}) \]  

Being \( f \) the clearance \( (f = D - d) \), \( D \) the dimension of the die, \( d \) the dimension of the punch, \( t \) the sheet’s thickness and \( R_c \) the shear strength (in kgf/mm²) [8, 9]. As stated before, a reduced clearance will result in more wear to the tool, but a bigger thickness of material to cut and shear strength will also incite this effect due to increased amount of work needed to execute the cut, which is directly related to the increase in temperature because it generates heat. When production rates are high, this can be a problem, because a high working speed will produce more heat than the material is capable of draining, even in good heat-conductive materials, meaning that the working speed should also be a parameter in this process [10].

The cutting process, when performed in presses, is comprised of three different steps: squeezing, real cut and rupture. When the component needs an accurate shape, some finishing tasks are needed. However, in order to avoid this step, one can use a special tool that compresses the sheet, before and while the cut is done, all around the cutting outline, usually called fine-cutting or precision-cutting. The precision-cutting is slower than the conventional cutting process, but it uses higher pressures and ten times less radial gap between the punch and the die. Thus, the final components offer much smoother cut surfaces (Ra between 0.3 and 1.5 µm), thinner tolerances, more complex geometry and reduced minimal cutting distances – see figure 1 for comparison.
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