International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

HARD TURNING OF AISI D2 STEEL IN CNC SETUP: ORIGINAL STUDY

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Abstract— D2 steel is an industrial tool steel. It is widely used in tool and die industry for making cutting tool inserts, bending insert, restriking inserts etc. which can be taken out after their tool life. D2 steel is very tough steel and difficult to machine also. High generations tool bits like Tungsten carbides and Titanium carbides are required to machine them. Heat treatment follows the machining process.Their mach inability is very low. CNC machines are often used to finish them. Often they are machined using programs on UG-NX Uni Graphics(CAM) and DELCAM. And they have to be machined in three steps. Roughing operations, followed by Semi-Finish machining and last step is finish machining. CNC machining centre are versatile in their applications in metal removal processes. Often they are so modernized that just like many manufacturing operations, metal removal can be automated too.
Need for CNC machining arises due to extensive finishing requirements in aerospace, automotive industries. However the CNC or Computer and Numerically controlled machining process usage is not limited to these industries only. Tool and Die industry also is heavily dependent on CNC material removal and machining processes as now replaceable inserts are widely used in this industry.
Keywords— Turning, D2, CNC, Surface finish, ATC, Turning centre specifications, Machining parameters, cutting tool , inserts.

I. INTRODUCTION

Turning is one of versatile material removal process since ages. In current scenario manufacturing industries bank heavily on CNC turning to produce myriad of products ranging from complex automotive parts to ultra precise syringe base, From high capacity boiler design to very stylish car to name a few. Aim of CNC based metal removal processes is to have faster production with a substantial reduction in cost. Mass production calls for faster delivery to customer. Consider the number of models a car company is launching in one year. About 2-3 depending on the company's brand value. CNC processes are used in combination with Finite Element Modeling and simulation methods to have better control over the process parameters and choice of optimum and high quality tooling[1-2].

Turning of hard materials whose hardness is above 45 HRC as AISI D2 steel is termed as Precision Hard Turning [3].Hard turning when compared with conventional process of grinding is superior in terms of higher metal removal rates, MRR, and time taken [4-5]. Since CNC processes are very costly, usually per hour cost is INR 5000-15000, so care has to be taken to reduce setting and removal time of jobs.

Hard turning is usually done dry with CBN or ceramic inserts. Also the choice of machine tool will determine the magnitude of cutting forces and the surface finish [6]. Al_2O_3 coating along with inserted ceramic coating have emerged useful while hard turning of D2 steel. Although Al_2O_3 has low room hardness as compared to TiC/TiN but at 1000˚C it is hardest and inert tool[7].

However CBN tools are considered good in hard turning applications where a higher accuracy and good surface finish is required [8].

II. CNC SETUP

A CNC machining centre consists of a computer for processing Machining programs, an ATC, automatic tool controller which can simultaneously holds many tools on machine and tool can be changed in accordance with the requirement.

The machine is equipped with magnetic chucks, touch trigger probes etc to ensure accuracy of setting of work piece[9]. Before start of turning CNC machine parameters have to be set up as per the requirements given in the machine catalogue. Work holding devices as jigs and fixtures should be accurate and precise, as mass production is usually done.

Now fixtures are being designed using CAFD, computer aided fixture design[10]. This saves a lot of time and idle cost of fixture adjusting can be reduced.

III. MACHINING PARAMETERS

The important cutting parameters are Cutting speed, feed, depth of cut, type of tool and its geometry and cutting conditions.

Out of these the first three determines power consumption, force and torque, surface roughness whereas the other two smoothens out the desired value. For example if we do turning of EN-31with TiC tool under air cooling, the temperature reached during machining process will be less. As a result the surface finish obtained will be better as compared to without cooling conditions.

On a CNC machine we tend to have cooled air as lubrication, as this will also aid MQL (Minimum Quality Lubrication).

IV. **TOOL GEOMETRY**

Increasing the cutting speed and feed decreases the processing time for a CNC turning machine. However the tooling cost will increase, as highly advanced coated tools will then be required for machining purpose. This can be considered a geometric simulation problem minimizing the processing time and optimizing the tooling cost [11].

