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A REVIEW PAPER TO FIND OPTIMUM COMBINATION OF DRILLING PARAMETER FOR MINIMIZING POWER CONSUMPTION.

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ABSTRACT

Drilling is one of the basic machining process of making holes in a work piece with metal cutting tools and it is essentially for manufacturing industry like aerospace industry, automobile industry, medical industries and semiconductors. It is greatly affected by the cutting parameters like depth of cut, spindle speed, feed rate, cutting edge angle, cutting environment and so on. This chapter presents an overview of the motivation towards the present work, the problem statement, objectives and scopes of the present work. A brief overview is presented in this chapter about the steps towards the initiative for the present research work.

1. INTRODUCTION

1.1 MACHINING PROCESS- Machining is a process of removing material from a workpiece in the form of chips, it covers several processes. The term metal cutting is used when the material is metallic. Most machining has very low set-up cost compared to forming, molding and casting processes. However, machining is much more expensive for high volumes. Machining is necessary where tight tolerances on dimensions and finishes are required. The three principal of machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planing, boring, broaching and sawing.

- Turning operations are operations that rotate the workpiece as the primary method of moving metal against the cutting tool. Lathes are the principal machine tool used in turning.
- Milling operations are operations in which the cutting tool rotates to bring cutting edges to bear against the workpiece. Milling machines are the principal machine tool used in milling.
- Drilling operations are operations in which holes are produced or refined by bringing a rotating cutter with cutting edges at the lower extremity into contact with the workpiece. Drilling operations are done primarily in drill presses but sometimes on lathes or mills.
- Miscellaneous operations are operations that strictly speaking may not be machining operations in that they may not be swarf producing operations but these operations are performed at a typical machine tool. Burnishing is an example of a miscellaneous operation. Burnishing produces no swarf but can be performed at a lathe, mill, or drill press.

1.2 THE DRILLING PROCESS- Drilling is a most common used industrial machining process of creating and originating a hole in mechanical components and work piece. The tool used, called a drill bit and the machine tool used is called a drill machine. Drilling involves a rotary end-cutting tool having one or more cutting edges called lips, and having one or more helical or straight flutes for the passage of chips and passing the cutting fluid to the machining zone. The drilling operations performed on a drilling machine, which rotates and feed the drill to the work piece and creates the hole. Drilling usually performed with a rotating cylindrical tool that has two cutting edges on its working end (called a twist drill). Rotating drill fed into the stationary work piece to form a hole whose diameter is determined by the drill diameter. Geometrically, drilling is one of the most complex machining process due to the complex geometry of the drill bit. The difficulty of producing drills with consistent geometries has traditionally limited accuracy although recently drill consistency and repeatability has greatly increased with the advent of CNC drill grinders. The same complexity of the tool geometry has inhibited the introduction of new tool materials to have the productivity gains in drilling, which lagged from those made in turning and milling over the past 30 years. Drilling is applied to a large variety of materials in different industries, but it has been mostly studied for metal cutting. In recent years non-metallic materials (plastics, ceramics and composite materials) are steadily replacing metallic parts in various industries. Drilling is the standard process for producing holes among the most common material removal process. Drilling is performed by a drill bit which is rotated by the spindle of a machine. The work-piece and the revolving drill (although in some cases the work-piece can be revolving and attached to the spindle) are positioned by movements of the machine table and/or the spindle assembly. When drilling starts a linear movement (along the drill rotating axis) occurs between the rotating drill and work-piece. Most of the time drilling operations are performed on specialized drilling machines of different configurations (upright, radial or specialized), but drilling can also be performed on lathe machine, milling machines and boring mills.

1.2.1 Drill- A drill or drill motor is a tool fitted with a cutting tool attachment or driving tool attachment, usually a drill bit or driver bit, used for drilling holes in various materials or fastening various materials together with the use of fasteners. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip, and sometimes edges, of the cutting tool does the work of cutting into the target material. This may be slicing off thin shavings (twist drills or auger bits), grinding off small particles (oil drilling), crushing and removing pieces of the workpiece (SDS masonry drill), countersinking, counter boring, or other operations. Drills are commonly used in woodworking, metalworking and construction and do it yourself projects. Specially designed drills are also used in medicine, space missions and other applications.

