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Lean Implementation in Production Unit (Round Tool Manufacture)

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ABSTRACT : *Implementation of lean tools and techniques in production unit-4 where round tools are being manufactured. This implementation makes use of value stream mapping to identify the non value added activities in the current state of gun drills, a deep hole drilling tool. The process sequence is being identified along with cycle time, setup time and various timings associated with process. This is again segregated in to value added time and non value added time. Then the value addition percentage is being calculated in the current state. By adopting techniques like setup reduction the future state is been derived excluding the possible non value added activities. But the ultimate motto of the lean journey is to make single piece flow .The vision state is also being mapped and this may happen as a part of continuous improvement. As a part of implementation program two alternate fixtures are designed to accommodate all the varying diameters lug in to two categories i.e. 4to15 &15 to 28mm.*

Keywords - lean tools, value stream mapping, fixtures.

I. INTRODUCTION

1.1 Introduction to pu-4

Basically KENNAMETAL –WIDIA (INDIA) LTD is a manufacturer of all varieties of cutting tools/inserts. It has nine-production units.PU-4 is one of them. PU-4 is one such area in WIDIA where we can get challenging jobs. It mainly deals with the production of different types of Drills & Special Tools. This PU-4 has 3 three sub sections namely,

- Brazed multi point tools
- Solid carbide multi point tools (SC tools)
- Gun drills

Here there is a chance that, the same tool has different designs.

1.2 Broad classification of all the tools:

- Ti ALN and TiCN coated end mills
- Straight and step drills
- Sold carbide slitting cutter
- Ball nose end mills
- Slot and step drills
- Gun drills, reamer, TiAlN, TiCN coated gun drills
- Brazed form tools
- Spherical cutter
- Fine pitch brazed cutter
- Chucking reamers
- Hole mill

PU-4 is the only unit that has sales people integrated with planning since it involves in manufacture of special tools. PU-4 has a target of Rs.18 crores for this academic year.

1.3 composition of carbides

X1 stands for hardness and reflects wear resistance.

X2 gives the transverse rupture strength and denotes the degree of shock resistance

X3 denotes low or high content of TiC or TaC or for both reflecting crater resistance

(Specification given by KENNAMETAL)

1. Low thermal expansion (compared to steel).
2. High thermal conductivity.
3. Low specific heat.
4. Weaker in tension than in compression.

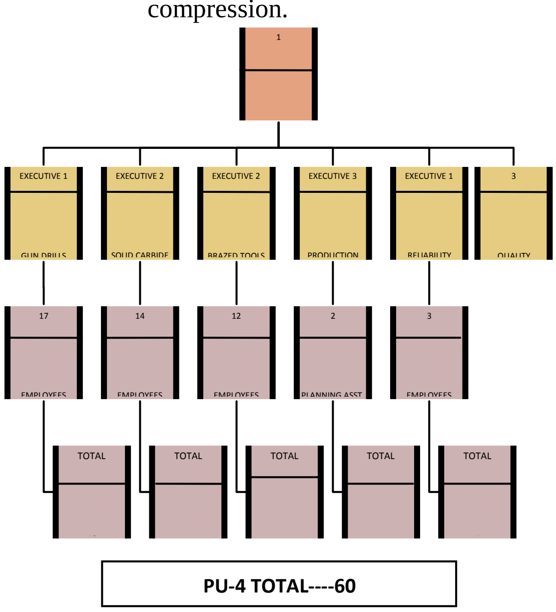

Fig 1.Organization Chart

Lean can give your company a competitive advantage. Lean Manufacturing principles can help you reduce your manufacturing lead time, improve the quality of your products and reduce your new product development time. All of these will be of direct benefit to both you and your customer. In evaluating the advantages of Lean Manufacturing you should compare your company to the best in class of other companies. Lean Manufacturing can save you money in a variety of ways. When moving from batch production towards one-piece flow, savings can be realized by increasing your inventory turns and reducing your Work in Process (WIP) inventory. With the money saved you can:

- Reinvest to grow your business
- Reduce your debt
- Add to the bottom line profit

Moving towards one-piece flow will also increase your quality level resulting in increased profit. One-piece flow will help you uncover any defects early in the process before a large number of parts are manufactured. A reduction in the amount of floor space required will also save you money. Lean Manufacturing can often lead to a floor space reduction from 35-50%. This additional area can be used to expand your business and maybe even eliminate the need for a plant expansion.

