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STUDY AND ANALYSIS COMPOUND DIE MANUFACTURING USING WC-EDM PROCESS

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ABSTRACT

Generally tool and die making includes forming rolls, lathe bits, cutters, etc. At present most of the industries around here use conventional type of machining, such as form cutting casting, etc. for manufacturing dies. This process though may seem cheap, actually compromises in quality of the die, its precision and accuracy and sometimes in the design of the component if not carefully made. To remove these errors off the equation in manufacturing dies, one of the modern techniques of manufacturing, Electrical Discharge Machining (EDM) can be implemented. Precision is important in die making; punches and dies must maintain proper clearance to produce parts accurately. Usually tool and die making mainly focuses on design and manufacture sector, since the outcome of product solely depends on these two factors. This paper's objective is to implement the Electrical Discharge Machining process to make dies for a simple but widely used component in mass production in a factory without sacrificing the quality and allowance in dimension and shape that is obtained in conventional machining.

INTRODUCTION

The primary method of impairing form and dimension to a work piece is the removal of material by the use of edged cutting tools. An oversize mass is literally carved to its intended shape. The removal of material from work piece is termed generation of form by machining, or simply machining. Form and dimension may also be achieved by a number of alternate processes such a cold extrusion, sand casting, and precision casting. Sheet metal can be formed or drawn by the application pressure. Metal removal can be accomplished by the chemical or electrical methods. A great variety of work pieces may be produced without resorting to a machining operation is deemed to be the wise choice.

Forming dies are typically made by tool and die makers and put into production after mounting into a press. The die is a metal block that is used for forming materials like sheet metal and plastic. For the vacuum forming of plastic sheet only a single form is used, typically to form transparent plastic containers (called blister packs) for merchandise. Vacuum forming is considered a simple molding thermoforming process but uses the same principles as die forming. For the forming of sheet metal, such as automobile body parts, two parts may be used, one, called the punch, performs the stretching, bending, and/or blanking operation, while another part, called the die block, securely clamps the workpiece and provides similar, stretching, bending, and/or blanking operation. The workpiece may pass through several stages using different tools or operations to obtain the final form.

Die cutting operations are done by power presses using a tool and die pair to produce the required shapes on the work piece. Though this operation is very economic and time efficient, it is difficult to produce complicated designs using conventional machining. To make this possible, unconventional machining method like electrical discharge machining is employed. The use of unconventional machining has caused a revolution in the field of manufacturing. Though the initial cost and skill required using the techniques, it is worth the final quality of the product for its finishing, accuracy and the ease with which the operation is done. It relieves the operator from a lot of pressure and stress during the operation, as his work encompasses mostly pre and post operation. Also conventional machining is more efficient than conventional and manual methods of machining.

Die blocks: A die is a specialized tool used in manufacturing industries to cut or shape material using a press. Like molds, dies are generally customized to the item they are used to create. Products made with dies range from simple paper clips to complex pieces used in advanced technology.There are about twenty types of dies and each is distinct and different from all the other types. Some of the more prominent are stated and briefly explained as follows.

Bending: The bending operation is the act of bending blanks at a predetermined angle. An example would be an "L" bracket which is a straight piece of metal bent at a 90° angle. The main difference between a forming operation and a bending operation is the bending operation creates a straight line bend (such as a corner in a box) as where a form operation may create a curved bend (such as the bottom of a drinks can).

Blanking: A blanking die produces a flat piece of material by cutting the desired shape in one operation. The finish part is referred to as a blank. Generally a blanking die may only cut the outside contour of a part, often used for parts with no internal features.

Three benefits to die blanking are:

Accuracy: A properly sharpened die, with the correct amount of clearance between the punch and die, will produce a part that holds close dimensional tolerances in relationship to the parts edges.

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Appearance. Since the part is blanked in one operation, the finish edges of the part produces a uniform appearance as opposed to varying degrees of burnishing from multiple operations.

Flatness: Due to the even compression of the blanking process, the end result is a flat part that may retain a specific level of flatness for additional manufacturing operations.

Broaching: The process of removing material through the use of multiple cutting teeth, with each tooth cutting behind the other. A broaching die is often used to remove material from parts that are too thick for shaving.

Bulging: A bulging die expands the closed end of tube through the use of two types of bulging dies. Similar to the way a chefs hat bulges out at the top from the cylindrical band around the chefs head.

