Productivity Improvement by Increasing Tool Life of Hot Extrusion of Cold Drawing Operation

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MAY 2016

Productivity Improvement by Increasing Tool Life of Hot Extrusion of Cold Drawing Operation

Major Project Report

Submitted in partial fulfillment of the requirements

For the Degree of

Master of Technology in Mechanical Engineering

(Computer Integrated Manufacturing)

By

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MAY 2016

Declaration

This is to certify that

1. The thesis comprises my original work towards the degree of Master of Technology in Computer Integrated Manufacturing at Nirma University and has not been submitted elsewhere for a degree.

2. Due acknowledgment has been made in the text to all other material used.

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Undertaking for Originality of the Work

I, **Praphul Purohit** , Roll. No. **14MMCM12**, give undertaking that the Major Project entitled "**Productivity Improvement by Increasing Tool Life of Hot Extrusion of Cold Drawing Operation**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Mechanical Engineering (Computer Integrated Manufacturing)** of **Institute of Technology, Nirma Univeristy, Ahmedabad** is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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This is to certify that the Major Project Report entitled "**Productivity Improvement by Increasing Tool Life of Hot Extrusion Of Cold Drawing Operation**" submitted by Mr. Praphul Purohit (14MMCM12) towards the partial fulfillment of the requirements for the award of Degree of **Master of Technology in Mechanical Engineering** (**Computer Integrated Manufacturing**) of Institute of Technology, Nirma University, Ahmedabad is the record of work carried out by him under our supervision and guidance. In our opinion the submitted work has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge, has not been submitted to any other University or Institution for award of any degree or diploma.

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Acknowledgments

It is indeed a pleasure for me to express my sincere gratitude to those who have always helped me throughout my project work.
My sincere thanks and gratitude to **Dr. R. N. Patel**, Head of Mechanical Engineering Department, Institute of Technology, Nirma University, for allowing me to carry out my project work in industry as industry project.
I would like to thanks my P.G. Coordinate **Dr. B.A. Modi** for his support and encouragement during my project work.
I am deeply indebted to my thesis supervisor for his constant guidance and motivation. He has devoted significant amount of his valuable time to plan and discuss the thesis work. Without his experience and insights, it would have been very difficult to do quality work. I am thankful to all the faculty member of Mechanical Engineering Department, Laboratory assistants, Library staff and all my friends, colleagues who have directly or indirectly helped me during this project work.
I am very much obliged to **Dr. B.K. Mawandiya** for guiding and inspiring me so high in my project work. Finally,
My special thanks to who was the first person I used to approach whenever I got stuck. I would also like to thank my friends of my class for their delightful company which kept me in good humor throughout the year.
I would like to give special thank to **Mrs. Telgy James**, P.A to P.G. Coordinator who supported and helped me in administrative work.
I would like to extend my gratitude: **Mr. Satya Deo Purohit** (director operation) Shera energy private limited for guiding me during my dissertation work and for giving me opportunity to carry Out my dissertation work at. Shera energy private limited for their encouragement.
Last, but not the least, no words are enough to acknowledge constant support and sacrifices of my family members because of whom I am able to complete the degree program successfully.

Praphul Purohit

Abstract

With the growing industrial development and globalization, there is a demand for high quality product to produce in minimum lead time. The manufacturing process of mechanical components plays a vital role in the product's life span. Structure component such as u channel, L channel shape angle and rectangular bars are manufactured through extrusion process. In hot extrusion process, manufacturing defects may occur due to fault die tools. The material of die, its chemical composition, physical properties, geometry of the components and machining process also affect the strength of finished product.

Aiming to resolve the faults occurring in L shape angle, the hot extrusion and cold drawing manufacturing process has been studied for defects and their causes. Further modification in the die tool has also been implemented for improving the quality of the product and in turn the improvement in productivity.

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Nomenclature

K	Shape factor
C_x	Perimeter of the non-circular extruded section
BCC	Body cantered cubic
FCC	Face cantered
R	Initial cross-sectional area
A_o	Final cross-sectional area
A_f	After extrusion

Chapter 1

Introduction

1.1 Preliminary Remarks

It is required to produce superior quality product at the minimum rate and appropriate time. Now demand of high speed and high precision machining tools are design with high accuracy and dynamic performance in the hot and cold extrusion tool die is important role in extrusion machine. Extrusion is a procedure in which a billet of metal is reduced in cross segment by forcing. Cold extrusion work on the room temperature where as hot temperature work on 50-70% melting point of metal. Heat treatment is a process in which tool or die steel must to be designed to maximize metallurgy property of materials in die stress created from manufacturing removing the chips. Residual stress in the steel itself produce expansion and contraction from heating and cooling rapidly in heat treatment these are the some of the reason of stress in the tool. Different type of paste which can use for the polishing in die for better surface finish .Lubrication is the key for hot extrusion for the heat treatment can use the surface hardening powder for greater result in the heat treatment for the lubrication in the hot extrusion graphite lubrication is used.

1.2 Motivation

Extrusion is depending on the life of die and we can say that die is heart of extrusion. Dies is subjected with high temperature as well as high contact pressure. Modification in the design of die results in change in its static and dynamic In order to have a good surface finish, accuracy and precision on the work produced, the die must be designed.

1.3 Problem Definition

Due to high pressure and high temperature life of extrusion die has been decries. Hot extrusion and cold drawing process mostly used for copper and copper alloy, mainly for solids and tubular wire and irregular shape It was observed that life of die tool are very low hence Improvement of productivity by increasing life of tool for hot extrusion and cold drawing in copper industry

1.4 Methodology

First of all, a detailed literature review is carried out. Then the Computer numerical control (CNC) and elector-discharge machining is studied. After that find out different material of extrusion die. Different composition grade and chemical properties of material. Different procedure for the hardening for die i.e. heats treatment and other process. After that manufacturing the extrusion die with help of machining and heat treatment after that apply finishing process i.e. polishing and lubrication for the better surface finish.

1.5 Thesis Organization

chapter 1: Introduction
chapter 2: Literature Review
chapter 3: Hot Extrusion and Cold Drawing
chapter 4: Die Design
chapter 5: Cause and Effect Analysis
chapter 6 Conclusion and Future Scope

Chapter 2

Literature Review

2.1 Literature

S.D.Purohit explains general overview the extrusion process is pushing a material in plastic condition through a suitable die under high pressure. Die is most critical and important part of tooling operating under high thermo dynamic stress, namely pressure and temperature. Deformation takes place at the throat region of the die where it encounters maximum force. Different material die i.e. aluminium oxide coating , plasma ceramic coated and zirconia but not prove to be very satisfactory A closed microscoping examination revealed that he ciramic coating remained intact but the base steel got defomred .from that was concluded that aluminium titenium caoting did not provied proper and desired insulation The pzs ceramic die given excellent result in experiments while the average extrusion in the case of ceramic dies have more than 1500 pushes where the life has in tungsten die ere only 150 pushes. While consider different materials it feels that properties comparatively good for extrusion At room temp Materials consists mainly monoclinic phase. Which increase in temp. as the temp. goes down during cooling ,reverse transformations take place and crystals regain tetragonal shape and then finally monoclinic phase . such transformation take place on account of lack of diffusion resulting in non-uniform distribution of alloy materials . this is similar to martensitic transformation. [1]

M.S jount and S.M.hwang Paper deal with procedure for optimal design in study state metal forming .for controlling tear and wear in die. During hot extrusion, reduction area is more and high extrusion speed is responsible for the high temperature in extrusion particularly close to the surface. In this paper. two models have been produced for the die profile. In the first model, the die profile is considering curve of line fragments, which may be viewed as multi-level conical die in extrusion. The second model utilizes a cubic spline representation, The model uses design variables in xl and x2 directions of the end purposes of cubic spline bend.[2]

J.F.beland, M.fafard et al. paper examine that To get the material behaviour , should be firstly cool before upgrade their mechanical properties. Since a high reduction is required, numerous drawing passes are necessary. For avoiding facture in processExtrusion is the most vital method for tube creation drawing procedure, after extrusion, permits reduction in thickness and diameter .In the analysis two dies are utilized i.e. the first is the sinker die t and the second one is the drawing for radial deformation. FE model for streamlining tube sinking taking after by tube drawing was produced. In the initial step, the model was adjusted taking into account the deliberate response strengths on the bite the dust and mandrel and twisting on tube surface. At that point in view of the adjusted and approved model, an advancement study was performed for having least hub stress in the attracted tube while attracting to diminish shot of crack in the tubes By lessening the quantity of drawing steps, the creation expenses of the tube drawing procedure are cut more than a half in light of the fact that we decrease likewise the tube taking care of and tooling support times and the power utilization[3]

M. Schikorra, A.E. Tekkaya et al In this paper examination have been completed for the investigation of enhanced quality and solidness and an incorporated capacity as disfigurement sensor or information transmitter the heaviness of space edge structures can be lessened considerably. the extrusion trial was completed for investigating the procedure and device geometry. Because of the likelihood of assembling a high quality lightweight auxiliary profile, a high temperature superconductor, or wear safe parts with aluminium base material just few assembling. Advancements have been created before. From the test To decrease conceivable deviations, an exact control of the material stream and its affecting parameters, for example, temperature field or bite the dust geometry is fundamental. At long last the investigation of the position of the wire encouraging mandrel demonstrated that wire deviations and splitting happens when sustaining the support too soon. In any case, when encouraging with too little separation to the profile's leave a deficient nook of the base material encompassing can be recognized. The thought of an utilization scope of the parameter is vital for every beyond words set[4]