A wooden drill handle and other carpentry tools found on board the 16th century carrack Mary Rose. The earliest drills were bow drills which date back to the ancient Harappans and Egyptians. The drill press as a machine tool evolved from the bow drill and is many centuries old. It was powered by various power sources over the centuries, such as human effort, water wheels and windmills, often with the use of belts. With the coming of the electric motor in the late 19th century, there was a great rush to power machine tools with such motors and drills were among them. The invention of the first electric drill is credited to Arthur James Arnot and William Blanch Brain in 1889, at Melbourne, Australia. Wilhelm Fein invented the portable electric drill in 1895 at Stuttgart, Germany. In 1917, Black & Decker patented a trigger like switch mounted on a pistol grip handle.

1.2.2 Types of Drills- There are many types of drills: some are powered manually, others use electricity (electric drill) or compressed air (pneumatic drill) as the motive power and a minority is driven by an internal combustion engine (for example, earth drilling augers). Drills with a

percussive action (hammer drills) are mostly used in hard materials such as masonry (brick, concrete and stone) or rock. Drilling rigs are used to bore holes in the earth to obtain water or oil. Oil wells, water wells, or holes for geothermal heating are created with large drilling rigs. Some types of hand held drills are also used to drive screws and other fasteners. Some small appliances that have no motor of their own may be drill powered, such as small pumps, grinders, etc

1.2.3 General Classifications

A. Classification Based on Construction

Solid Drills: Those made of one piece of material such as high speed steel

Tipped Solid Drills: Those having a body of one material with cutting lips made of another material brazed or otherwise bonded in place

Composite Drills: Those having cutting portions mechanically held in place

B. Classification Based on Methods of Holding or Driving

Straight Shank Drills: Those having cylindrical shanks which may be the same or different diameter than the body of the drill; the shanks may be made with or without driving flats, tang, grooves or threads

Taper Shank Drills: Those having conical shanks suitable for direct fitting into tapered holes in machine spindles, driving sleeves or sockets; tapered shanks generally have a driving tang.

Taper Shank Square Drills: Those having tapered shanks with four flat sides for fitting brace.

Shell Core Drills: Core drills mountable on arbors specifically designed for the purpose; commonly used with shell reamer arbors.

Threaded Shank Drills: Those made with threaded shanks generally used in close center multiple spindle applications or portable angle drilling tools.

Beaded Shank Bits: Drills with flat shanks having raised beads parallel to the axis

C. Classification Based on Number of Flutes

Two Flute Drills: The conventional type of twist drill used for originating holes.

Single Flute Drills: Those having only one flute, so only used for originating holes.

Three Flute Drills (Core Drills): Drills commonly used for enlarging and finishing, drilled, cast or punched holes, they will not produce original holes.

Four Flute Drills (Core Drills): Used interchangeably with three flute drills; they are of similar construction except for the number of flutes.

D. Classification Based on Hand of Cut

Right Hand Cut: When viewed from the cutting point the counter clockwise rotation of a drill in order to cut; the great majority of drills are made "right hand".

Left Hand Cut: When viewed from the cutting point the clockwise rotation of a drill in Order To Cut.

1.2.4 Nomenclature of Twist Drills

The following terms are used in the nomenclature of twist drill. These terms relate to the various geometry features and other terminologies used while carrying out a drilling process. Fig.1.1, Fig.1.2 and Fig.1.3 depicts the various geometry features described below.

Axis: The imaginary straight line which forms the longitudinal centre line of the drill.

Back Taper: A slight decrease in diameter from front to back in the body of the drill.

Body: The portion of the drill extending from the shank or neck to the outer corners of the cutting lips.

Body Diameter Clearance: That portion of the land that has been cut away so it will not rub against the walls of the hole.

Built Up Edge: An adhering deposit of nascent material on the cutting lip or the point of the drill.

Chisel Edge: The edge at the end of the web that connects the cutting lips.

Drill Diameter: The diameter over the margins of the drill measured at the point

Flutes: Helical or straight grooves cut or formed in the body of the drill to provide cutting lips, to permit removal of chips, and to allow cutting fluid to reach the cutting lips

Flute Length: The length from the outer corners of the cutting lips to the extreme back end of the flutes; it includes the sweep of the tool used to generate the flutes and therefore, does not indicate the usable length of the flutes.

Helix Angle: The angle made by the leading edge of the land with a plane containing the axis of the drill.

Land: The peripheral portion of the body between adjacent flutes.

Land Width: The distance between the leading edge and the heel of the land measured at a right angle to the leading edge.

Neck: The section of reduced diameter between the body and the shank of a drill oil.

Grooves: Longitudinal straight or helical grooves in the shank, or grooves in the lands of a drill to carry cutting fluid to the cutting lips.