Bulging fluid dies: Uses water or oil as a vehicle to expand the part.

Bulging rubber dies: Uses a rubber pad or block under pressure to move the wall of a workpiece.

Coining: It is similar to forming with the main difference being that a coining die may form completely different features on either face of the blank, these features being transferred from the face of the punch or die respectively. The coining die and punch flow the metal by squeezing the blank within a confined area, instead of bending the blank. For example: an Olympic medal that was formed from a coining die may have a flat surface on the back and a raised feature on the front. If the medal was formed (or embossed), the surface on the back would be the reverse image of the front.

Compound operations: Compound dies perform multiple operations on the part. The compound operation is the act of implementing more than one operation during the press cycle.

Compound die: A type of die that has the die block (matrix) mounted on a punch plate with perforators in the upper die with the inner punch mounted in the lower die set. An inverted type of blanking die that punches upwards, leaving the part sitting on the lower punch (after being shed from the upper matrix on the press return stroke) instead of blanking the part through. A compound die allows the cutting of internal and external part features on a single press stroke.

Curling: The curling operation is used to roll the material into a curved shape. A door hinge is an example of a part created by a curling die.

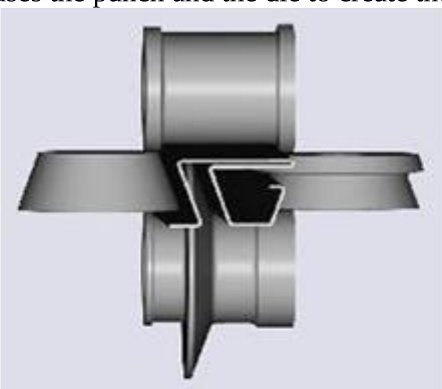
Cut off: Cut off dies are used to cut off excess material from a finished end of a part or to cut off a predetermined length of material strip for additional operations.

Drawing: The drawing operation is very similar to the forming operation except that the drawing operation undergoes severe plastic deformation and the material of the part extends around the sides. A metal cup with a detailed feature at the bottom is an example of the difference between formed and drawn. The bottom of the cup was formed while the sides were drawn.

Extruding: Extruding is the act of severely deforming blanks of metal called slugs into finished parts such as an aluminum I-beam. Extrusion dies use extremely high pressure from the punch to squeeze the metal out into the desired form. The difference between cold forming and extrusion is extruded parts do not take shape of the punch.

Forming: Forming dies bend the blank along a curved surface. An example of a part that has been formed would be the positive end(+) of a AA battery.

Cold forming (cold heading): Cold forming is similar to extruding in that it squeezes the blank material but cold forming uses the punch and the die to create the desired form, extruding does not.



Roll Forming Stand

CNC Wire-cut EDM machine

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Roll forming: a continuous bending operation in which sheet or strip metal is gradually formed in tandem sets of rollers until the desired cross-sectional configuration is obtained. Roll forming is ideal for producing parts with long lengths or in large quantities.

Horning: A horning die provides an arbor or horn which the parts are place for secondary operations.

Hydroforming: Forming of tubular part from simpler tubes with high water pressure.

Pancake die: A Pancake die is a simple type of manufacturing die that performs blanking and/or piercing. While many dies perform complex procedures simultaneously, a pancake die may only perform one simple procedure with the finished product being removed by hand.

Piercing: The **piercing** operation is used to pierce holes in stampings.

Progressive die: Progressive dies provide different stations for operations to be performed. A common practice is to move the material through the die so it is progressively modified at each station until the final operation ejects a finished part.

Shaving: The shaving operation removes a small amount of material from the edges of the part to improve the edges finish or part accuracy. (Compare to Trimming).

Side cam die: Side cams transform vertical motion from the press ram into horizontal or angular motion.

Sub press operation: Sub-press dies blank and/or form small watch, clock, and instrument parts.

Swaging: Swaging (necking) is the process of "necking down" a feature on a part. Swaging is the opposite of bulging as it reduces the size of the part. The end of a shell casing that captures the bullet is an example of swaging.

Trimming: Trimming dies cut away excess or unwanted irregular features from a part, they are usually the last operation performed.