Wallmeier – Extrusion consulting the paper exhibits the innovation of extrusion depends to a vast degree on the improvement from the materials for extrusion bites the dust MHC is especially suitable for extrusion of copper composites, and demonstrates a long life and great surface nature of expelled items. The advancement of the innovation of extrusion depends to a huge degree on the improvement from the materials for extrusion bites the dust. The limits of hot work apparatus steels are not no sufficiently more to meet the present prerequisites of the extrusion at high temperatures and high squeezing weights. MHC and made in this manner a superior material for the assembling of extrusion kicks the bucket for extrusion of high softening metals. MHC is especially suitable for extrusion of copper composites, and demonstrates a long life and great surface nature of expelled items. Determination of material for the assembling of extrusion passes on is basically critical the extrusion temperature. MHC is suitable for extrusion temperature reach up to 1250ºC. The main materials which are being used for the assembling of extrusion kicks the bucket. At temperature > 800ºC are Nickel-base composites (up to 1000ºC), Satellites (up to 850ºC) and Co-base compounds. In any case, every one of these materials don't accomplish the estimations of MHC.Thermal development is an essential border in the extrusion The great durability MHC is not vulnerable to breaking. Initially extrusion the bite the dust may close 0.1 to 0.15 mm. After the comparing amendment, the kick the bucket is steady the preheating of the pass on to least 250ºC is totally important so as to maintain a strategic distance from warm stun. Also to accomplish a decent durability of the material [5]

Z. jurkovic and M. jurkovic in this paper demonstrates that minimization of hardware burden. With the distinctive procedure decide ideal estimations of logarithmic strain, bite the dust point and coefficient of erosion with the reason to discover insignificant device stacking acquired by cool forward extrusion process. For the examination two test are did i.e. in light of factorial outline of examination and orthogonal exhibit and the Taguchi approach, individually. Metal framing procedure incorporates the state of the work piece and item, shaping succession, states of apparatuses or bites the dust, contact, framing rate, temperature and material property of the work piece and those of the tools.in the examination cool and hot extrusion are grouped into geometry, to be specific, strong and empty segments. Outline of trial is a capable device for demonstrating and breaking down the impact of procedure parameters. On the fundamental of Performed trial can be spoken to the useful relationship between reaction of extrusion procedure,. Taguchi methodology is utilized to accomplish the more productivity extrusion parameters, particularly incredible, and to contrast results got and both procedures. Table 3 demonstrates that the exploratory arrangement has three levels.[6]

D.Tang, W. Fang et al. The reason for this study is smaller scale channel tube is the recently sort of tube extrusion one of the primary issue in tube extrusion is way amazing Miniaturized scale channel are somewhat warmth trade tube with a line of one next to the other channels whose distances across are under 1 mm. The widths of the mandrels framing the Micro channels are additionally exceptionally small. The mandrels are of cantilever structure and simple to twist or break amid the extrusion process. In this manner, to expand the mandrel lifetime, the length of the cantilever ought to be as short as could be allowed. Nonetheless, short mandrel will bring about poor crease welding state of the extrusion process. A harmony between weld quality and mandrel execution ought to be found in extrusion kick the bucket outline. In the two sorts of kick the bucket level and hemispherical are explored Microstructure of the tube shaped with hemispherical bite the dust are permits deciding and evaluating the grain sizes and sub grain miss introductions. From the examination tubes framed with hemispherical pass on is higher than that of level.[7]

Z. Lin, X. Juche et al. The paper goal is strategy to get the ideal kick the bucket profile which yields more uniform surface-load dispersion on pass on profile surface by means of coordinating limited component examination is connected to the hot extrusion process. The above methodology can enhance the kick the bucket life in hot extrusion procedures Die life is a critical component in the efficiency and the nature of the completed items in hot extrusion forms. All in all, the administration lives of instruments in metal-shaping procedures are to a substantial degree constrained by wear, weakness break, plastic twisting, In this paper for enhancing pass on life a streamline strategy limited component investigation for the determination of kick the bucket profile surface is recommended. the geometry of a kick the bucket utilized as a part of hot enduring state procedures is critical Thus to minimize, the extrusion burden can be considered as one of the goal capacities. Also, the quality of a bite the dust can lose adequacy principally by wear, including rough wear, cement wear, and exhausted wear. This wear is firmly identified with the heap on the surface of a bite the dust hole. In examination investigate, an enhanced ideal configuration technique for enhancing pass on life in hot extrusion procedures has been proposed. It gives a successful way to deal with ideal outline of the die band [8]

Xiong, Shoumei et.al. A new methodology is connected in the extrusion a suitable limited distinction plan has been presented and received in the scientific displaying of the warmth move issue in the pass on throwing procedure. Kick the bucket throwing is a standout among the most flexible throwing procedures, offering the likelihood of making close net shape castings of high dimensional exactness and throwing quality bite the dust throwing procedure, it is key to think seriously about the essentials of the pass on temperature and its control inside of close points of confinement. A few strategies, for example, warm liquid cooling/warming frameworks, kick the bucket splashing, and warm imaging methods, pass on throwing procedure in one of the three way

- steady-state answers for the pass on temperature
- Distributions to beat the discretion of the system

- The consistent occasional arrangement in the bite the dust

The operations of opening and shutting the kick the bucket are thought to be did in a split second and along these lines the work cycle of a pass on throwing machine and the comparing pass on is separated into four computation arranges: the hardening period, the part extraction period, the pass on oil period and the scooping period. limit conditions amid the pass on throwing procedures, for example, kick the bucket/throwing, bite the dust/air, bite the dust/cooling Channel, and kick the bucket/oil, and so on., which are considered and treated by warmth exchange A completely stable limited contrast conspire, the segment astute part technique, has been presented. Furthermore, embraced in the scientific displaying of the warmth move issue in the bite the dust throwing procedure. Taking into account the segment shrewd part strategy, warm investigation framework for the pass on throwing procedure has been created. Specialized contemplations, for example, the limit conditions and the sporadic enmeshment plan, and so forth., have additionally been exhibited. The confirmation and application illustrations demonstrate that sporadic lattice size can extraordinarily decrease the matrix number of the examination framework and that generally bigger time step can be utilized subsequent to the part savvy part technique is totally[17]

S.Z. Qamar, A.K. Sheikh et.al this paper reposts that investigation and experiment on the heat treatment for the{h-13} alloy steel. The most important tools die and mandrel (used for hollow profiles) are highly stressed tools and are most susseptible tofutur wear in extrusion. The tool steel needs to have high temperature fatigue property and good wear resistance for reliability and durability of an extrusion die, in order to get the best combination of high toughness and high hardness temperature range 525-550ºC. Durability and hardness values for H13 instrument heat treatment and mechanical testing has additionally been done on exceptionally manufactured H13 tests strength first declines and after that expansions, while hardness first increments and afterward diminishes, with expanding temper temperature. Ideal treating temperature for H13 kick the bucket steel utilized as a part of business expulsion seems, by all accounts, to be in the 525-550ºC territory, to get the most good blend of high durability and high hardness.

Chapter 3

Hot Extrusion and Cold Working

Extrusion is a procedure in which a billet of metal is reduced in cross section . Extrusion is used for bar and tubes. Hot extrusion work in high temperature where as cold extrusion work on room temperature. Die create lots of effect on extrusion the span of expulsion is figure out by littlest circle known as surrounding circle. In cold and hot extrusion dies are at high contact with pressure and temperature. The form the proper die material selection and proper finishing and control heat treatment life of die can be increased). AISI grade hot work die steels are (H10, H11, H13, H14 and H19) the most ordinarily utilized for applications. [16]

3.1 Process description

Types of extrusion:

Extrusion ratio: Ratio of area of cross-section of the billet to the area of cross-section of the extrude $R = A_o/A_f$

R is stand for the initial cross-sectional area ,

A_o define as final cross-sectional area ,

A_f known as after extrusion. [16]

Classification:

Extrusions are sub divided into four different extrusions. They are:

- Direct extrusion,
- indirect extrusion,
- impact extrusion
- Hydrostatic extrusion.

Direct extrusion:

Direct extrusion , known as forward extrusion in which is the billet moves along the same side as the ram and punch. The friction is high. So that, more force is needed. A dummy of somewhat lower than billet in diameter is utilized as the billet in hot extrusion tubes can be extruded by direct method [16] as shown in Fig. 3.1.

