Research on Improvement of Blank Precision and Life Span Extension of Nail Clipper Die with Uneven Shear Area

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Abstract

This paper provides technical support guidelines that address problems related to nail clipper progressive die for Three Seven Inc., also known as "777" in the global beauty supply market. The company's nail clippers have not been recognized as the best of their kind because the cross sectional areas on the sides of these multipurpose nail clippers that are more recognized in the global market than in Korea are not even and have a large fracture angle and rough surface. Although 24-hour barrel work is relied upon after heat treating a nail clipper product that is produced from die to achieve even cross section, technical support for die is still needed. In this regard, clearance is revised, structure of blanking stage is changed, and strip layout drawing is modified. High-temperature tempering is conducted when constructing die in order to eliminate corrupted layers and residual stress. The results of this technical support for die through the aid of the heat treatment technical support business unit of Kongju National University showed 2.5 times and 1.3 times improvement in die repair/maintenance cycle and die life span, respectively, with a 20% increase for both quantity produced and sales. In addition, the defect rate has significantly decreased from 5% to 0.1%.

Keywords: *Die Life extension, nail clipper, Strip layout, Clearance, Skeleton*

1. Introduction

Mass producing by constructing progressive dies for manufacturing beauty tools particularly nail clippers has not resulted in widely acknowledge excellent tools. Nail clippers possess a large fracture angle and rough surface due to uneven cross section. Because these products are exported goods, they must obtain a higher quality to be more competitive in the international market. Fundamental support in die technology is necessary since only barrel work (24 hours) after heat treatment is being utilized by factories despite requests by buyers for better performing products. In order to achieve improvement in this aspect, expertise knowledge (theoretical technology) support and technology upgrade (design technology/constructing technology) in blanking work with the extension of die life span were targeted.

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1.1. Research Trend in Korea and Overseas

1) The cross section of Korean and Japanese products are almost equally unsatisfactory.

2) Having unsatisfactory cross sectional appearance among products due to load imbalance in the forging stage and blanking stage in the strip layout of progressive die is an effect present in all countries. Therefore, technical support through on-site experience in die machining and heat treatment method is needed.

1.2. Goal Achievement Index

▪ **Cross-sectional Appearance**

1) Cross-sectional appearance before support: Shape of cross section on both sides is uneven and inconsistent.

2) Cross-sectional appearance after support: Shape of cross section on both sides is even and lengths of cross section are equal.

▪ **Die Life**

1) Die life span before support: 1,500,000 strokes

2) Die life span after support: 2,000,000 strokes

▪ **Die repair/Maintenance Cycle**

1) Repair/maintenance cycle before support: 200,000 strokes

2) Repair/maintenance cycle after support: 500,000 strokes

2. Experiment

2.1. Features of Technical Support

▪ **Clearance**

The length size of a cross section and the size of burr affect the precision of products and determine their punch dimension and punch hole dimension. Here, the factor that directly affects the life span of die is the clearance. Clearance is determined by side x%t according to the size of the cross sectional area or through the penetration rate of material. For presupport design, punch dimension and die hole dimension are designed by having side 5%t. In general, when they are designed with 5% clearance or with a material thickness 1.2mm or greater, it is common for secondary cross section to be produced. The most appropriate clearance is 8-10% but for this support, punch dimension and die hole dimension are determined with side 7%. In shearing works, clearance plays the role of determining punch dimension and die hole dimension and it greatly affects the precision of shear cross-section and die life span. Generally, if clearance increases, rollover (sagging, rollover, shear droop, penetrating), burr, bending, and fracture angle would increase although shear force would decrease. Figure 1 illustrates clearance.

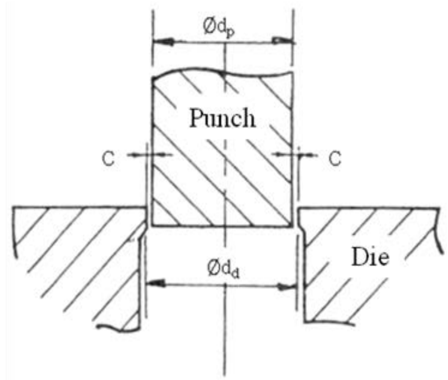

Figure 1. Clearance

If clearance is less, though shearing force is increased, roll over, burr, camber, and breaking angle become decreased, the second shearing surface is created at cross cut and die life will be decreased, and die cost will be increased by maintaining high accuracy at shearing surface. Therefore, optimum value for clearance needs to be decided [1].