COMPOUND DIE A compound die performs only cutting operations (usually blanking and piercing) which are completed during a single press stroke. A compound die can produce pierced blanks to close flatness and dimensional tolerances. Compound dies are particularly useful for producing blanks close to dimensional and flatness tolerances. Generally, the sheet material is lined off the blanking punch by a spring- actuated stripper, which may be provided with guides to feed the material and a stop to position it for the next stroke. The blank tends to remain in the die, from which it is removed by a stripper or by a knockout. A knockout is more satisfactory when blanking relatively hard or heavy materials that remain flat without the use of a hold down or pressure pad. A combination spring actuated blank holder and knockout is used for blanking thin and springy materials when flatness and accuracy are required. It also is used when a press has no knockout attachment, or when the blank is too large to eject properly. Ejection of the blank from the die by spring or knockout makes angular clearance unnecessary, assuring constant blank size through the entire life of the die. During the cutting operation, the stock is held between the faces of the stock stripper and blanking die. The blanking die makes contact with stock slightly before the piercing punch, which pierces the hole in the center of the piece after it is blanked out of the strip. As the piece is blanked out, the strip is carried below the cutting edge of the blanking punch brought back slightly above the punch level by the lower stripper.

Top Plate: The upper working member of the die set is called the top plate. The name also implies its relationship with punches, which are normally applied above the strip and fastened to the underside of the top plate. The upper surface of top plate bears against the underside of the press ram. Punch components are fastened to the lower surface. The assembly including the punch, punch holder and punch holder is mounted on the top plate. The tool shank that locates the whole tool centrally with the press ram is also scrwed on the top plate. The tool shank that locates the whole tool centrally with the press ram is also screwed on the top plate. The top plate is made of mild steel or cast iron. This plate should be thick enough to prevent bending.

Bottom plate: The bottom working is the lower member of the die sets. Its shape corresponds with that of the top plate except that it is provided with clamping flanges having slots for bolting the bottom plate to the bolster plate of the press. The lower surface rests on the bolster plate, and the die block and other components are fastened on the upper surface.

Pierce punch holder: The punch holder is usually fixed in with a light press fit in the punch holder. Some means to prevent the profiled punches from rotating should be provided in the punch holder (a key or a dowel).

Blanking punch: It is one of the main elements of a compound die. They are made out of food quality alloy steels. They are tempered and hardened to 58-62 HRC.

Punch Back Plate: While performing the cutting operation the punch exerts an upward thrust. So the punch should be backed up by a hardened plate to prevent it from digging into the soft to plate. The hardness is about 45-50 HRC.

Stoppers: After each and every stroke of the press, the strip has to be fed forward for one pitch length. This can be accomplished by means of stopper. The function of a stopper is to arrest the movement of the strip when it is fed forward to one pitch length.

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Stripper: The main function of a stripper is to remove the stock material off the punches after each stroke. In addition the stripper may act as a guide for the punches, as well as hold the strip flat and tight while the strip is being worked on.

Gauge (strip Guide): In most of the press tools, the stock material is fed into the tool in the form of long strips. For the efficient functioning of the tool. The strip should be guided longitudinally during its travel through the tool. This is achieved by employing gauges.

Side Cutters: A side cutter is a trimming punch, which trim the side of the stock material, providing in the spacer. In small tools the spacer may be the fully hardened to avoid the insert. The width of the side cutter is equal to the pitch. The allowance for the side cutting depends on the type and thickness of the stock material.

Guide pillars: Guide pillars are precision ground pins which are press fitted into accurately bored holes in the bottom plate. They engage guide bushings to align punch and die components with a high degree of closeness and accuracy. Small guide pillars are usually hardened and center less grounds, particularly for the commercial die set grades. Larger pillars are usually ground between centers after hardening.

Blank punch holder: This plate is also called punch plate. All the punches are accurately held in this plate. This plate should be thick enough to accommodate punch shoulder and keep the punches perpendicular. It is made out of mild steel.

Holding components: In order to hold the abovementioned important parts if a die set, several small components are used for example, dowels, fasteners, screws, rivets, cotter pins and shanks.

WIRECUT EDM

In wire electrical discharge machining (WEDM), also known as wire-cut EDM and *wire cutting*, a thin single-strand metal wire, usually brass, is fed through the workpiece, submerged in a tank of dielectric fluid, typically deionized water. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.The wire, which is constantly fed from a spool, is held between upper and lower diamond guides. The guides, usually CNC-controlled, move in the *x–y* plane. On most machines, the upper guide can also move independently in the *z–u–v* axis, giving rise to the ability to cut tapered and transitioning shapes (circle on the bottom square at the top for example). The upper guide can control axis movements in *x–y–u–v–i–j–k–l–*.