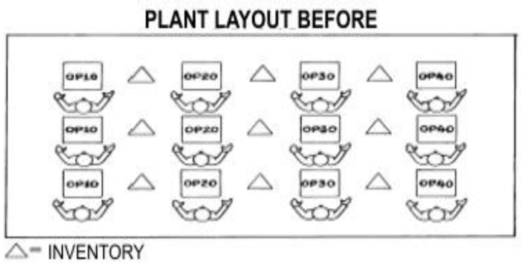

Fig.2 Plant Layouts before Lean

With Lean Manufacturing you only produce to meet your customer's requirements (how they want it, when they want it, in the quantity they want). When this becomes your mindset you will be able to meet those requirements with less capital equipment, reducing your investment. The first change occurs when you learn to "see" your organization in a new way. Once you see what are there, areas of waste become apparent and a plan for change soon follows. Every plan is different, but the common factors are eliminating the seven types of waste. To "see" your organization means to understand the processes and flows of your product from incoming raw material to shipped final goods. The best way to "see" is to do Value Stream Mapping. Value Stream Mapping (VSM) involves diagramming every process required to produce your product or service in a step-by-step block diagram form.

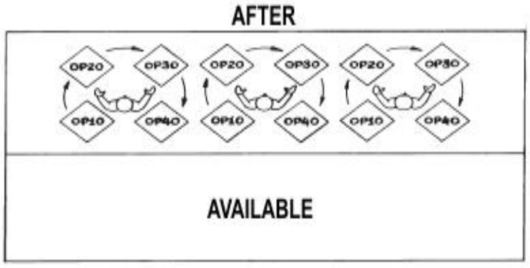

Fig.3 plant layout after lean

Lean has been defined in many ways they are as follows "A systematic approach to identifying and eliminating waste (non –value added activities) through continuous improvement by flowing the pull of customer in pursuit of perfection". "A manufacturing philosophy that shortens the time line between the customer order and the shipment (figure -4) by eliminating waste(non value added activities)". The following figure completely explains the role of lean and it's Importance.

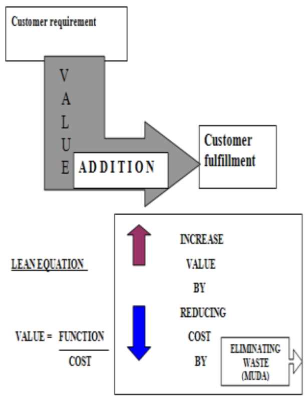

Fig.4 Role of lean

2. LEAN PRINCIPLES

2.1 Specify value:

The critical starting point of lean thinking is value. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of specific product which meets the customer's need at a specific price at a specific time.

Value is created by producer. From the customer's standpoint, this is why producers exist. Yet for host of reasons value is very hard for producers to accurately define. Business school-trained senior executive of American firm routinely greet us when we visit with a slick presentation about their organization, their technology, their core competencies, and strategic invention. Then, over lunch, they tell us about short-term competitive problems and the consequent cost-cutting initiative. These often involve clever way to eliminate job, divert revenues from their downstream customers and extract profit from the upstream suppliers by dessert, we may be hearing about their personal career issues in the correct age of "downsizing."

2.2 Identify the value stream:

The value stream is the set of all specific actions required to bring a specific product through the critical management task of any business:

- The problem-solving task running from the concept through detailed design and engineering to production lunch
- the information management task running from the order-taking through detailed scheduling to delivery,
- The physical transformation task proceeding from raw materials to finished the product in the hands of customer. Identifying the entire value stream for each product is next step in lean thinking, a step which firms have rarely attempted but which almost always expose enormous, indeed staggering, amount of muda.

Specifically, value stream analysis will almost always show that three types of action are occurring along the value stream:

- many steps will be found to unambiguously create value
- many other steps will be found to create no value but to be unavoidable with the current technologies and the product asset
- many additional steps will be found to create no value and to be immediately avoidable

2.3 Seven Value Stream Mapping Tools

- Process activity mapping. Origin: Industrial Engineering.
- Supply chain response matrix. Origin: Time compression/logistics.
- Production variety funnel. Origin: Operations Management.
- Quality filter mapping.
- Demand amplification mapping. Origin: Systems Dynamics.
- Decision point analysis. Origin: Efficient Consumer Response/logistics.

Physical structure mapping.

3. Typical Value Stream Mapping

Value stream mapping enables you to identify the wastage in your processes. If an activity is not adding value to your products it is waste and should be removed. When the value stream is analyzed most companies are shocked as to the amount of time that none Value adding activities are taking place. Building batches and keeping it as Work In Progress (WIP) is simply adding waste to the process and extending the total processing time.