Overall Length: The length from the extreme end of the shank to the outer corners of the cutting lips; it does not include the conical shank end often used on straight shank drills, nor does it include the conical cutting point used on both straight and taper shank drills.

Point Angle: The angle included between the cutting lips projected upon a plane parallel to the drill axis and parallel to the two cutting lips.

Shank: The part of the drill by which it is held and driven.

Web: The central portion of the body that joins the lands; the extreme end of the web forms the chisel edge on a two flute drill.

Web Thickness: The thickness of the web at the point, unless another specific location is indicated.

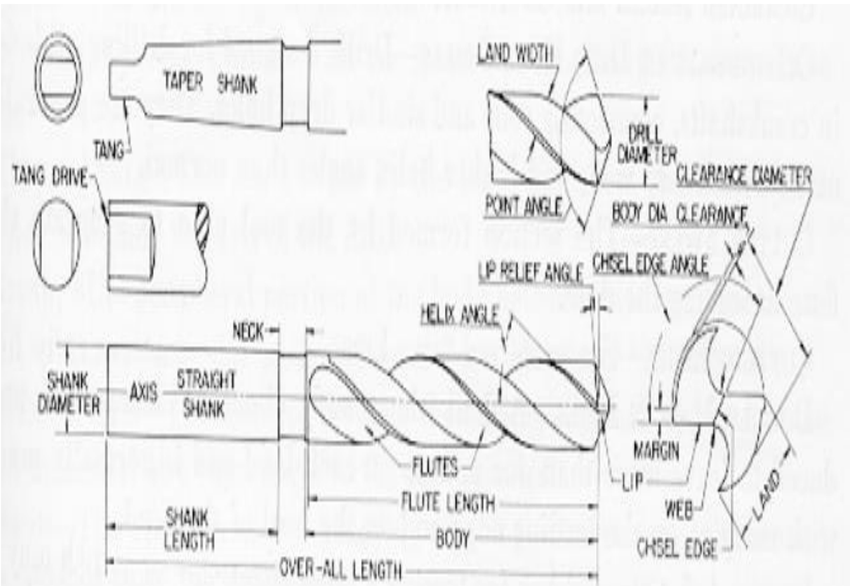

Fig. 1.1 Illustrations of terms applying to twist drill

Fig. 1.2 Types of twist drill

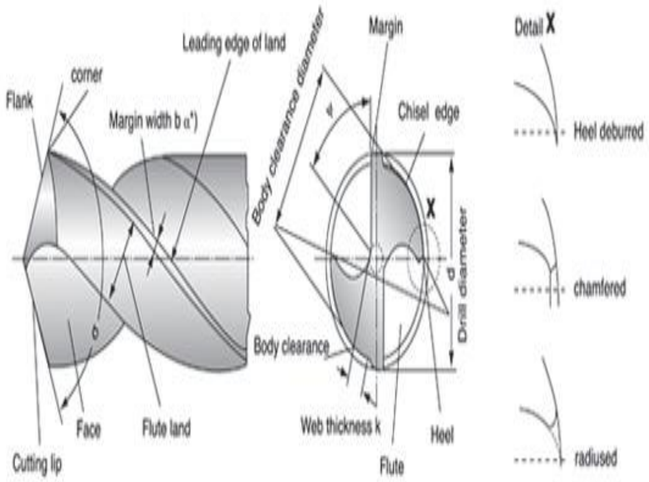

Fig. 1.3 Twist Drill Geometry (σ = point angle, ψ = chisel edge angle)

1.2.5 Forces Acting On Drilling

The various forces acting on a drill are shown in Fig. 1.4 All the elements of a drill are subject to certain forces in drilling. Resolving the resultant forces of resistance to cutting at each point of the lip, we obtain three forces (F_Z, F_V and F_H) acting in directions mutually perpendicular to each other. The horizontal force (F_H) acting on both lips are considered to counter balance each other. The Vertical force (F_V) also called as thrust force comprises of the forces F_Z, F_V and F_H. The forces F_C and F_m are not shown. The force F_{V1} acts on the web. This force is quite large and is about 60% of the total thrust force. This force F_{V2} acts on each of the two lips and forms the real cutting force which depends upon the work material, cutting variables and cutting point geometry and is about 37% of the total thrust force. The forces F_C and F_m are of smaller magnitude. The force F_C is due to the rubbing of chips, flow from the hole against the sides of the hole and flutes on the drill. This force this force is about 1% of the total thrust force. The force F_M is due to the rubbing action of margin of the drill against the sides of the hole and is about 2% of thrust force (Matsumura, T. and Tamura, S., 2014).