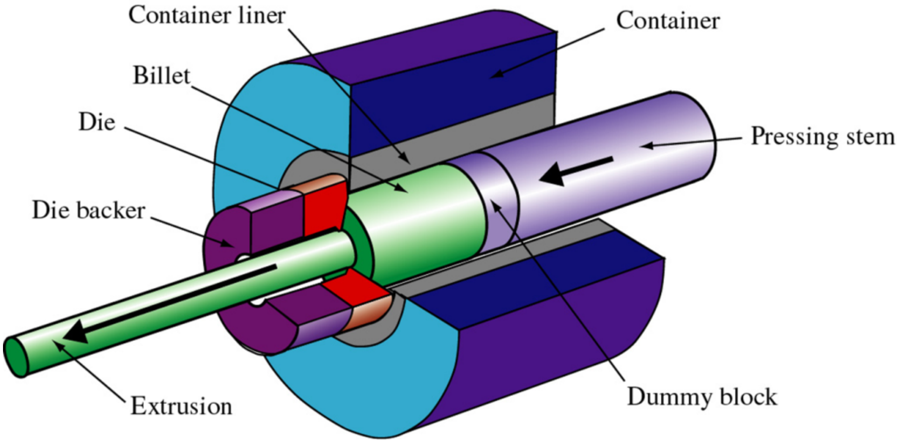

Figure 3.1: Direct extrusion process[16]

Indirect extrusion:

In direct extrusion is a procedure in which punch moves inverse to that of the billet. There is no relative movement in the billet. As comparison with direct extrusion in direct extrusion req. less force for extrusion. In direct extrusion is not suitable for the longer length billets for extrusion.[16]as shown in Fig. 3.2.

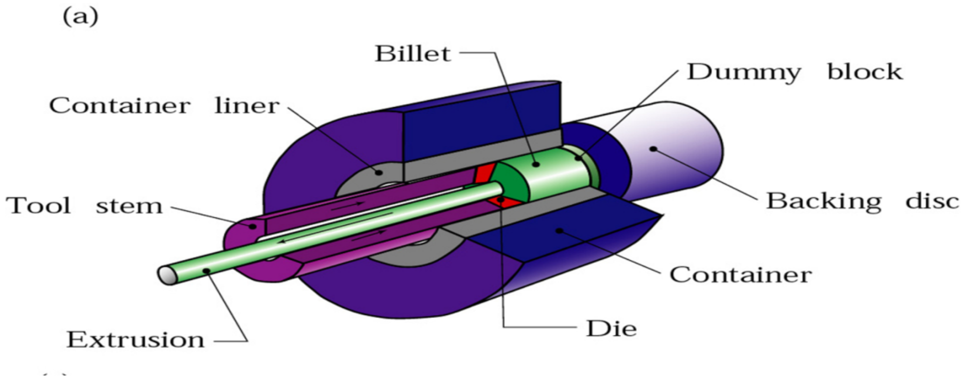

Figure 3.2: Indirect extrusion[16]

Hydrostatic extrusion:

In hydrostatic extrusion the holder is loaded with a liquid. Extrusion Friction is eliminated in this process because of there is no contact between billet and container wall.Brittle material is mostly extruded as shown in Fig. 3.3.

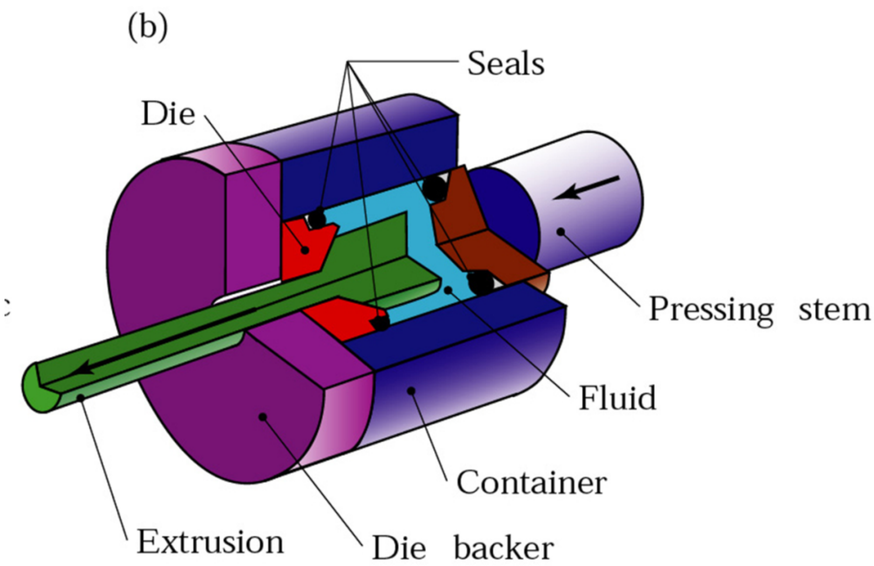

Figure 3.3: Hydro static extrusion[16]

Impact extrusion:

With the help of impact extrusion toothpaste holder and hollow section are manufactured. The punch is made strike with high speed. For the typically metals like copper, aluminium, lead can be used for impact extrusion[16]as shown in Fig. 3.4. Table 3.1 shows the various elements at different extrusion temperature.

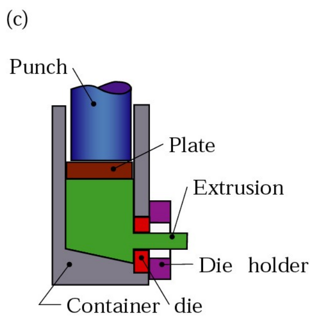

Figure 3.4: Impact extrusion[16]

Elements	°C
Lead	200-250
Aluminium and its alloys	375-475
Copper and its alloys	650-975
Steels	875-1300
Refractory alloys	975-2200

Table 3.1: Temperature ranges for various metals

3.2 Cold and hot extrusion:

Cold extrusion has great surface and high quality because of accuracy and hardening, and high productivity. On the other hand pressure is high side so die have more stresses. Appropriate oil can use for lubrication for safety of tool and product. Some of the metal like aluminium molybdenum copper and titanium alloy are used for cold extrusion [18]

Favorable circumstances:

- No oxidation happens.
- Good mechanical properties because of cold
- Good surface with the utilization of lubrication oils.

Hot extrusion:

Hot extrusion can be utilized for higher extrusion proportions. Hot extrusion molybdenum di-sulphide or graphite is the strong lubrication in hot extrusion hot extrusion done at high temperature.

3.3 Mechanical and chemical properties

Table 3.2 shows the H13 property for hot extrusion.

Density	7.88/cc	
hardness rockwell c	28 - 53	air or oil quenched and tempered at 705°-650C
Tensile Strength, Ultimate	1900MPa	at HRC = 55 air or oil quenched from 995-1025°C
Tensile Strength, Yield	1650 M	at HRC = 55 air or oil quenched from 995-1025°C
Elongation at Break	9.0 %	at HRC = 55 (air or oil quenched from 995-1025°C
Modulus of Elasticity	210 GPa	at HRC = 55 (air or oil quenched from 995-1025°C
Bulk Modulus	160 Gpa	Typical for steel.
Poissons Ratio	.30	
Machinability	50%	
Shear Modulus	81Gpa	Estimated from elastic modulus
Thermal Properties		
CTE, linear	11.0 µm/m-°C	Temperature 25.0 - 95.0 °C
Specific Heat Capacity	0.460 J/g-°C	Temperature 0.000 - 100 °C
Thermal Conductivity	24.3 W/m-K 24.3 W/m-K	@Temperature 215 °C @Temperature 475 °C
Processing Temperature	540 - 650 °C	1000 - 1200 °F Tempering Temperature
Annealing Temperature	845 - 900 °C	
Carbon, C	0.32 - 0.40 %	
Chromium, Cr	5.13 - 5.25 %	
Iron, Fe	90.95 %	
Molybdneum	1.33 - 1.4 %	
Silicon, Si	1.0 %	
Vanadium, V	1.0 %	

Table 3.2: AISI type H13 hot work tool steel[17]

3.4 Advantage of extrusion

In the different metal forming processes, Extrusion has definite advantages over others for the production of three dimensional section shapes. Now it is becoming essential to pay more attention to the extrusion of section rod from round stock.

The process is also attractive because press machines are readily available and the necessity to purchase. Fig 3.5 shows the various stranded design of extrusion.

1. Thin walls can be obtained.
2. High reduction ratio.
3. Process redesign cost is low in extrusion process.
4. Nearly good dimensional accuracy is obtained.
5. Less cost of extrusion die with respect to other.
6. Flexibility

Expensive section stock corresponding to a multiplicity of required sections is eliminated. There are many advantage of extrusion as follows;

- Uniform cross-section areas obtain in whole process.
- Strain and hardness are increased due to strain hardening.
- Low cost of die and it's economical to make small quantities of a shape and size.
- Good surface finish obtained by any other metal forming process.