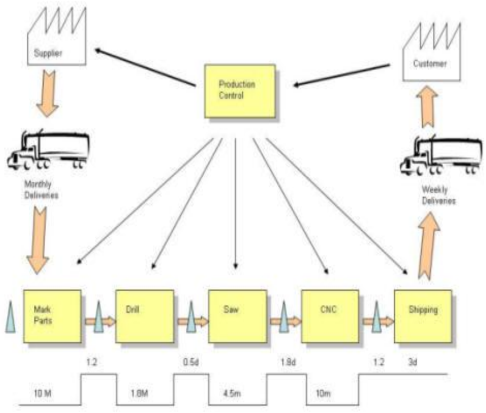

Fig.5 vsm – example.

Value Stream Mapping is a visual method of mapping the flow of materials and information from the time products come in from goods inwards, through all the manufacturing processes and finally ready for dispatch. Value stream mapping is a key tool in Lean Manufacturing Principles. This tool can be extended out of the confines of the organization to look at the effect your suppliers have on the complete supply chain.

Mapping of the manufacturing/production processes including:

- Cycle Times
- Downtimes
- In process Inventory
- Material flow
- In process storage

Will allow you to produce a visual guide to your current manufacturing situation and where waste has been introduced. OEE solutions can provide valuable information for cycle times and Downtime information.

An initial map should be produced showing the "Current State" and then through analysis and design a "Future State" map should be generated.

3.1 Benefits of Mapping

- Identifies the complete production process not just a single process.
- Allows you to identify the sources of waste.
- The Current state map and future state map helps form an implementation plan for change and improvement.
- The maps can be used to target Kaizen activities.
- Gain a better understanding of the linkages between material and information flow.
- Create the basis for an effective lean implementation plan by designing how a facility's door-to-door material and information flow could operate.
- Provides a common language and interface for managers, supervisors, engineers and operators to use to analyze waste and plan improvements.

3.2 DEEP HOLE DRILLING

A deep hole-drilling machine can drill holes with depth-diameter-ratio above 100due to its special design and construction. In a deep hole drilling operation, good hole tolerances with respect to bore diameter, roundness and straightness can be obtained. The hole surface qualities equal those from reaming, honing and grinding, sometimes even surpassing them.

With such excellent machining performance, deep hole drillings are often applied in high precision manufacturing such as the military industry, machine tool and automobile industries. Applications examples are hydraulic cylinders, landing gears for aircrafts, large holes in diesel truck applications, turbines, heat exchangers, and oil industry components etc.,

There are three kinds of deep hole drilling, namely, gun drilling, BTA – Boring and trepanning Association and ejector drilling. The gun drilling is used for small size of holes and BTA or ejector drilling is used for large size of holes. In a deep hole drilling process the pressurized coolant is used.

Gun Drilling

Gun drilling is known for making first-pass high finish straight holes of varying depth and diameter. This drilling method can reduce scrap, eliminate secondary machining, and cut tooling inventory. The straightness of the hole produced depends on many factors. However a normal shift of 0.1 per 100 mm in the axis of the hole is inevitable and proper designing the system can control it. Surface finish at 6 - 20µm is achievable. The process helps to produce a hole of reamed quality.

In Gun Drilling, the coolant is fed through the gun drill and the chips are flushed out from the ***crescent shaped groove*** provided on the gun drill. Since the flushing of chips is quite effective with high-pressure coolant, holes *up to L/D ratio of 100* can be drilled very effectively.

The reliability of the gun drilling process in the automotive industry is greatly affected by tool stability. This stability is defined as a complex issue consisting of the sub-items, Entrance, *Static and Dynamic stabilities.* Entrance stability plays the chief role when the rotational speed and feed rate are high, which is the common case in the automotive industry where engine heads made of aluminium alloys are drilled. Entrance instability is the prime cause for the so- called 'unpredicted' drills' failure, which often appears as a fatigue crack(s) on the drill shank and cannot be explained when only stable drilling is considered.

Gun drill used to drill a wide variety of materials used in the automotive, mould and die, aerospace, firearms, medical, power and other industries. They work best when the combined cutting speed (rpm), feed, tool geometry, carbide grade and coolant parameters properly match the work-material hardness, composition and structure, the deep-hole machine conditions and required hole quality. Process efficiency is measured by the cost per unit length of drilled holes. Every system component - the gundrill, machine and controls, fixture and accessories, work piece, operator and maintenance -- affects efficiency.

