Effect of Cutting Parameter on Hard Turning by using Different Lubricating Conditions: A Review

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Abstract *The major problem in mass production is concerned with achieving the good dimensional products with high quality, high productivity, less wear and cutting fluid on the cutting insert, and less time consumed. Now a day in manufacturing hard turning plays an important role, its techniques are very essential for replacing grinding/ finishing operations with the help of single point cutting tools. Hardness above 45 HRC can be machined in hard turning operation very easily or effetely. In this article; review of different techniques and effect of cutting parameters were studied along with different lubricating conditions; which plays a significant role in hard turning. The objective of this study is to know about optimum machining parameters and best conditions with dry or solid lubricants for hard turning operation and it is also important to find the research gap through different studies.*

Solid lubricants were used in hard turning for better results. It has been found that with solid lubricants surface roughness value decreased as compare to dry hard turning. The proper selection of lubricants in the solid state along with cutting conditions and tool angles is essential for achieving the overall improvement in hard turning process. With the use of lubricants in the solid form hard turning may become a viable alternative to dry and wet hard turning process.

Keywords - *Hard turning, Cutting parameters, Cutting forces, Surface finish, Tool wear, Lubricants***.**

I. INTRODUCTION

Hard turning is a process in which hard material which have hardness above 45 HRC is machined with the help of single point geometrical tools [1]. To reduce the cost, improve quality and minimize setup times in order to remain competitive is a challenge to the manufacturer of those components and manufacturer of goods. Grinding is a process which is used in industries but it involves expensive machinery and lengthy setup times, high manufacturing time, costly equipment's. In hard turning material removal rate is high that is why it is a fast process as compare to grinding hard turning process. The other advantages of precision hard turning over grinding include less production costs, high flexibility and enriched work piece quality [2]. Hard turning is generally a replacement of grinding which is mostly used in automotive industries.

As compared to grinding process turning process for hard steel is preferred. A main factor takes towards the use of hard turning in place of grinding has been the development of various cubic boron nitride (CBN) cutting tool insert, PCBN, Ceramic insert, coated carbide, etc. which is capable of machining the high-strength materials with properly defined cutting edge. Ceramic tools are less hard then CBN tools in both low and high temperatures. High thermal conductivity and low thermal expansion coefficient are also important properties of CBN which are used in hardened steel turning.

High CBN (around 90%), and lower CBN content (around 60%) are two different grades of CBN tools with a ceramic phase added to the material, usually titanium nitride. High CBN content tools are generally recommended for the turning operation of hardened steels with interrupted surfaces because these tools exhibit higher toughness than tools with an added ceramic phase (low CBN content tool). Therefore, the high CBN content of these tools makes them harder than those with a lower amount of CBN. The CBN grade in which part of the CBN content is replaced by a ceramic phase loses in hardness and toughness, but gains in chemical stability. This is important for the finish operations of continuous surfaces, where a high temperature is reached, and diffusive wear must be avoided (Sandvik, 1994). Usually these tools have a chamfer on the cutting edge to strengthen it and protect it against chipping and breakage [22].

Cutting Fluids

In conventional machining, cutting fluid fails to control the chip-tool interface temperature and thus cannot remove heat with effectiveness due to which the quality of the surface damaged and also the tool life. To solution of this problem is some of the alternatives like dry machining and machining with lubricants (solid or wet). Dry machining is of high importance in today's era and meet with success in the field of environmental friendly manufacturing.

However, it is sometimes less effective when high machining efficiently, high surface finish and difficult cutting conditions are required then solid lubrication or wet lubrication may be the alternate.

Cutting fluids used in hard turning process are generally of two types such as solid lubricants, wet lubricants. Graphite and boric acid are termed as solid lubricants; vegetable oil and water soluble lubricants are some examples of wet lubricants.

With the use of these lubricants, acceptable levels of part quality has been found and it refines continuously during the use, while the pressure for manufacturing per piece cost is high and it has been influenced constantly down due to competition and market strategies.

Higher quality with low cost and smaller batch sizes is the trend being followed by the manufacturer competitors. It is necessary to find out innovative new technological solutions that can help and provide the platform to the business playing field to compete against producing countries.

Table -1

Comparison between HT and Grinding

S. No	Grinding	Hard Turning
1	It required more time for setup	Less time required for set up
2	More than one clamp is used	Only one clamp is used
3	Manufacturing times is long	Manufacturing times is short
4	Multi point cutting edge	Single point cutting edge
5	Multiple dressing is non-productive	More effective cutting time