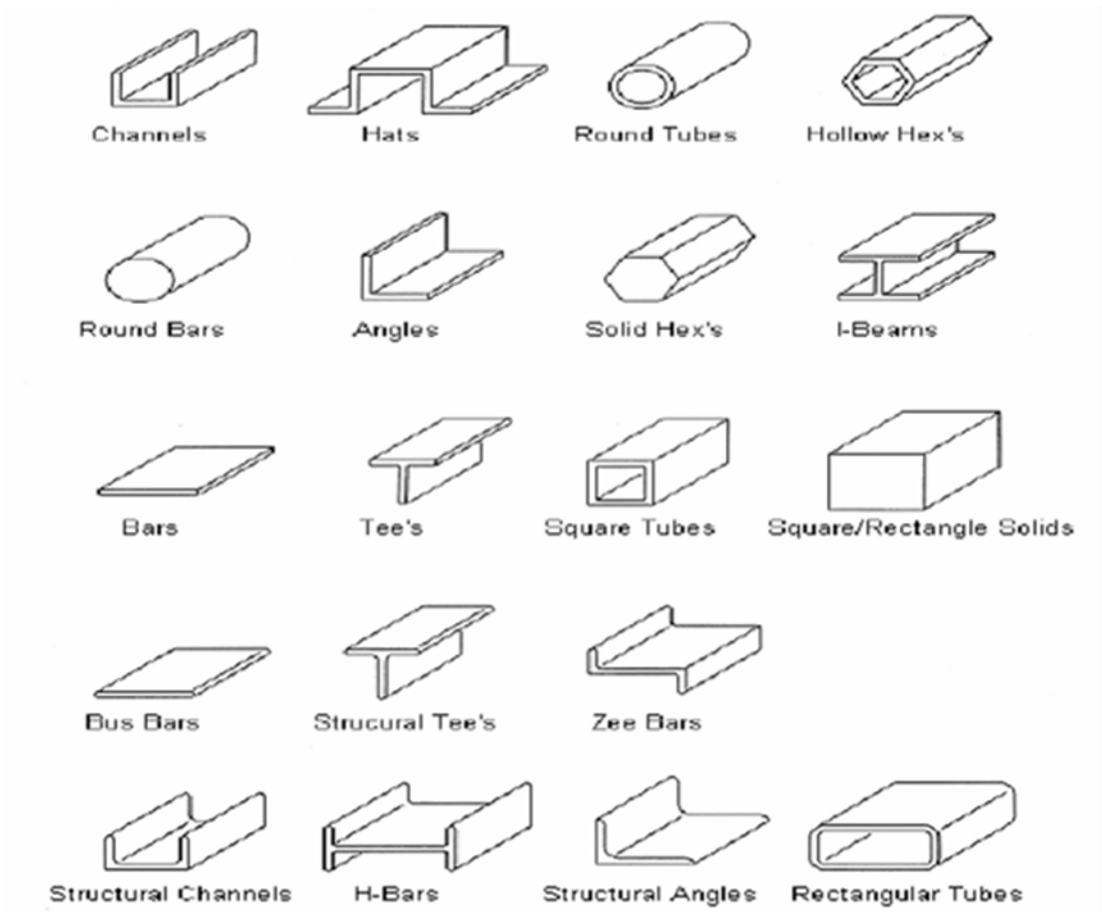

Figure 3.5: Standard extrusions

3.5 Limitation of Extrusion

Extrusion is limited to only a few metals and cannot be done any chosen material. Most materials require high temperature and pressure which makes equipment costly. During extrusion process die material should be able to withstand the load, high temperature and wear.

In the case of steel extrusion process the equipment is costlier due to the magnitude of temperature to which the metal must be heated (2300F).

Indirect extrusion complicates the handling of extruded or output parts.

3.6 Application of Extrusion

Extrusion is one of the most important methods of metal forming process with we can produce many product of high industrial applications with good quality. Some of the applications of the extrusion process are given below;

- Railing for sliding doors.
- Tube for various cross-sections.
- Structure and architectural shapes.
- Doors and window frames.
- Extrusion process used to make collapsible tubes of soft alloys such as tooth paste containers

3.7 Extrusion Defects

Fig.3.6 shows the defects form the extrusion operation.

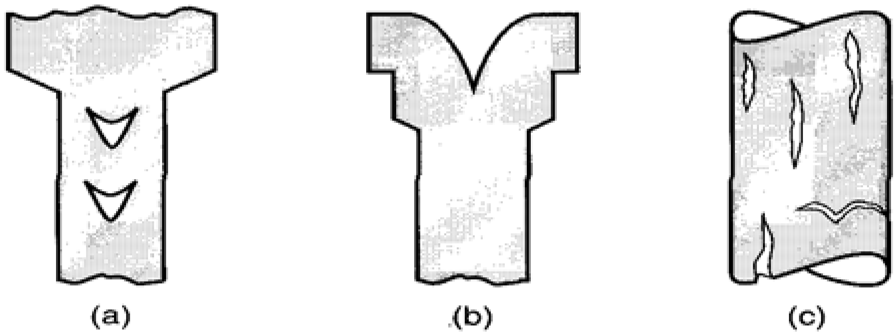

Figure 3.6: Standard extrusions defects

a) Center-burst: internal crack due to excessive tensile stress at the center possibly because of high die angle, low extrusion ratio. Fig. 3.6. a shows the center-burst

b) Piping: sink hole at the end of billet under direct extrusion. Fig. 3.6. b shows the piping.

c) Surface cracking: High part temperature due to low extrusion speed and high strain rates. In Fig. 3.6. c shows surface crackes.

3.8 Cold Drawing Operations

As shown In Fig 3.7 cold drawing process double cylinder heavy duty hydraulic draw bench machine.

Figure 3.7: Double cylinder heavy duty hydraulic draw bench machine photo courtesy shera industry

3.9 Process Flow chart for cold drawing

In Fig. 3.8 shows the process flow hart for cold drawing operation.

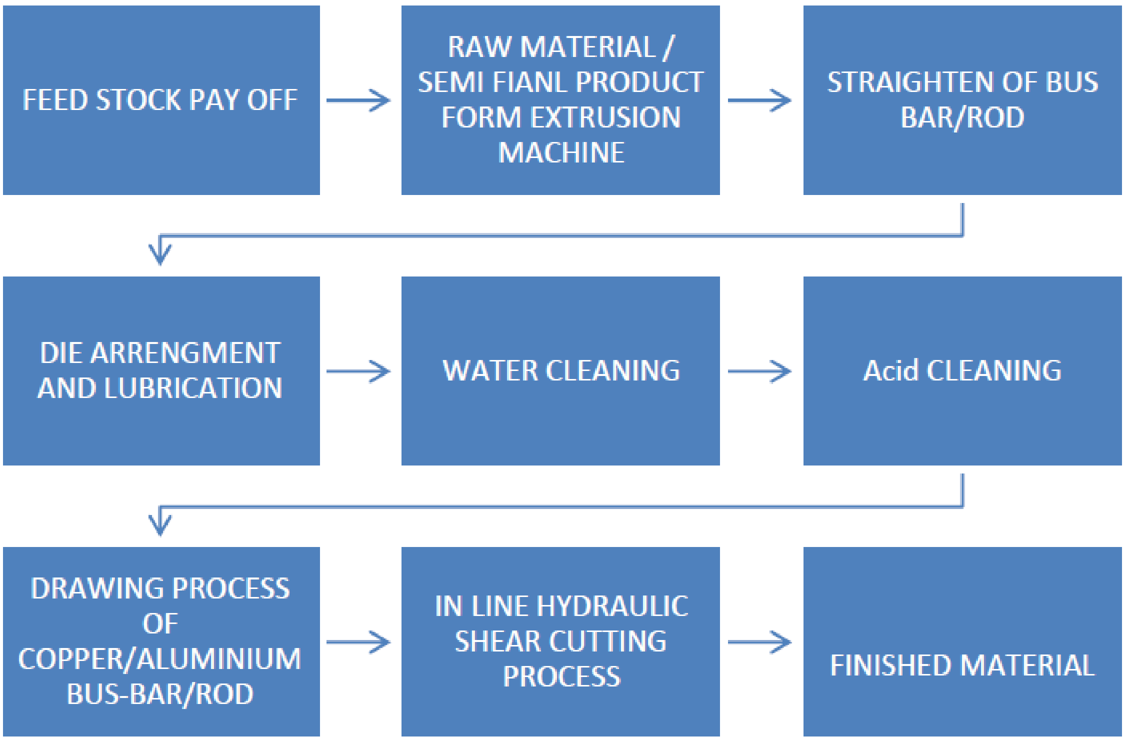

Figure 3.8: Process flow chart for cold drawing

3.10 Cold Drawing Process

As shown in Fig 3.9 - 3.13 s step for cold drawing operation in Double cylinder heavy duty hydraulic draw bench machine.

Figure 3.9: Cold drawing feed stock photo courtesy shera industry

Figure 3.10: Cold drawing rolling photo courtesy shera industry

Figure 3.11: Cold drawing die photo courtesy shera industry

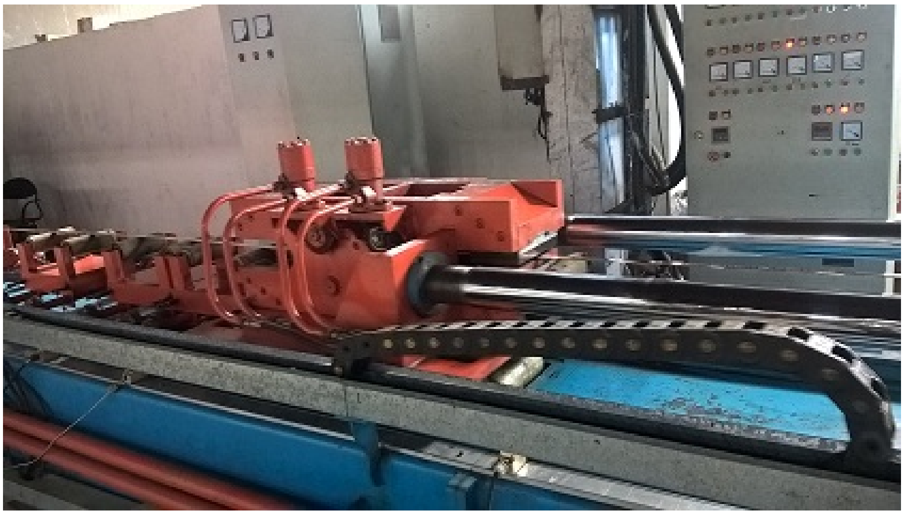

Figure 3.12: Cold drawing holder photo courtesy shera industry

Figure 3.13: Cold drawing cutter photo courtesy shera industry

In a cold drawing process cross section of material is reducing with the help of pulling it through a die. Cold Drawing process is similar to extrusion process but in drawing process force which is applied i.e. tensile forces. Accurate Dimensions, specified cross-section and clean and excellent quality of surface to work. Material must require high ductility and good tensile strength. Fig.3.14 shows the schematic drawing of drawing process. Fig. 3.15 shows the die used in cold drawing

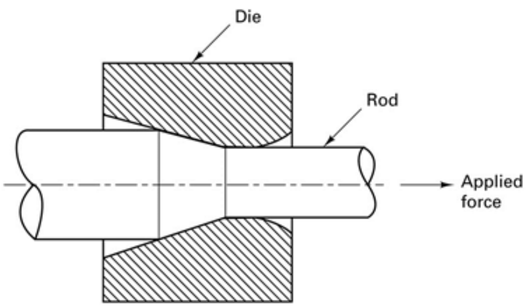

Figure 3.14: Schematic drawing of the rod-or bar-drawing process.