A gundrill consists of

1. Solid or brazed carbide tip
2. Rolled crescent shaped steel tube with 'V' flute
3. Shank – driver

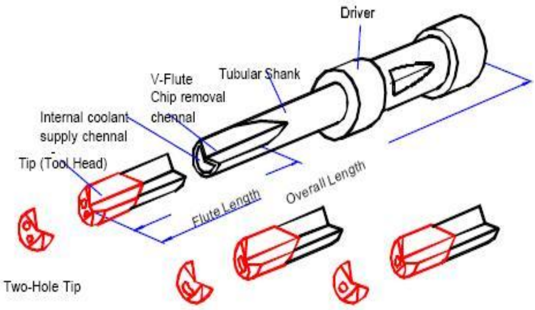

Fig.6 Gundrill

Solid or Brazed carbide Lug:

The drilling tip is made out of solid tungsten carbide. It is brazed with steel tube as shown in fig. The cutting edge of a gun drill is so designed that it cuts only on one side of the hole and this cutting edge extends across the centre resulting in clean cutting action in front of the drill. The cutting edge is divided in to two parts – *outer and inner* as shown in fig.

By grinding the outer cutting angle and inner cutting edge angle which meet at a point normally at a distance of one quarter of the diameter from the outer periphery of the drill.

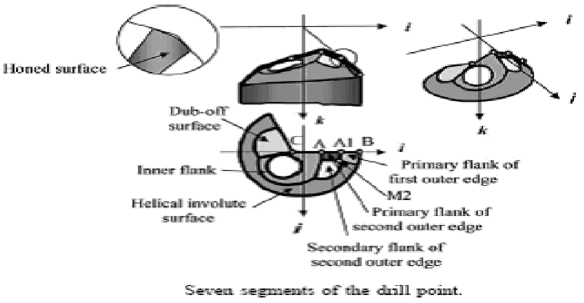

Fig.7seven segments of the drill point

Inner cutting edge angle is called as Primary angle and outer cutting edge angle is called as Dub off angle. Geometry, which represents these two angles, is called as *Face Geometry* and the geometry, which represents carbide lug grinding angles, is called as *PAD Geometry*.

Face geometry will differ in accordance with material to be drilled, type of operation, speed, feed etc., so various face geometries are used for various type of materials.

The Available carbide lug face geometry for various types of material / operations is as follows:

1. Standard Grinding for Well machinable Steel and NE Metals

   For drilling well machinable steel, the face geometry used is shown in *fig.* Its cutting edge length is normally one fourth of finish diameter. Outer cutting angle is around 30° and inner cutting edge angel – dub off angle is normally 20°

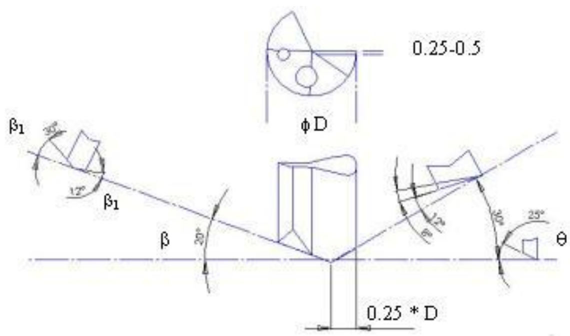

Fig.8 face geometry

2. Special Deep boring

For deep bore drilling with lowest center special geometry is selected as shown in fig. Normally cutting edge length is one third of finish diameter.

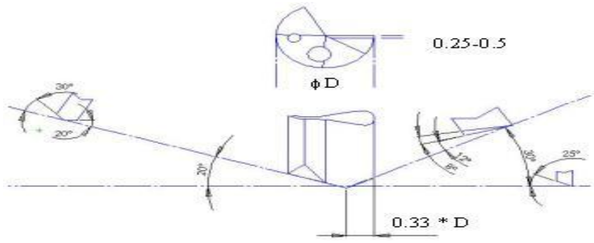

Fig.9 face geometry

3. Well Machinable steels

For well machinable steels, compared to grind 1 & 2 closer boring tolerances are generally obtainable. Primary angle and Dub off angle are lower when compared to others seen before, because of strength of boring material is more. Cutting edge length is normally one fourth of finish diameter as shown in figure.