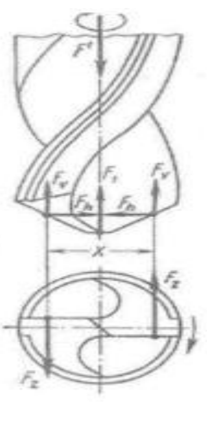

Fig. 1.4 Forces acting on drill

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1.2.6 Power Consumption

The total power consumed during drilling process is equal to the sum of the power consumed in rotating the drill and the power consumed in feeding the drill in to the work piece. According to Rao Thella Babu

Total power required $= \frac{T * N}{975000} + \frac{(P * f * N)}{(612 \text{ X } 104)} \; Kw$

N = Speed of drill in rpm

T = Torque acting on drill (kg-m)

P = Thrust force in kg

f = Feed rate in mm/rev

1.3 DRILLING PARAMETERS AFFECTING THE PROCESS

a) Cutting Speed

Cutting speed is the speed difference between the cutting tool and the surface of the workpiece it is operating on. It is expressed in units of distance along the workpiece surface per unit of time. The speed of the work piece surface relative to the edge of the drilling tool during a cut, measured in meter per minute. Cutting speed of a material is the ideal number of Feet-per-Minute that the tool-bit should pass over the work-piece. This "Ideal" cutting speed assumes sharp tools and flood coolant. Adjustments need to be made for less than ideal cutting conditions. Different materials (High-Carbon/Low-Carbon Steels, Aluminums, Different kinds of Plastics) have different Cutting Speeds and can be worked/ cut at different rates. In addition, some tools or processes (like threading, knurling, or cutting-off) will need to be worked at slower speeds than the Cutting Speed would indicate.

b) Spindle Speed

The spindle speed is equal to the cutting speed divided by the circumference of the work piece where the cut is being made. The rotational speed of the spindle and the work piece in revolutions per minute.

c) Feed

Feed refers to how fast a lathe-tool should move through the material being cut. This is calculated using the feed per Revolution for the particular material. The feed is measured in millimetre per revolution.

, resulting in weight reductions of the vehicle without sacrificing strength. Metallic material such as aluminium and magnesium, high-strength steels, carbon-carbon composites as well as a number of novel metallic composites is all under investigation in terms of viability and practicality for use in high production in automobile.

A unique combination of properties puts aluminium and its alloys amongst our most versatile engineering and construction materials. All alloys are light in weight, yet some have strengths greater than that of structural steel. For automotive applications aluminium alloy sheets have the advantages of corrosion resistance, high strength to weight ratio, and recyclability.

Workpiece Material Selection

Aluminium is the most commonly used material in industries. There are some key characteristics of this material which proves this material is very important for industrial use. Its various properties are its durability, light weight, corrosion resistive, economical and good workability. Aluminium casting work piece is prepared in college foundry shop. Mould is prepared in different molding boxes and then casting is done metals are cast into shapes by melting them into a liquid, pouring the metal in a mould.

When metal has solidified and cools then molded material is removed and finally found the casted workpiece as shown in Figure 3.1. Casted material is not used directly for working. So, making desired workpiece, removed extra casted material. It was done in machine shop available in the college. Turning and facing operation is done on the lathe machine then workpiece is prepared.

Workpiece of aluminium Casting used for the experiments have similar dimensions and taken out from 20 mm diameter rod of aluminium casting. Total 16 numbers of workpieces of 100 mm length have been used for experimental work, as shown in figure 3.2. These work pieces were drilled up to 50 mm of depth. Every drilled work-piece was having a number so that it can be easily distinguish that which work-piece drilled with which spindle speed and feed.

Drill bits are some of the most common and versatile parts of any machine shop or home tool shed. They can drill into metals, solid wood furniture, porcelain and even glass, and with a variety of different drill bits available, one can find an appropriate bit for almost any situation. One major aspect of drill bit selection is the material makeup of the drill bit itself. Not all twist bits will work on all applications. It’s important to match the material of the bit to the material being drilled to produce the best results.

High Speed Steel (HSS) is a special type of carbon steel that is prized for the way it can withstand high temperatures while maintaining structural integrity, specifically its well, but only at a level equal to standard carbon steel. HSS can also take coatings, such as titanium nitrate, which give the drill bit better lubricity, decreasing friction and helping to extend the bit's life hardness. Friction created by high speed turning can raise temperatures dramatically, but HSS can undergo these types of drillings. HSS can function at normal temperatures.