Figure 3.15: Cold drawing H-13 Alloy steel die photo courtesy shera industry

3.11 Different type of Drawing

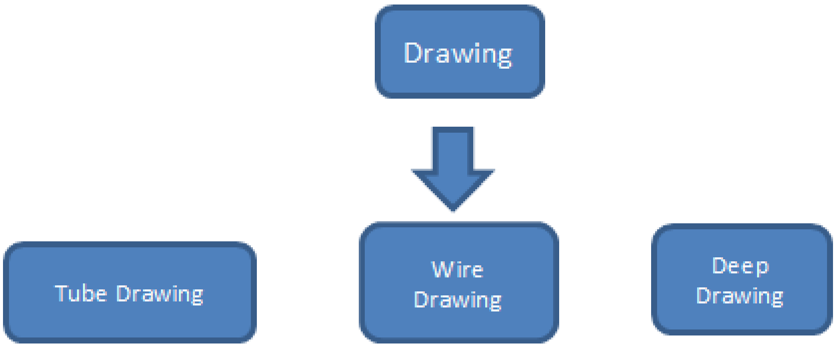

Figure 3.16: Different types of drawing

3.11.1 Wire Drawing

In Wire drawing process wire end is reduced and passes from opening of die i.e. entry of die and diameter is reduced .

3.11.2 Tube drawing

Tube drawing involves reducing the cross section and wall thickness through a draw die.IN tube drawing operation thickness and cross section are both reducing simenatniuosly from die.

3.12 Cold drawing design:

Die angle which is range from 6 to 15 degrees.

Two angles are present in a die:

- Entering angle
- Approach angle

Bearing Surface (land): sets final diameter of the drawn stock.

Back relief angle: exit zone

3.13 Defects in Cold Drawing:

In cold drawing process defects are produces like micro cracks and macro cracks and burst and fish scaling and cracks in center

3.14 Lubrication for cold drawing process:

In cold Drawing process use of lubrication is required for improvement of life of die and proper surface finish with the help of lubrication :

Drawing forces reduce

Temperature reduces

3.14.1 Different type of lubrication can use in cold drawing process these can be of three types

- Wet drawing lubrication
- Dry drawing lubrication
- Coating

3.14.2 Types of Lubricants

- Oil
- Copper Sulphate Solution
- Acid clean

3.15 Cold Drawing Die Materials

- Chromium plated steel

- Alloy steel h 13
- Titanium nitride coated carbide

3.16 Extrusion mechanism

As shown In Fig 3.17 hot extrusion process in extrusion press.

Figure 3.17: Hot extrusion press

3.17 Extrusion Process Flow chart

In Fig. 3.19 shows the process flow hart for hot extrusion operation

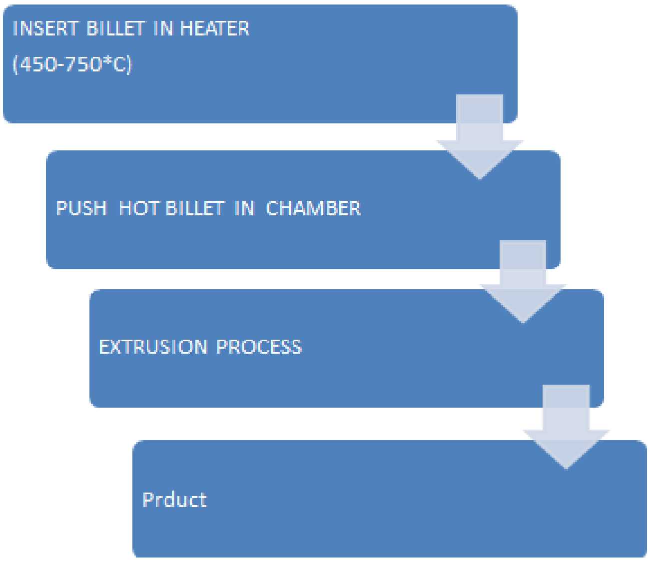

Figure 3.18: Process flow chart for hot extrusion

3.18 Extrusion Process

As shown in Fig 3.20 - 3.23 step for hot extrusion operation in press

Figure 3.19: Hot extrusion process photo courtesy shera industry

In this step billet comes from heater in heater temperature rises gradually from 450 to desire temperature i.e. 700-750 degree

Figure 3.20: Hot extrusion process photo courtesy shera industry

In this step billet came in front of chamber and pushing for the extrusion by the hydraulics pump for the pushing mandrel is fixed in horizontal moving arm.

Figure 3.21: Hot extrusion process photo courtesy shera industry

Figure 3.22: Hot extrusion process photo courtesy shera industry

Chapter 4

Die Design

4.1 Materials for Die

• Die is at the heart of extrusion. Dies must be suitable with thermal expansion shocks and stresses. In cool and hot extrusion, the proper material for die proper hardening and proper finishing can increase the life of die for the manufacturing of die Steels are (H arrangement) H10, H11, H13, H14 and H19 are the most ordinarily utilized for producing applications.

• Dies are produced form alloy steel (zirconia, Si3N4) for cold extrusion g longer instrument life and diminished ointment utilized, great wear resistance.

• Wall thickness as 0.5 mm or 0.7 mm can be made for aluminium extrusion.

• Heat treatment use for increasing hardness

• Dies must be suitable with thermal expansion shocks and stresses.

• Dies are produced alloy steel or ceramics (ZIRCONIAA OR SI3N4)

• Wall thickness as little as 0.5 mm or 0.7 can be made for aluminium extrusion.

• Heat treatment oil can use for lubrication. Oil may be quenching oil. For the polishing of die diamond past can use for better surface finish.[18]

4.2 Die Profile Design

Die is very important part of extrusion assembly for extrusion of the materials

Requirement of die preparation

The requirement for die material should be accurate, dimensionally stable, setting expansion and contraction; variations in response to change in temperature need to be minimum, strong and durable withstand the desire and finishing procedures economical and easy to use.

The different type of curved dies used for extrusion of materials.

1) Cosine profile dies

2)Convex circular profile dies

3)Concave circular profile dies

4) Convex elliptic profile dies

5) Concave elliptic profile dies

6) Convex parabolic profile dies

7) Concave parabolic profile dies

8) Convex hyperbolic profile dies

9) Polynomial shaped profile dies

10) Bezier shaped profile die

The different type of materials used for manufacturing of curve dies profiles..

1) Molybdenum high speed steel.

2) The various grades of tool steels.

3) Cemented carbides.

4) Steel bonded carbides.

4.3 Advantage of Die

There are certain advantages of die as listed below.

1) Very good toughness

2) Excellent thermal conductivity.

3) High resistance to thermal shock.

4) Good hot oxidation resistance.

5) Wear resistance Excellent.

6) Softening resistance is very good.

4.4 Limitation of die

Different limitations of die is listed below.

1) Stability of support tooling.

2) Formation of thermal fatigue cracks.

3) Plastic deformation and cracking.