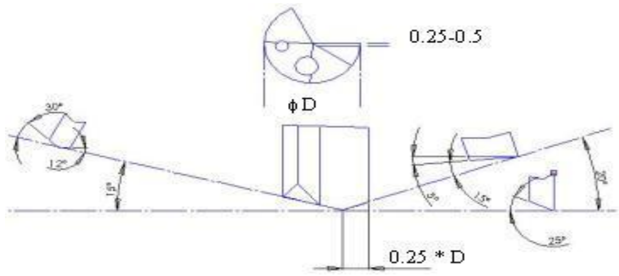

Fig.10 face geometry

4. Heat treated steels

For heat-treated steels, Primary angle is lesser when compared to well machinable steels because heat-treated materials strength is more. Cutting edge length is normally one fourth of finish diameter as shown in figure.

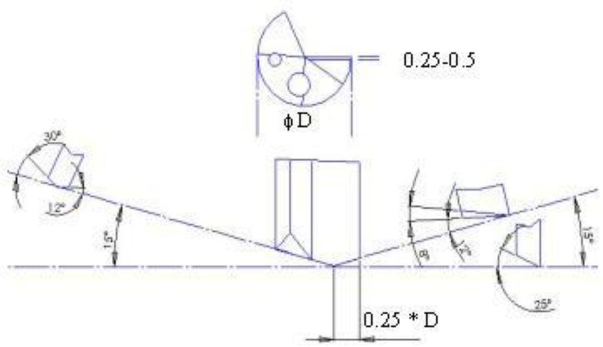

Fig.11 face geometry

5. For exceptionally long – chipping steel

Gundrills of maximum length around 1500 mm are manufactured with Primary angle of 15° and Dub off angle of 12°. This geometry results in good performance as same as other lengths irrespective of more length. Normally cutting edge length will be one fourth of finish diameter.

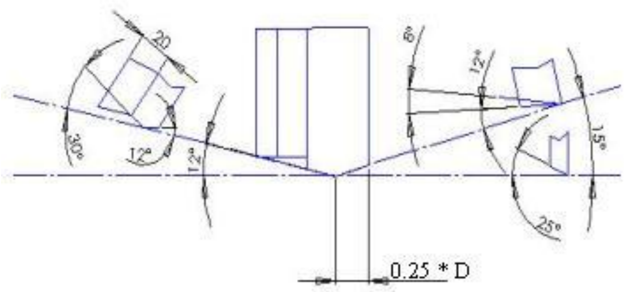

Fig.12 face geometry

6. Stainless steels

For stainless steels, face geometry is as shown figure. Because of stainless steels material property, tool will penetrate easily; so primary angle and dub off angle is more then any other geometries, which results in more clearance for chip flow.

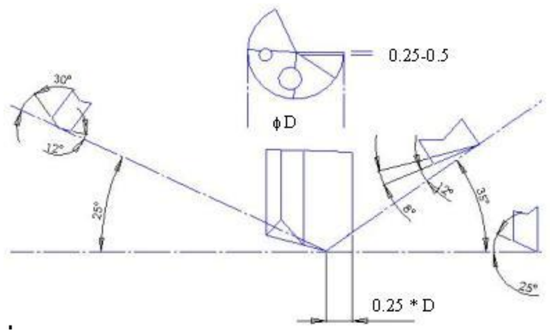

Fig.13 face geometry

The peripheral speed is maximum at the outer edge and minimum at the inner edge. Outer and inner cutting edge angles are kept different which results in different chip thickness produced by the two cutting edges. The difference in speed and chip thickness was produced by the two cutting edges. The difference in speed, chip thickness and the different directions of chip flow build up a tension and split the chips into comparatively shorter coils, which facilitates the flushing out of chips through the drill flute.

As the drill point angle depends on the work material, the type of job and various other factors, it is extremely difficult to standardize it. However, a compromise can be made on a few sets of point angles to cover most of the requirements.

Cutting edge shape:

As face geometry plays a major role in boring, shape of the cutting edge also plays a vital role in material removal. Since cutting edge is the only portion that has contact with the work material and maximum heat produced is more, selection of cutting edge shape is more important in gun drill selection.

Cutting angles must efficiently remove two simultaneous generated chips produced by the drill tip from a limited space. For single-flute tools, the chip formed by the inner angle should strike the chip sheared by the outer angle to break well. This is not the problem in brittle materials. In ductile materials, however, compression produced by the two chips can result in a heavy backbone that prevents the outer-angle chip from curling over enough. In design, to produce shorter chip, must change angles and possibly the tool point. The goal is to balance the angles to distribute cutting forces over the tool’s bearing areas. Otherwise, excess pressure on the outer cutting edge angle can rub away bearing surfaces. Unbalanced force on the inner angle can produce an oversized hole, poor finish and high margin wear. Various cutting point shapes are as follows.