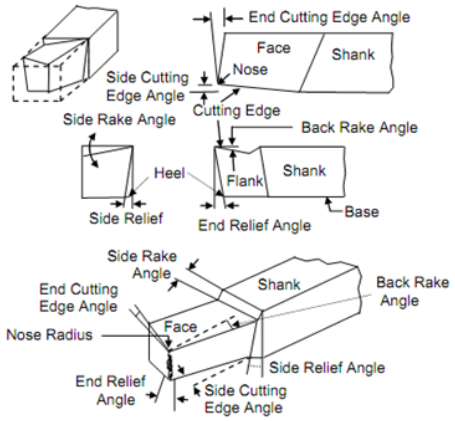

Figure 1: Geometry of single point cutting tool

Source:www.expertsmind.com

Whereas in hard turning we use cutting inserts which can be secured to main body with bolts and dowels.

Figure 2 :Tool insert

Source:http://www.directindustry.com/prod/sandvik-coromant-usa/product-35541-837663.html

Since the high speed tooling wear out very fast these are replaceable inserts which can be taken out once they worn out.

V. CUTTING PARAMETERS

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VI. AUTOMATIC TOOL CHANGER

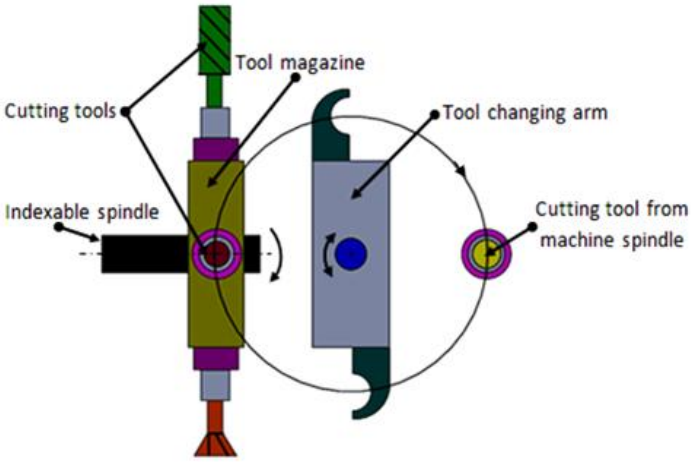

Figure 3: ATC

source:http://nptel.ac.in/courses/112103174/module4/lec6/3.html

Here tool changing arm picks the tool from spindle and places back in magazine. Where as new tool is picked from magazine and placed in tool spindle. Since automatic tool changing is precise and fast, this reduces dependency on the operator.

VII. TURNING CENTRE SPECIFICATIONS

A. *Type of Tooling*

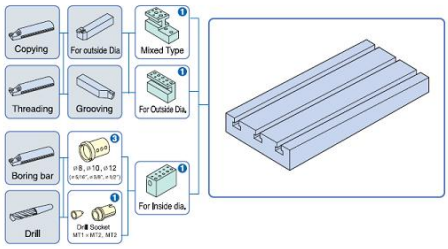

Figure 4: Tool types

Source: compumachine.com/Regional/hyundai-kia/BlackBrochures/KIT250.pdf

B. *Machine* Specifications

HYUNDAI-KIA CNC Turning Center KIT250

ITEM			SPECIFICATIONS
CAPACITY	MAX. SWING	mm (in)	ø 320 ø 12.6"
	MAX. TURNING DIA.	mm (in)	ø 130 ø 5.1"
	MAX. TURNING LENGTH	mm (in)	150 5.9"
	BAR CAPACITY	mm (in)	ø 32 ø 1.26"
	CHUCK SIZE	inch	5" HOLLOW [6"]
SPINDLE	MAX. SPEED	rpm	7,000
	SP. THRU HOLE	mm (in)	ø 42 ø 1.65"
	TRAVEL (X/Z)	mm (in)	250/200 (9.8"/ 7.9")
FEED	RAPID TRAVERSE (X/Z)	m/min (ipm)	24/30 (945/1,181)
	NUMBER OF TOOLS	st	5
	O.D HOLDER SIZE	mm (in)	□ 20 (□ 3/4")
	I.D HOLDER HOLE DIA.	mm (in)	ø 25 (ø 1")
	SP. MOTOR (MAX/CONT)	kW (HP)	5.5/3.7 7.3/5
OTHERS	FEED MOTOR (X/Z)	kW (HP)	0.75 (1)
	FLOOR PLAN (L × W)	mm (in)	1,680 x 1,695 (66.1" x 66.8")
	MACHINE HEIGHT	mm (in)	1,570 (61.8")
	MACHINE WEIGHT	kg (lb)	1,900 (4,189)
	BED TYPE	-	FLAT
	ELECTRIC POWER SUPPLY (220V/60Hz)	kVA	15
	MEMORY CAPACITY	M	320
	CNC TYPE	-	FANUC 0-TC