4) Indentation

Overview of materials for Cold Work Steel

Density	7.31 - 8.14 g/cc	
hardness rockwell c	10.0 - 69.0	Average value: 57.7 Grade Count:53
Tensile Strength, Ultimate	380-2380 MPa	Average value: 1650 MPa Grade Count:35
Tensile Strength, Yield	205-2100 MPa	Average value: 701 MPa Grade Count:16
Elongation at Break	0.00-30.0%	Average value: 11.2 % Grade Count:15
Modulus of Elasticity	20.6 - 250 GPa	Average value: 210 GPa Grade Count:37
Bulk Modulus	160 GPa	Average value: 160 GPa Grade Count:4
Machinability	50.0 - 125 %	Average value: 75.5 % Grade Count:15
Shear Modulus	58.5 - 82.0 GPa	Average value: 78.1 GPa Grade Count:13
Thermal Properties	6.30 - 14.7 µm/m-°C	Average value: 12.0 µm/m-°C Grade Count:39
Specific Heat Capacity	0.418 - 0.460 J/g-°C	
Thermal Conductivity	14.0 - 32.0 W/m-K	Average value: 22.3 W/m-K Grade Count:23
Processing Temperature	150 - 1070 °C	Average value: 626 °C Grade Count:19
Annealing Temperature	343 - 900 °C	Average value: 787 °C Grade Count:25
Carbon, C	0.0500 - 2.90 %	Average value: 1.16 % Grade Count:82
Chromium, Cr	0.300 - 13.0 %	Average value: 5.78 % Grade Count:77
Iron, Fe	63.0 - 99.1 %	Average value: 89.3 % Grade Count:63
Molybdneum	0.200 - 7.00 %	Average value: 1.49 % Grade Count:70
Nickel, Ni	0.250 - 4.00 %	Average value: 1.31 % Grade Count:8
Vanadium, V	0.100 - 9.80 %	Average value: 2.12 % Grade Count:56
Tungsten, W	0.500 - 6.75 %	Average value: 2.45 % Grade Count:23
Phosphorous, P	0.0250 - 0.0350 %	Average value: 0.0289 % Grade Count:31
Sulfur, S	0.100 - 1.25 %	Average value: 0.0288 % Grade Count:33

Table 4.1: Overview of materials for cold work steel**[17]**

Overview of materials for hot work steel

Physical Properties	Metric	
Density	6.45 - 8.19 g/cc	
hardness rockwell c	26.0 - 66.0	Average value: 49.4 Grade Count:54
Tensile Strength, Ultimate	1010 - 2310 MPa	Average value: 1650 MPa Grade Count:35
Tensile Strength, Yield	800 - 1900 MPa	Average value: 1400 MPa Grade Count:32
Elongation at Break	8.00 - 15.5 %	Average value: 11.2 % Grade Count:15
Modulus of Elasticity	203 - 228 GPa	Average value: 210 GPa Grade Count:37
Bulk Modulus	160 GPa	Average value: 160 GPa Grade Count:4
Machinability	45-95%	Average value: 70.0 % Grade Count:17
Shear Modulus	80.0 - 81.0 GPa	Average value: 80.5 GPa Grade Count:4
CTE, linear	7.00 - 14.3 µm/m-°C	Average value: 12.3 µm/m-°C Grade Count:27
Specific Heat Capacity	0.418 - 0.461 J/g-°C	
Thermal Conductivity	14.4 - 42.0 W/m-K	Average value: 28.4 W/m-K Grade Count:29
Processing Temperature	540 - 1220 °C	Average value: 918 °C Grade Count:9
Annealing Temperature	845 - 900 °C	
Carbon, C	0.220 - 2.10 %	Average value: 0.449 % Grade Count:74
Chromium, Cr	1.10 - 12.8 %	Average value: 4.54 % Grade Count:74
Iron, Fe	71.3 - 96.0 %	Average value: 89.6 % Grade Count:60
Molybdneum	0.150 - 1.50 %	Average value: 0.447 % Grade Count:60
Nickel, Ni	0.300 - 1.70 %	Average value: 0.829 % Grade Count:14
Vanadium, V	0.100 - 5.40 %	Average value: 0.897 % Grade Count:7
Tungsten, W	1.00 - 19.0 %	Average value: 7.89 % Grade Count:15
Phosphorous, P	0.0300 %	Average value: 0.0300 % Grade Count:8
Sulfur, S	0.00100 - 0.0300 %	Average value: 0.0134 % Grade Count:22

Table 4.2: Overview of materials for hot work steel **[17]**

4.5 Draw Dies

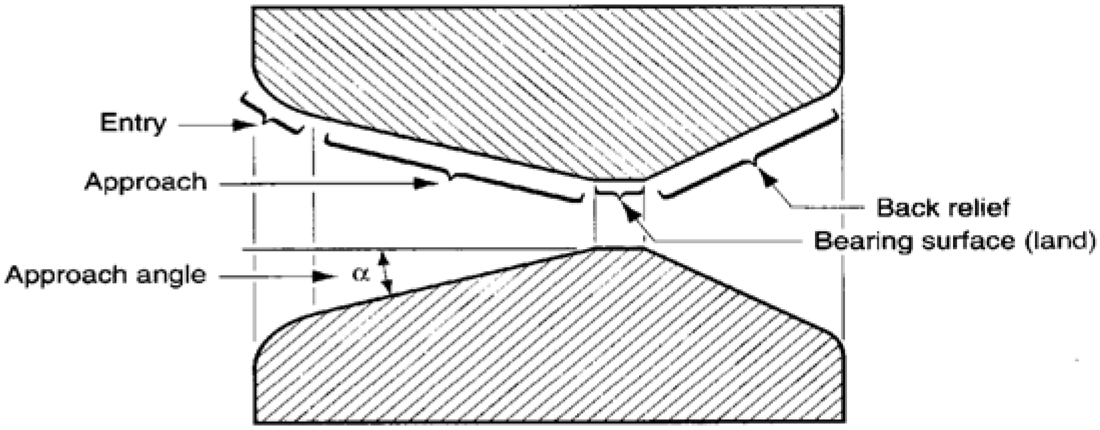

Figure 4.1: Die design

Approach angle about 6 to 20 degree

Back relief angle about 30 degree

Die for Round Drawing :

4.6 Die Materials Overview

Tungsten Carbide:

- Lowest cost, shock resistance, eases of production, large sizes available.
- Lower life expectancy.

Natural Diamonds:

- Wear resistance, gives excellent wire surface, high thermal conductivity, longer life expectancy Susceptible to fractures from shock or wear, limited availability in required high quality and quantity, constantly escalating price.

Synthetic Single Crystal

- Consistently uniform material, gives excellent wire surface, high thermal conductivity, predictable wear schedule, uniform wear pattern gives longer life expectancy.
- Larger size ranges are still costly at this time.

Polycrystalline Diamond:

- Excels in life expectancy, wear resistance of diamond, shock resistance of carbide, high availability, cost effectiveness
- Higher drawing force, smaller fines requires more filtration, may be damaged by temperatures above 700^{o}C, wire surface condition less than from natural diamond.

4.7 Heat treatment

Heat treatment is a process in which tool or die steel must to be designed to maximize metallurgy property of materials

Sources of Stress:

• Residual stress in the steel itself Die is heat treated and residual stress will be relieved, and again strain or potential movement in the die Pre-hardened stock is known to have a very high level of residual stress

• Stress created from manufacturing removing the chips creates a deformation zone surrounding the tool itself. Any time there is a deformation zone, stresses will be created. The more severe the machining, the higher the stresses is. Once again, the main risk is the relief of these stresses during heat treatment and movement of the die from this relief From the EDM and grinding m/c generates high temperature so it's under high pressure and heat effected zone. Under extreme conditions these crack create propagation during heat treatment.

• Thermal expansion and contraction from heating and cooling during heat treatment. Most of alloys, are at a single inch of steel expands as well as contracts not sound like much, but a long bar of tool steel thin sections heat and cool faster than the surface heats and cools faster than the core the differences b/s hot n cold can lead to large stresses in the steel.

Machining Features on a Die that Can Increase the Risk of Distortion of Cracking during Heat Treatment

Rough Machining: Deep tooling marks create stress risers.

EDM before heat treatment: micro cracks in recast layer Recast layer should be removed.

Weld repair: Welding in general is a very risky procedure on tool and die alloys. It should be completely avoided if at all possible.

Toughness: specimens that are welded to the block can create stress risers Preheating, post-heating should be performed on the weld

Steels for Strength:

- Steel = 0.06% to 1.0% carbon
- Must have a carbon content of at least .6% (ideally) to heat treat.
- Must heat to authenticate temperature range.
- Must rapid quench to prevent formation of equilibrium products.
- Basically crystal structure changes from BCC to FCC at high Temp.

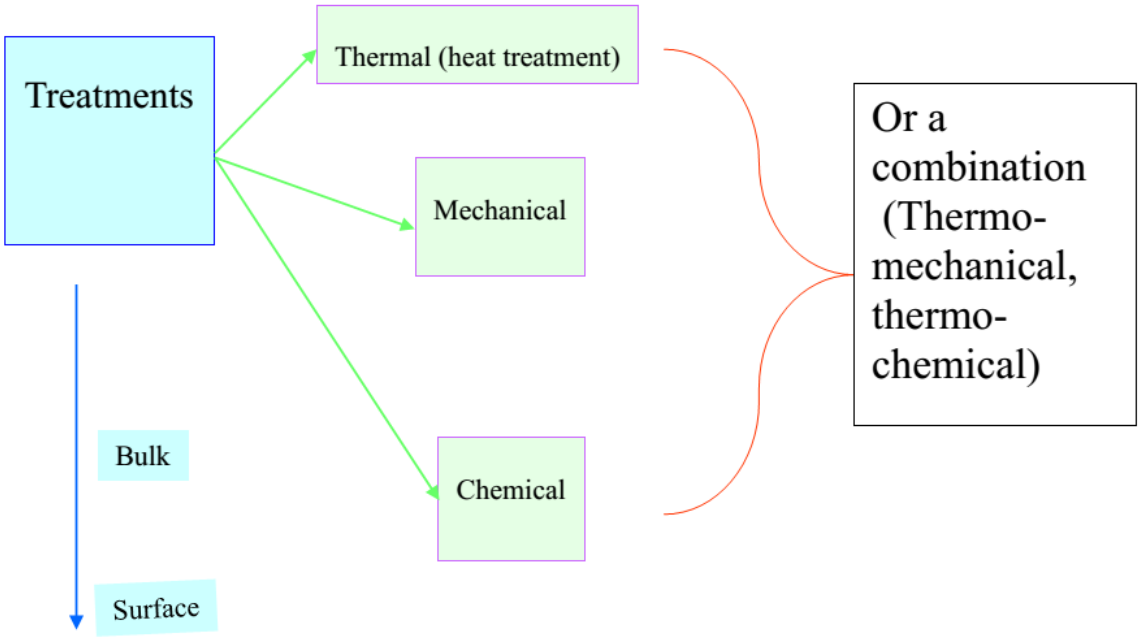

Figure 4.3: An overview of important heat treatments

Figure 4.2: An overview of important heat treatments[15]

Chapter 5

Cause and Effect Analysis

In cause and effect diagram we study the various parameters which affect the quality as well as productivity. Fig. 5.1 shows the cause and effect diagram for defective product.