1. Berel Type

This is the common shape used in various gundrill applications. Ratio between Primary angle and dub off angle is 30°: 20° or 42°: 20°. Normally cutting edge length is one fourth of finish diameter that gives more clearance for chip flow and coolant flow.

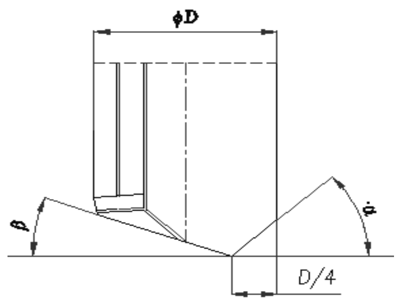

Fig. 14 cutting edge.

2. Notch Type

Notch type cutting edge is the special type of cutting edge used to machine materials like Carbon, Aluminium etc., Notch shaped flat clearance is given in non-cutting edge to easy penetration of tool and easy flow of coolant.

For Carbon materials, ratio between primary and dub off angles will be 20°: 30° or 42°: 20° and for pure Aluminium materials ratio will be 5°:5°

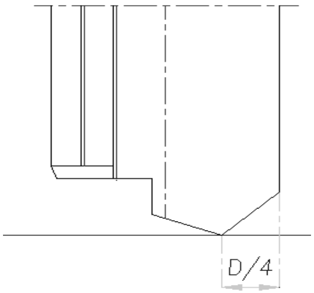

Fig.15 cutting edge

3. Stack Point Type

In Stack point type, cutting edge length will be on one eighth of finish diameter. This type of cutting edge is used to bore multiplayer materials, stainless steel work materials and difficult to machine materials. Since it has very less outer cutting edge angle of around 5° and more clearance of about 45° allows tool to remove harden materials.

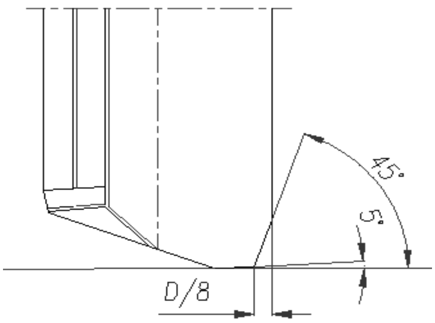

Fig.16 cutting edge.

4. Flat Bottom

Flat type cutting edge is also used to achieve flat bottom hole for special purposes. It has no outer cutting edge, and has inner cutting edge angle as 5° and clearance is of 15° as shown in figure.

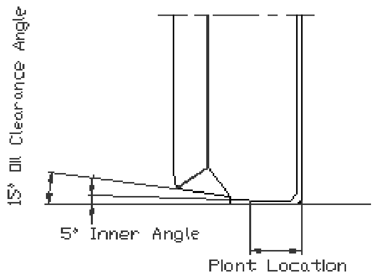

Fig.17 cutting edge

5. Spherical Radius:

More accuracy is obtained by using right nose cutting edge geometry on a gun drill. Cutting angles influence chip shape, size, hole finish and tool life. The radius is normally half of finish diameter. This allows tool to penetrate in the work material and maintains the tool guide. Step notch is also given for easy flow of chip and coolant as shown in figure.

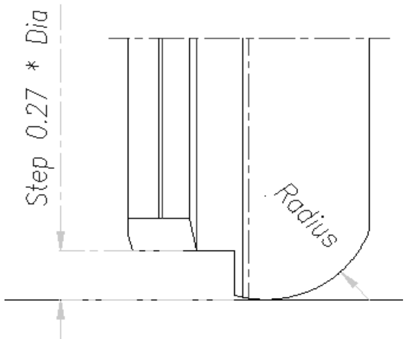

Fig.18 cutting edge

Carbide lug Pad geometry:

Rubbing Pads are made by Tool & Cutter machine for giving body clearance in finished carbide dia. It prevents rubbing of full carbide lug with hole surface, which further leads to welding action due to heat. Pads also gives support to the cutting edges by passing resultant forces due to cutting action to the hole surface.

It also improves hole surface finish and allows tool to rotate freely inside the hole during drilling (i.e.) perfect bearing action is maintained with hole surface by pads.

There are various types of PAD geometry available. Pad geometry is selected in accordance with face geometry and material tube drilled. Four basic types of Pad geometries are commonly used, and also special Pad geometry is used for special purposes.

The commonly used basic types of Pads are

1. A type pad
2. B type pad
3. C type pad
4. G type pad

1. *A type pad:* This type is of two-pad geometry as shown in figure.