2.2. Die Constructing Technology

- **W-EDM Machining Technology**

Removal of corrupted layer and residual stress: Although the formation of corrupted layer is present in W-EDM machined surface and residual stress is distributed in its properties, these are not removed and instead grinding assembly is used as the method to complete the mold construction. Because it has already been verified that die life span is 1/3 the life span from traditional manual machining, high-temperature tempering is applied since sorbite control or high-temperature tempering would be able to eliminate it. Such treatment has provided highly effective results after dozens of application.

2.3. Tryout

Trial is conducted by using the modified die that has been completed with its construction. The press for trial is a 110 ton mechanical press that belongs to another company. A highly experienced technician is used for this trial and punching oil is sprayed.

2.4. Results of Tryout

Products (blanks) are visually inspected by first stamping approximately 100 pieces. Results are compared with products pressed from premodification die.

- **Flatness**

Flatness is observed visually by placing the tool on plate without using any measuring device. While the product used prior to technical support is not in full contact with the upper part of the plate, the post-modification product is in full contact with the upper part of the plate.

3. Support Outcome

3.1. Technical Outcome

▪ Die Designing Technology

The designing technology for progressive die is a technology responsible for the degree of strip layout that determines its success and failure. By providing a flow chart that is used in technological support, dies are modified for in-house design standardization purposes.

1) Essential technical information related to die design
  A. Technology and information on die repair/maintenance
    ① Maintenance outage method
    ② Preparation and compatibility of spare parts
    ③ Equipments for repair/maintenance
    ④ Repeatability and no adjustment measures
    ⑤ Reliability
    ⑥ Work instruction
  B. Die machining technology and information
    ① Die machining machine
    ② Tools
    ③ Machining sequence
    ④ Machining limitations
    ⑤ Geometry of material
    ⑥ Machining standard
  C. Other technical information
    ① Information on plastic working
    ② Care
    ③ Prevention of miss
    ④ Die material
    ⑤ Outsourced machining
    ⑥ Standardization
    ⑦ Marketed standard part
    ⑧ Simulation

2) Flow chart of die designing
  A. Flow chart of progressive die design focusing shearing process
  B. Flow chart of progressive die design focusing bending
  C. Flow chart of progressive die design focusing drawing
  D. Flow chart for single die focusing on single machining
  E. Flow chart using standard data

▪ Die Component Machining Technology

1) It has been understood that main machining must be conducted after premachining in preparation for occurrence of deformation around hole-working that appears in W-EDM machining.

2) Methods to eliminate corrupted layer and residual stress that occur on electrical discharge machined surfaces have been acquired.

3) Inspection on degree of dynamic precision of machine tool for die machining is made to take place frequently.

▪ **Post-work Treatment Technology**

1) Inspection of Q.T. work cycle control

2) Surface hardening treatment

3) Die component design is conducted according to understanding of evenness per unit area of blank holding force when running the die.

Table 1. Process Comparison Before and After Technical Support [2-6]

Item	Before support	After support
Clearance	5 % at side	7 % at side
Blanking die type	Solid type	Sectional type
Blanking die material	SKD11 /HRC 57	Core SKH51 /HRC 59
Materials of blanking punch	SKD11	Added surface hardening treatment(Tin) on SKH51
Modification of strip layout	Number of forging stage 2	Number of forging stage 1
Guide post/bushing	In house machining	Outsourcing (added precision grinding)
Punch holder thickness	150 mm	130 mm
High temperature tempering	Grinding after W-EDM	Added high temperature tempering after W-EDM
W-EDM machining method	In house machining (deformation occurs)	Outsourcing (improved machining method /removed deformation)
Die hole machining	Grinding and assembly after W-EDM	Tempering and lapping after W-EDM
Structure /pressure of blank hole	Solid type 50Kgf	Split type 100Kgf
Slotting stage	Slotting omitted before blanking	Added slotting before blanking
Die hole maintenance method	Filing	Lapping by tools
High temperature tempering	Not executed	Tempering added

Figure 2. New Die (Left) and Old Die (Right)

4. Conclusion

The following results are obtained regarding improvement of blank precision and life span of nail clipper die that has uneven shear cross section:

1) Although slotting process is eliminated before blanking, slotting process has been added in this paper to improve having even cross-section.
2) While the process is completed with grinding assembly after W-EDM in the past, high-temperature tempering is added after W-EDM in order to extend die life span.
3) As an effect of extending die life span, the shortening of die repair/maintenance and quantity produced are increased by 20%.
4) Although SKD11 is used as material for blanking die before, it is changed to SKH51 and surface hardening is conducted.

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<Research Interests>

Press Die, Forging, Mold heat treatment

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CAD/CAM, CAM Programming, 3D Die Design