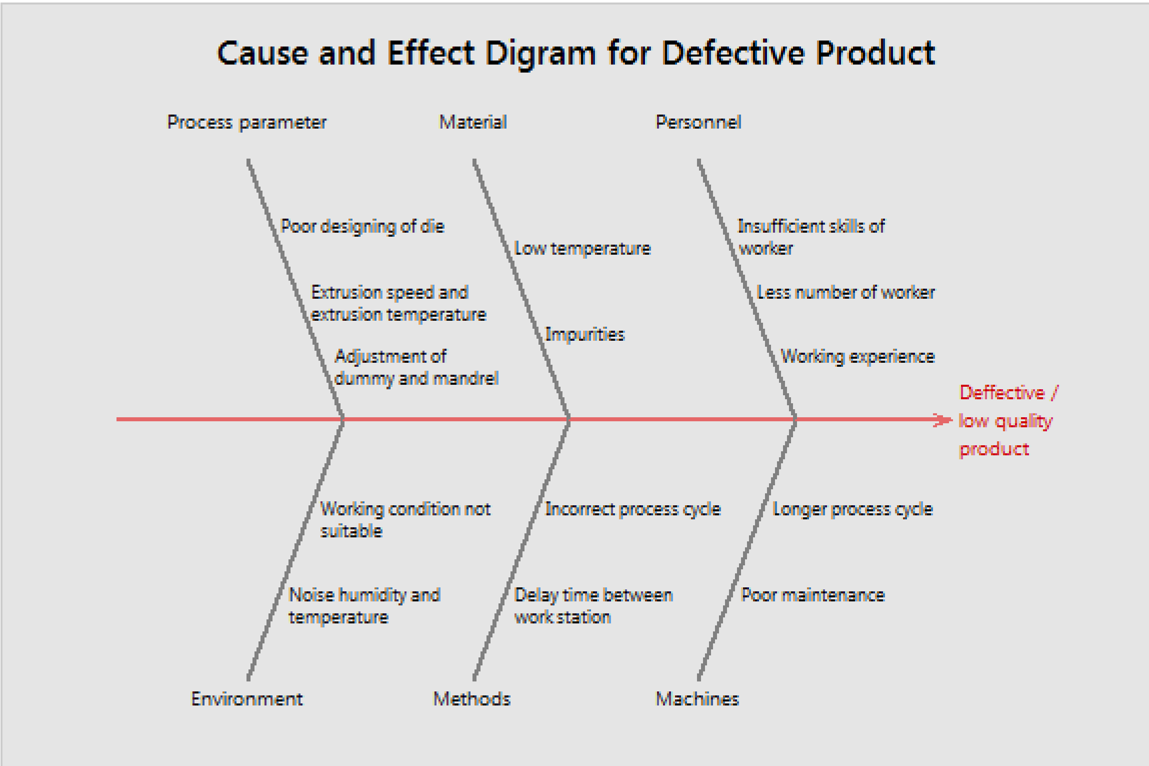

Figure 5.1: Cause and effect diagram for defective Product

5.1 Environment

5.1.1 Noise humidity and temperature

Due to heavy machinery too much noise problem is there, and also temperature and humidity effect the working condition

5.1.2 Working condition not suitable

Work station is not cleaned at proper interval of time and also due to less working space at each work station problems are faced.

5.2 Method

5.2.1 Delay time between stations

Due to more stoppage between heater and chamber Temperature is dropped

5.2.2 Incorrect Process Cycle

For different products selection of proper die, lubrication and dummy is required.

5.3 Machine

5.3.1 Poor Maintenance

fault hydraulic problem or pump problem it create machine breakdown so production effect. Due to poor maintenance breakdown increased due to which production is affected.

5.3.2 Longer Process Cycle

In extrusion process delay in process time is very expensive for the production side. More number of stoppages in process sudden accident and any technical fault in process create bad impact in production and increase the defect product probability

5.4 Process Parameter

5.4.1 Poor designing of Die

For different extrusion process and for different products selection of proper die is required. Design of die is suitable according to different shapes.

5.4.2 Extrusion speed and Temperature.

For the shape selection of suitable temperature and suitable speed is required.

5.4.3 Adjustment of Dummy and Mandrel

According to different shape and size of billet different dummy are required and according to that lubrication required on mandrel.

5.5 Material

5.5.1 Low Temperature

Due to long distance between heater and chamber temperature loss.

5.5.2 Impurities

Impurities were not removed at the time of casting and also certain defects were present after casting

5.6 Man power

5.6.1 In sufficient skills of worker

Due to less training of worker for handling the machine or work in respected work station the Chance of sudden accident increased.

5.6.2 Less number of workers

Each work station having less number of worker due to which improper handling of machine ,raw material and final product

5.6.2.1 Working Experience

In industry technician is not have work experience to work on the machine and how to handle technical problem so at the time of extrusion lots of chances are there for production

5.7 Causes of all the parameter

All parameter leads towards the low quality products due to which productivity was affected. One major parameter selected as "poor designing of die" due to which defects are occurs in the product so, our study focused on the proper design of die.

5.7.1 Defects in L shape channel

In the extrusion process the defective product and irregular surface is shown. The life of the die as well as the product was decreased and also effect the productivity Fig. 5.2 shows the irregular surface using die with 0° entry angle. Cracks are occurs due to the improper flow of material at the corner of die. In Fig. 5.3 shows the general diagram for die entry. Fig. 5.4 shows the die with 0° entry angle. Also as entry angle increased to 5° the same defects are there but in less amount as shown in Fig. 5.5.

