Sustainable Progressive-Stamping by Using the Low-Temperature Plasma Nitrided Dies

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Abstract. The semi-dry progressive stamping was strongly required to make mass production of clothing parts and beverage cans with minimum use of mineral-oil base lubricants. Without the surface treatment and protective coating, the bare punches had to suffer from severe wear and high friction to shorten their life time. Among several candidate treatments, the low temperature plasma nitriding at 673 K was employed to harden the seven kinds of punches for semi-dry progressive stamping in the previous works in our research. The micro-structure and nitrogen mapping in these nitrided punches were investigated by SEM-EDX to demonstrate that nitrogen super saturation into punch materials could prolong their life time. In the present paper, the engineering impact of this approach on the semi-dry stamping was discussed with use the sustainability index (S_{total}). This S_{total} was defined by (S_{energy} + S_{wear}) / $S_{accuracy,}$ where S_{energy} denoted for the energy consumption for stamping, S_{wear}, the punch wear, and, $S_{accuracy}$, the quality ratio of products. The endurance experiments were performed to describe the dry progressive stamping behavior with 300 strokes per minute in fabrication of American snaps from the copper-base alloy sheets. S_{energy} was calculated by (number of products) x (energy cost per one shot). The micro-hardness was employed to prove that the seven punches have uniform hardness even at the vicinity of punch head edges. In second, the wear of punches was investigated by using the optical microscopy in every million shots to estimate the time history of tool wear. Without use of the low temperature plasma nitriding, severely scratches were observed on the heat treated SKD11 punches; they were exchanged to new ones after continuously stamping for 6 x 10^5 shots. When using the plasma nitrided SKD11 punches, this tool life limit was found to prolong up to 1.1 x 10^7 shots. This impact of low temperature nitriding was explained by using the calculated sustainability indices.