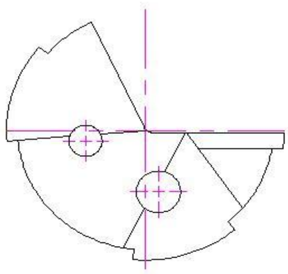

Fig.19 A type PAD.

2. *B type pad:* This is also two-pad geometry with equal angles in both sides as shown in figure.

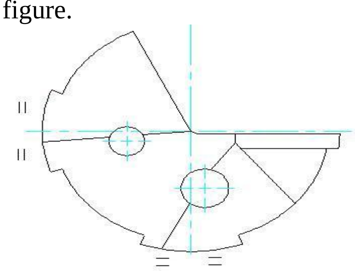

Fig.20 B type PAD.

3. *C type pad:* This type is of two-pad geometry as a pad but differs in orientation of pads as shown in figure.

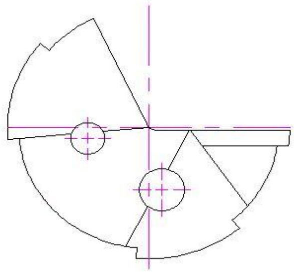

Fig.21 C type PAD.

4. *G type pad:* This type has only one pad of 180° orientation that is commonly used for smaller diameter gundrills as shown in figure.

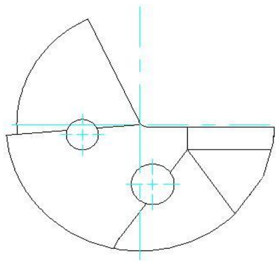

Fig.22 G type PAD.

Special type pad: The special type of Pads used for various special face geometries where more balance is required during cutting. One of the special type pads is shown in figure.

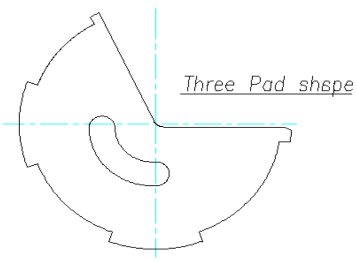

Fig.23 Special PAD - Three PAD Shape.

Steel Tube:

The tube is the connecting piece between the shank and the cutting end, which is made up of steel. The outside diameter of the tube must be smaller than the nominal diameter of the head. It must not be too small, however, because if it is the danger could arise that chips could become jammed between the wall of the hole and the tube.

The coolant is delivered to the cutting edges through the tube. The tube is fluted on the outside so that chips and spend coolant can be easily flushed out. This is the weakest part of the tool and should not be fluted over any length greater than absolutely necessary. Considering required surface finish and flow of chips, two basic types of tubes are used in gundrill assembly.

1. Single fluted tube
2. Double fluted tube

1. Single fluted steel tube:

Single fluted tube is commonly used in gundrills with single fluted lug of one, two or kidney shaped coolant holes. They allow chips to flush out from the cutting portion with coolants. They normally used in applications more depth is needed. They usually used in SPMs (Deep hole drilling machines)

The crescent shape in the tube is achieved by rolling process carried out in rolling machine; usually rolled angle will be between 118° to 120°. The length of the tube depends on L/D ratio.

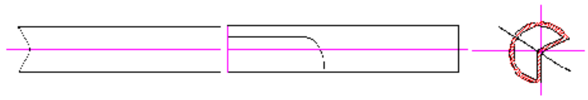

Fig.24 Single fluted steel tube.

2. Double fluted tube:

Double flute tube is brazed with special lug with double fluted geometry. This tube is selected for special applications where chipping is more and more space for chip flow is required. Since it is crimped both sides, this type of tube is more balanced than single fluted one.

Double fluted gun drill is commonly used in machining centers for shorter length. It is not recommended for longer length because of no support.

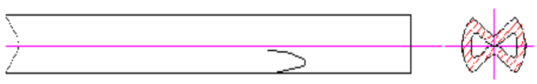

Fig25 Double crimp steel tube.

Shank:

The design of the shank depends on the tool holder of the machine, and the holders are varying greatly. This is particularly true for machines that are home made. For this reason it is possible to maintain a stock of only few types of shanks. The other types of shanks must be produced new and individually for every separate application. This results in longer production time and leads to higher prices. According to the machine type and working condition the shank type was decided.