Properties of HSS is having hardness of 180 BHN, it can be elongated up to 18%, its tensile strength is 490 MPa, yield strength of high speed steel is 460 MPa and young's modulus of rigidity is 225 GPa. As figure 3.3, shows a drill bit of 9 mm of diameter having mark after every 10 mm length to measure the thrust force and power consumption by dynamometer and wattmeter at each 10 mm depth of cut. On the basis of it effect of depth of cut on thrust force and power consumption can also be examine.

Selection of Equipment

The selection of machine-tools is largely a matter of judgment, based on the consideration of many variable factors. Our work is done for finding power consumption and thrust force for drilling operation on conventional lathe machine. For accomplishment of the work, experimental setup was needed and which involves a set of machineries which were necessary for completion of the work along with the material used for work piece. Thus, the following requirements of experimental setup were needed:

- Conventional lathe machine
- Dynamometer
- Workpiece holder
- Wattmeter

Conventional lathe machine

Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is secure1y and rigid1y held in the chuck or in between centres on the lathe machine and then turn it against a single point cutting tool which wi1l remove meta1 from the job in the form of chips.

Lathes are manufactured in a variety of types and sizes, from very small bench lathes used for precision work to huge lathes used for turning large steel shafts. But the principle of operation and function of all types of lathes is same. If there is a work piece in which many operations are required like taper turning, internal thread, drilling, knurling and turning operation is needed then all these operation can be performed on lathe machine. So there will not require a separate drilling machine for drilling operation, because it will not be economical process. It was the reason that present experiments of drilling in work piece of aluminium casting have been performed on lathe machine.

Table 3.1 Technical Specifications of Conventional Lathe Machine

Sr. No.	Specifications	Range
1	Spindle speed	32-1200 rpm
2	Spindle motor power	3 kW
3	Made	HMT-LTM
4	Number of station of turret head	8
5	Weight	1550 kg

(Source: Lathe Laboratory Manual)

According to present work, experiments were performed on conventional centre lathe machine. The machine tool selection is a main factor which affects the outcome of experimental work. The major technical specifications of the lathe machine used shown in Figure 3.4 are given in Table 3.1.

Dynamometer

The drilling forces experienced by the work piece material during the cutting process were measured using strain gauge type three component lathe tool dynamometer mounted on specially designed fixture as shown in Figure 3.6. It consists of three force components measurement circuit's i.e. cutting force, feed force and thrust force with balancing for initial zero setting of the bridge settings. The strain gauge with tool holder was attached to the tool post of the lathe machine. The readings of thrust force were recorded after output stabilization and then have been used for analysis. Dynamometers are devices used to measure cutting forces in machining operation. The cutting force cannot be detected or quantified directly but their effect can be sensed using Transducer. For example, a force which can neither be seen nor be gripped but can be detected and also quantified respectively. Lathe Tool Dynamometer designed to measure vertical & horizontal/(radial force in case of three component) forces on tool during cutting process. The unit consists of a mechanical sensing unit or tool holder and digital force indicator. With this dynamometer, students can study the change in these forces due to change in speed and feed.

Workpiece holder

Workpiece holder is must required for the experiment work. It has been prepared in mechanical workshop by another researcher for his studied. It was modified for fixing Aluminium Casting workpiece of 100 mm length and 20 mm diameter as shown in figure

Workpiece holder is made from a rod of mild steel of 75 mm length and 50 mm diameter by drilling it with the drill bit of 22 mm diameter and its handle is made from 12×12 mm^2 solid square rod of mild steel with length of 70 mm. It is having two screws for fixing workpiece in it as shown in figure 3.6. So, with the help of these fasteners workpiece can be fixed in workpiece holder. Work piece holder can be fixed in the tool holder of lathe tool dynamometer.

Tool holder of dynamometer was fixed on the tool post of the lathe machine and this tool holder of dynamometer was connected with dynamometer display box with the help of a cable. Workpiece holder was fixed in tool holder of dynamometer with the help of screw which tool holder is having in it as shown in figure

Workpiece holder fixed at lathe tool holder with the help of screw in tool holder. Tool holder was fixed at tool post of lathe machine and whole set up can move to and fro. With the help of a cable tool holder was connected with the display device and display device connected with switch of electric current. When lathe machine start, tool post having workpiece holder start to move towards the chuck of lathe machine in which drill bit was mounted, and when workpiece was touching the drill bit drilling was started and display device was showing forces (thrust force, feed force and cutting force as shown in Figure 3.5).

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