❖ Machine specifications and other features are subject to change without notice. [ ] Option

Standard

- 6"-HYDRAULIC HOLLOW CHUCK
- SOFT JAW 1SET
- TOOL HOLDER (I.D) 1EA
- TOOL HOLDER (O.D) 1EA
- TOOL HOLDER (MIXED) 1EA
- BORING BAR SLEEVE 1SET
- DRILL SOCKET MT#1 1EA
- FLOOD COOLANT
- COOLANT TANK
- DOOR INTERLOCK
- WORK LIGHT
- STD. TOOL KIT & BOX
- LEVELING PADS & BOLTS
- FOOT SWITCH 1EA
- SPINDLE RPM, LOAD OVERRIDE
- SPINDLE ORIENTATION

Option

- 6"-HYDRAULIC SOLID CHUCK
- PARTS CATCHER
- WORK COUNTER
- TOTAL COUNTER
- CHUCK OPEN/CLOSE CONFIRMATION DEVICE
- CHUCK AIR BLOW (UPPER CHUCK)
- BARFEEDER INTERFACE
- CHIP CONVEYOR (REAR)
- CHIP WAGON
- CALL LIGHT (3 COLORS)
- AUTO DOOR
- TRANSFORMER
- SPECIAL COLOR
- COOLANT SUPPLYING (UPPER CHUCK)
- GUN COOLANT

Figure 5: Turning centre specification

Source: compumachine.com/Regional/hyundai-kia

VIII. TYPES OF JOBS ON CNC TURNING CENTRE

There can be different variety of jobs which can be loaded on a CNC turning centre. Some peculiar jobs will be discussed here:

A. *Eccentric jobs*

Figure 6: Eccentric job

Source: http://www.pioneerserviceinc.com/capabilities/cnc-turning-and-milling/

Jobs having eccentric diameters at various places can easily be turned by specifying the required geometry of shape, and a program can be generated for turning using incorporated software for machining.

B. *SMALL OUTER DIAMETER UPTO 8''*

Figure 7: Different jobs

Source: http://www.pioneerserviceinc.com/capabilities/cnc-turning-and-milling/

Parts having small outer diameters (up to 8'') can easily be turned using Automated Turning centre.

C. *AUTOMOTIVE PARTS- LIKE BEARINGS, ROLLERS ETC WITH VERY HIGH PRECISION.*

D. *TOOL INSERTS FOR DIES AND MOULDS.*

E. *HIGH PRECISION SYRINGES AND OTHER MEDICAL EQUIPMENTS.*

IX. CONCLUSION AND FUTURE SCOPE

CNC turning centre is a versatile machining centre where automation is possible along with mass production. It enhances rate of production as well as quality of production. Also with invent of modern and high generation tooling various intricate shapes are possible to manufacture. The advancement in design of various articles led to the stretching of process and machine capability. In this era of advanced manufacturing machines a lot of research is required for green machining also. As high efficiency machines are consuming lot of power and generating scrap at very high rates. Concept of MQL is catching up. In industries cooled air is extensively used on CNC machining centre. Various automatic features like ATC, automatic tool changer allows for faster tool change and with great accuracy. Also programming can be done using machining software which permits the user to select machining parameters also.However the setting up cost of turning centre is very high but that can be offset after mass production starts.

But maintenance of these centre are must, as with time their accuracy starts fading away. Very closer tolerances can be achieved on the centre. CNC Turning centre are bridging CAD/CAM gap also. Since designers are using to generate designs as well as machining programs, the CAD/CAM is more of labor reducing and digital approach to manufacturing.

Earlier calculation of tool path involved several hours, but due to availability of advanced machining softwares one needs to specify the cutting geometry and the parameters of cutting process. Prototype manufacturing is also aided by the machining centre. 3D design can be simulated through software and possible bottlenecks in assembly can be zeroed down. Further simulation of machining process can give the data about quality of surface achieved, no. of hours taken for machining and total expenditure incurred on the process.

So these centre are versatile in nature which aided in product development process, prototype development process, CAD process, FEA of designed process, developing fixtures etc. for the work piece and at last generating the machining programs. The future of these machines seemed to be progressing without stop, as robots are replacing skilled labor on these highly advanced centre. Days are near when the so called mechanized process of metal removal will be robotized.

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