The three categories of shank used are

1. Straight Shank
2. Taper Shank
3. Special Shank

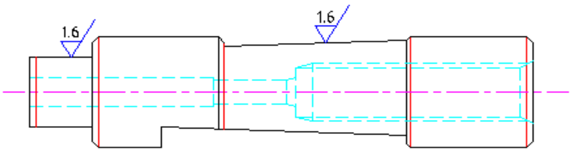

Fig.26-Taper shank.

Length of the shank-to-diameter ratio classifies Gun drills. A ratio less than 10 is short, between 11-50 is normal, and between 51-100 is long; those exceeding 100 require extra-long gun drills. If the shank length of an 8-mm drill rotating 3,000 rpm is 400 mm, a whip guide is necessary because the maximum distance between supports is 350 mm.

Short gun drills.

The key here is drill-holder-starting bushing alignment, because a short gun drill shank is rigid and causes significant additional force proportional to the misalignment. This force may exceed the cutting force and cause multiple drilling problems such as chipping of the cutting edge, poor surface finish, and inadequate diametric accuracy and reduced tool life. Misalignment shouldn't exceed 2 microns. When this accuracy cannot be achieved, the gun drill length must be increased for the gun drill to self-pilot and avoid problems.

Normal-length gun drills.

Must adjust the drill holder-starting bushing alignment no more than 4 microns here. This is crucial when the drill rotates because the additional misalignment force causes alternating bending stress in the shank, which fails due to accumulated fatigue. This unpredictable failure occurs without any obvious warning.

Long and extremely long gun drills

Long and extremely long gun drills suffer low torsion strength. For a given drilling torque, the shank twist angle is proportional to its length. The maximum twist angle is found at the shank-driver connection. The shank fails when this angle exceeds its critical value, making the gun drill resemble a twist drill with a helical V-flute. A gun drill shank must be constructed from high-yield-strength material, with heat treatment transforming it to a tempered structure. Binate is the best metallurgical structure.

High-strength materials create problems when crimping the V-flute; so tubular 4130 steel products are commonly used. When the shank is brazed to the driver, excessive brazing heat can anneal the tube in the area adjacent to the driver, where its strength is most needed. A high-yield-strength material shank properly heat-treated and properly connected to the driver with low-temperature brazing filler, can increase the gundrill's penetration rate to twice that of common gun drills.

The drill holder-starting bushing alignment is insignificant when using extremely long gun drills. Clearance between the gun drill tip and the starting bushing is important and should ideally be next to zero. Achieving zero clearance in the starting bushing, isn't practical due to free penetration, tip back-taper and starting-bushing wear. When the rotational speed and feed rate are high, as in drilling aluminium automotive engine heads, excessive clearance in the starting bushing is the main reason for entrance instability. Entrance instability is the main cause of unpredicted drill failure.

4. VSM ANALYSIS

Future state

INFERENCE& SUGGESTION

Table1 – future state

OPERATION	CHANGES	STATUS
lug angle matching	Setup reduced from 30minutes to 10 minutes	Implemented
OD roughing and finishing	Eliminating of fixtures, by using pneumatic clamping	Still to be implemented
Rake roughing and finishing	Setup reduced standardization of fixtures	Yet to be implemented

Coating and dispatch	Search for vendor Around Bangalore	Yet to be implemented
Wheel dressing in all grinding operation	To be given to maintenance department which is to be performed in the break timings	Yet to be implemented

Vision state: -
INFERENCE& SUGGESTION

Table2- vision state

Operation	Changes	duration
Initial straightening	automation for whole process	12 months planned
Final bend removal	automation for whole process	12 months planned
Face geometry	Making use of automation angle adjustment assembly which is already made	6 months planned
Coating and dispatch	To be coated in Kennametal only	18 months planned

5. IMPLEMENTATION PHASE

The objective of the implementation phase is to assure that the approved proposals are rapidly translated into action to achieve saving and project improvements that were proposed.

The following are the steps in implementation:

- The department approved the designs.
- The design was forward to vendor.
- The developed fixture was brought to shop floor and handed over to concerned operation
- The performance is being checked after the implementation

Result:-

The setup time has been reduced from 30 min to 10min.

6. CONCLUSION

The project concludes with the implementation of the fixture and reduction in the Setup time. Hence the objective is fulfilled. The percentage of value addition is being increased to certain extent in the future state from the current state.This project gives us the complete knowledge of most of the cutting tools and all the manufacturing activities that takes place.

REFERENCES

[1]. Lean thinking “banish waste and create wealth in your cooperation”- james.p.womack and daniel .t.jones
[2]. “theory of metal cutting” by a. Bhattacharya
[3]. “tool design”-. Cyril donaldson, george h lecain vc goold