Figure 5.2: Cracked product 0 degree at entry angle

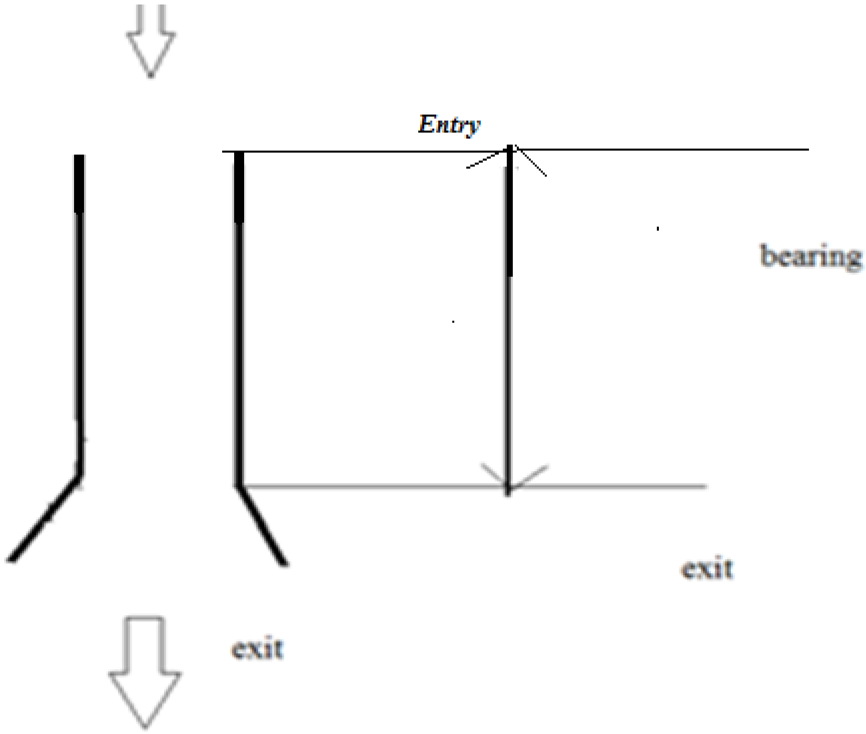

Figure 5.3: Die design at 0 degree entry angle

Figure 5.4: Extrusion Die alloy steel H-13 at 0 degree entry angle

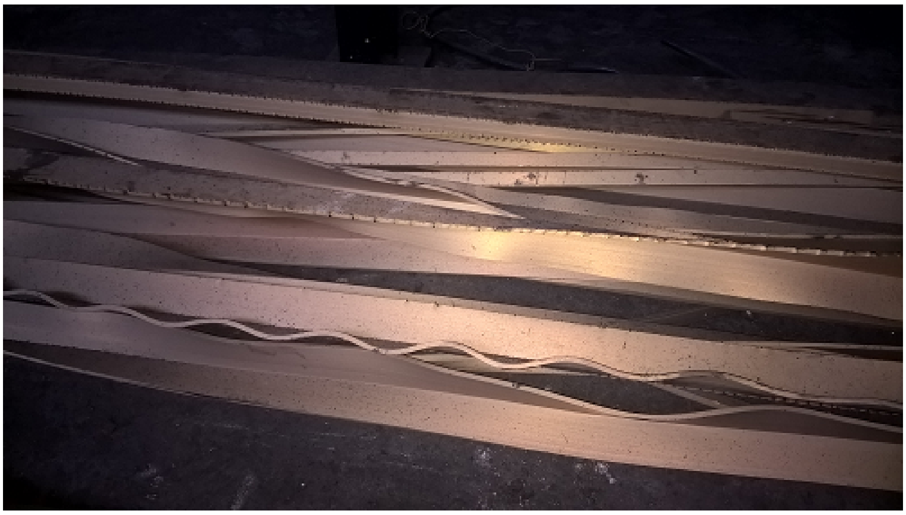

Figure 5.5: Cracked product at 5 degree entry angle

To overcome this problem the entry angle are changed from 0 to 9 degree by using hit and trial method and it was observed that as we increasing entry angle of die the proper flow of metal at the corner takes place the size of crack is reducing as we increase the entry angle If the corner of die and shape of profile semi spherical hence at the time of extrusion due to its shape, metal flow properly and fill all the area of die. There for pressure is generated more in central compared to corners. The location of bearing in die and the use of lubrication in extrusion thus gives better result and cracks is not propagate. Fig 5.6 shows with entry angle of 9°. Fig. 5.7 shows the finished product without crack using 9° entry angle. Fig. 5.8 shows the die with 9° entry angle.

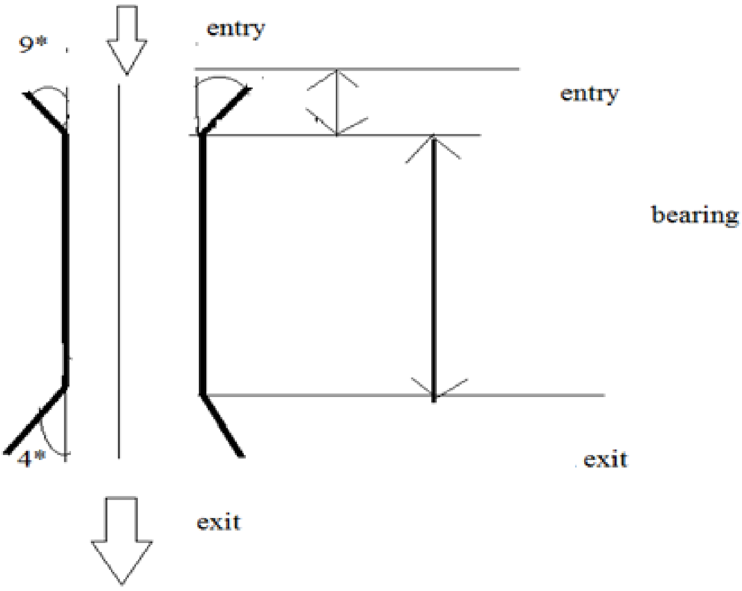

Figure 5.6: Die design at 9 degree wall angle

Figure 5.7: Finished product at 9 degree entry angle

Figure 5.8: Extrusion Die Alloy Steel H-13with 9° entry angle design

5.8 Production data

Table 5.1 and 5.2 shows the production data for using hit and trail method.

product	billet length (mm)	Number of billet at a time	Number of billet	TEMP (°C)	Die hole	Bearing (mm)	Entry	Exit
c-385	300	4	5	750	4	5-5	NO	YES
c-385	250	2	4	720	2	3-5	NO	YES
c-385	250	2	4	680	2	3-5-3	YES	YES

Table 5.1: Production Data

Product	Trail	Comments
c-385	1	HEAVY CRACKS AT CORNER AND HAVING PROBLEM IN HANDLING 4 ANLGE AT A TIME
c-385	2	cracks at Corner and twisting Non similarity un even flow of angle from the center of die
c-385	3	Extrusion was ok. No twisting, no cracks. Slow speed extrusion low temp. of billet

Table 5.2: Production Data

Total production:	Temp	Billet length:	Billet at a time:	Bearing:
700 kg	680°C	250 mm	2	3-5-3 mm

Table 5.3: Production Data

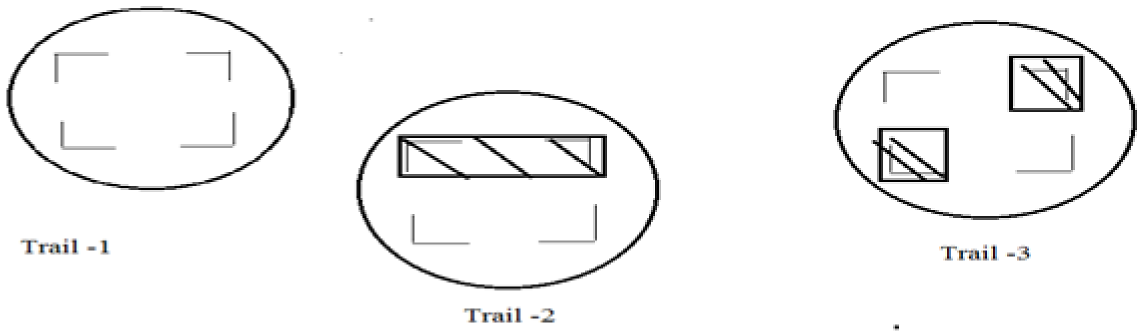

Figure 5.9: Diagram for different number of entry section

In trail 1st: Die has 4 holes i.e. very hard to control the production.
In trail 2nd: In this die for balancing of angle so that balancing two angle are blocked so that easy to control overlapping of angle is reduced. In this die both angle is not eccentricity hence product come in crack and deform shape.
In trail 3rd : In this die both angle are same distance from the center points hence the production can easily control and well balance so that production come properly and cracks are reduced and get proper surface finish.As shown in Table 5.3 the final finished product.

Chapter 6

Conclusion and Future work

6.1 Conclusion

By applying the entry angle (9°) to the die, there is proper flow of material at the corner of the die. Due to which the defect free L shape channels are produced, which has greater tolerance accuracy.
As we use the die having two L shape at diagonal (trail number 3) the production rate is increasing and there is no chances of bending of L shape at exit of the die.

6.2 Future work

The dissertation work can be extended in following direction:

1. Finite Element Analysis can be carried out for different design of die for hot extrusion and cold drawing manufacturing process
2. Lean manufacturing concept can be applied for further of the productivity.

Bibliography

[1] S.D Purohit, hot extrusion dies an experiment minerals and materials review , (September 2010)65-68.

[2] M.S jount and S.M.hwang .optimal process design in steady-state metal forming by finite element method–ii. Application to die profile design in extrusion, J. Mach. Tools Manufact. Vol. 33, pp.63-70, (1993.),

[3] J.F.beland, M.fafard et al Optimization on the cold drawing process of 6063 aluminium tubes Applied Mathematical Modelling vol. 35 5302–5313 (2010)

[4] M. Schikorra, A.E. Tekkaya et.al Experimental investigation of embedding high strength reinforcements in extrusion profiles CIRP Annals - Manufacturing Technology vol. 57 313–316 (2008).

[5] Wallmeier – Extrusion consulting Heinz-Ludwig Wallmeier MHC, a high performance material for high-stressed extrusion dies.

[6] Z. jurkovic and M. jurkovic et.al Optimization of extrusion force prediction model using different technique Journal of Achievements in Materials and Manufacturing Engineering VOLUME 17 353-356 (aug 2006)

[7] D.Tang, W. Fang Effect of die design in micro channel tube extrusion, Procedia Engineering 81 628 – 633 (Oct. 2014)

[8] Z. Lin, X. Juche, Optimization of die profile for improving die life in the hot extrusion process Journal of Materials Processing Technology 142 659–664 (april2003)

[9] Xiong, Shoumei F. Lau et.al. An efficient thermal analysis system for the die-casting process Jan, Journal of Materials Processing Technology 128 pg.19–24(2002)

[10] S.Z. Qamar, A.K. Sheikh et .al. Heat treatment of a hot-work dies steel. International Scientific Journal Volume 28 Pages 503-508(Aug 2007)

[11] N. Loginov, S.L. Demakov, et al lEvolution of defects in the production of capillary copper. May Journal of Materials Processing Technology 224 80–88 (2015)

[12] Karen L. Wang Design and analysis of direct cold drawing of section rods through a single die Journal of Materials Processing Technology 166 ,345–358 (June 2005)

[13] David Schwam John F. Wallace et.al die materials for critical applications and increased production rates. No 2002

[14] Milivoje M. Kostic Design of Extrusion Dies.

[15] 26th Edition machinery hand book by Industrial press NY(2000)

[16] Types of extrusion and extrusion equipment R. Chandramouli sastra University, NP-TEL

[17] Forming and Forging, 9th Edition ASM Metals Handbook_ Vol 14,(1993)

[18] 2nd edition Introduction-to-Physical-Metallurgy-Abner by McGowan-HILL B00K (Sep 1974)