This allows the wire-cut EDM to be programmed to cut very intricate and delicate shapes.The upper and lower diamond guides are usually accurate to 0.004 mm, and can have a cutting path or *kerf* as small as 0.12 mm using Ø 0.1 mm wire, though the average cutting kerf that achieves the best economic cost and machining time is 0.335 mm using Ø 0.25 brass wire. The reason that the cutting width is greater than the width of the wire is because sparking occurs from the sides of the wire to the work piece, causing erosion. This "overcut" is necessary, for many applications it is adequately predictable and therefore can be compensated for (for instance in micro-EDM this is not often the case). Spools of wire are long—an 8 kg spool of 0.25 mm wire is just over 19 kilometers in length. Wire diameter can be as small as 20 micrometres and the geometry precision is not far from +/- 1 micrometre.The wire-cut process uses water as its dielectric fluid, controlling its resistivity and other electrical properties with filters and de-ionizer units.

The water flushes the cut debris away from the cutting zone. Flushing is an important factor in determining the maximum feed rate for a given material thickness. Along with tighter tolerances, multi axis EDM wire-cutting machining center have added features such as multi heads for cutting two parts at the same time, controls for preventing wire breakage, automatic self-threading features in case of wire breakage, and programmable machining strategies to optimize the operation. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material. If the energy/power per pulse is relatively low (as in finishing operations), little change in the mechanical properties of a material is expected due to these low residual stresses, although material that hasn't been stress-relieved can distort in the machining process. The work piece may undergo a significant thermal cycle, its severity depending on the technological parameters used. Such thermal cycles may cause formation of a recast layer on the part and residual tensile stresses on the workpiece.

FEATURES OF WIRE CUT EDM PROCESS

1. **Electrode Wear:** During machining process, the wire electrode is constantly fed into the workpiece. So the wear of the tool is practically ignored.
2. **Surface Finishing:** A very thin electrode is constantly fed into the workpiece at speed of about 10-30mm/s by the wire feed mechanism. So machining is continued without ant accumulation of chips and gases. It gives high surface finish and reduces the manual finishing operating time.
3. **Complicated Shapes:** By using program, complicated and very minute shapes can be efficiently machined. So there is no need of skilled operators.

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4. **Economical:** Since most of the programming can be easily done, it is economical for batch production, including prototypes manufacturing.
5. **Time Utilization:** Since all the machine motions of wire cut EDM processes are controlled by NC, it can be operated very fast. Cycle time for the die manufacturer is shorter, as the whole work is done on one machine. Inspection time is reduced due to single piece construction of dies with high positioning accuracy. Though the capital cost is high and cutting rate is low, about 0.828mm/min, it doesn't compensate with the finish of the product.
6. **ADVANTAGESOF COMPOUND DIE:**

   Piece parts produced form compound die are very accurate and identical because all operations are carried out in a single station. This is possible because the accuracy of the piece does not depend on the accuracy of the advance of the strip or the accuracy of the layout of the stations in the case of progressive dies.

   Scrap stocks from the other tools can be employed to produce piece parts in a compound die.

   In a compound die burrs resulting from the piercing an blanking are on the same side of the piece part.

   Cost of manufacturing a compound tool is normally lesser than that of a progressive tool or casting for the same component.

   Though the above highlighted points portray the compound dies as better tool of manufacturing, it like ever other tool has its setbacks. If the pierced holes are too near to the outer edge of the piece part, the dies, will become very weak. This is the major disadvantage because the punch may break either during manufacture or during the course of the die life. When the piece parts are having pierced holes are too near to their outer edges progressive tools are preferred.

CONCLUSION

The electrical fuse link component was perfectly manufactured as per the required dimensions using the compound die produced with the help of WC-EDM.A compound die known to be produced commonly by conventional processes like casting, form cutting, etc., was successfully manufactured using programming codes in Wire Cut EDM.This process of manufacturing was found to be accurate and is best suitable for various contours.Moreover the se of programming codes in this process reduces human effort that is encountered in ordinary machining process.

FUTURE SCOPE

Die making is just one of the applications for Wire Cut Electrical Discharge Machining. There are numerous applications for it in the manufacturing and other fields.In this modern era where the industries are looking for automation in all the sectors, this manufacturing process is one of the best options.