II. DIFERENT WORK MATERIALS, WORKING CONDITIONS & TOOLS USED IN HARD TURNING: A REVIEW

S. NO	OBJECTIVE	AUTHERS	JOURNAL NAME VOLUME ISSUE & YEAR	MATERIAL & HARDNESS	WORKING CONDITION			TOOLS OR INSERTS
					v	f	d	
1	To study the various parameters of metal cutting and analysis its impacts on surface roughness with these parameters.	A Srithara, K.Palanikumarb B. Durgaprasad	Science Direct Procedia Engineering, 2014	AISI D2 Steel, 66 HRC	135	0.05	0.2	Coated Carbide Insert
					215	0.102	0.4	
					325	0.159	0.6	
2	Comparison of surface texture generated in hard turning and grinding operations.	W. Grzesik, Krzysztof Zak, Piotr Kiszka	Science Direct Procedia Engineering, 2014	41Cr4 (AISI 5140) , 57±1 HRC	150	0.1	0.2	CBN (TNGA 160408S01030) Chamfered insert & Al_2O_3 ceramic wheel
					150	0.075	0.2	
3	Effect of machining parameters on tool wear in hard turning of AISI D3 steel.	B. Varaprasad, R.C. Srinivasa, P.V. Vinay	Science Direct Procedia Engineering, 2014	AISI D3 Steel 62 HRC (68mm×360mm)	145	0.05	0.3	CC6050 Mixed ceramic
					155	0.075	0.6	
					165	0.1	0.9	
4	To study the effect of cutting parameters on cutting forces and surface micro-topography.	Tao Chen. Suyan li. Bangxin Han. Guangjun Liu	International Journal of Advance Manufacturing Technology (2014) 72:1639–1645.	GCr15 Bearing Steel.	100	0.05	0.1	PCBN tool, Eight Coated Sandvik CNGA 120404S01030A 7050
					150	0.05	0.1	
					200	0.05	0.1	
					300	0.05	0.1	
5	To study the tool wears in different tools using arc hard wear model.	H-J Hu. W-J Huang	International Journal of Advance Manufacturing Technology (2013) 69:31–39.	AISI H13 58-62 HRC	200	0.1	0.1	Tool- Ultra fine - grained ceramic & Common ceramic
6	To study the process forces and influence of tool corner radius on tool wear in hard	Roland Meyer. Jens Kohler. Berend denkena.	International Journal of Advance Maf.	16MnCrS5 (AISI5115) Steel.	150	0.1	0.1	CBN Insert ,used for this performance

	turning.		Tech. (2012) 58:933–940.	60-62 HRC				
7	To remove the thermal distortion generated due to heat during machining and improves the waviness of bore with the help of pressurized coolant.	Jinming M. Zhou, Stefan Hognas, Jan-Eric Stahal.	International Journal of Advance Manufacturing Technology (2010) 49:469–474.	AISI 52100, 60-62 HRC	160	0.08	0.1	PCBN Cutting tool with CBN content and ceramic (TiAl) binder material
8	To study the surface finish with solid lubricants in hard turning, with different cutting speed and tool geometries and also compare with dry hard turning.	Singh Dilbag, P.V.Rao	Springer- Verlag London Limited 2007	AISI 52100 Steel, 58+02 HRC	50	0.04	0.4	Mixed ceramic inserts of different geometry were used.
					75	0.08	0.8	
					100	0.12	1.2	
					150	0.2	2	
9	To study about orthogonal cutting model and oblique cutting model. Show that the hard turning is new machining process.	A.G.Mamalis, J.Kundrak, A.Markopoulos, D.E. Manolakos.	Springer- Verlag London Limited 2007	AISI H-13 Steel, 55 HRC	200	0.05	1.5	CBN tool , cutting tool with -5º rake angle, clearance angle 5º, Cutting edge radius 0.02.
					250	0.05	1.5	
					300	0.05	1.5	
10	To study the cutting conditions (cutting speed & feed) and tool geometry (effective rake angle & nose radius), and their effects on surface finish during hard turning.	Singh Dilbag, P.V.Rao	Springer- Verlag London Limited 2006	AISI 52100 Steel, 58 HRC	100	0.1	0.2	Mixed ceramic inserts of different geometry were used
					150	0.2	0.2	
					200	0.32	0.2	
11	To develop a methodology to model the CBN tool crater wear rate to both guide the design of CBN tool geometry and optimize cutting parameters in finish hard turning.	Yong Huang, Steven Y.Liang.	Springer- Verlag London Limited 2004	AISI 52100 Bearing Steel , 62 HRC	2.29 m/s	0.168	0.203	CBN content tool inserts (Kennametal KD050) is used.
					1.52 m/s	0.076	0.102	
12	Modeling and predicting of surface roughness with the use of new HMM-SVM (hidden markov model and least squares support vector machine) model based on bayesian inference in hard turning.	Kang He, Qingsong Xu	IEEE Transaction on automation science and engineering	AISI 4340 Steel. AISI D2 Steel. 55 and 60 HRC.	100	0.03	0.2	Cutting tool CNGA120408W-BNC160 used.
					140	0.04	0.1	
					180	0.12	0.3	
13	To study the surface roughness of AISI H 13 with the use of minimum cutting fluid through the ANN model in hard turning.	B. Anuja, E.Kirubakaran, P.Ranjit Jeba Thangaish,	Science Direct Procedia Engineering, 2014	AISI H 13, 45 HRC	75	0.05	0.5	Tool insert SNMG 120408 is used.
					95	0.075	0.75	
					115	0.1	1	
14	To investigate the effect of cutting parameters on the cutting temperature in hard turning with the use of RSM and multilayer coated carbide insert.	S K .Shihab, Z. A.Khan. A. Mohammad, A. N. Siddiqueed	Science Direct Procedia Engineering, 2014	AISI 52100 Steel, 58+02 HRC	100	0.1	0.2	CNMG 120408 - TN7105 hard multicoated carbide insert (TiN -TiCN - AL_2O_3-TiN)
					175	0.16	0.6	
					250	0.22	1	
15	To study the effects of cutting parameters on cutting forces, chip-tool interface temperature and surface roughness during the hard turning and soft turning.	A. Pal, S.K. Choudhury, S. Chinchanikar	Procedia Materials Science 6 (2014) 80 – 91.	AISI 4340 Steel, 35, 45 and 55 HRC.	100	0.081	0.1	TiC based alumina ceramic insert having geometry CNMG 120408 used as a cutting tool.
					120	0.088	0.2	
					150	0.113	0.3	
					200	0.15	0.5	

16	High precision hard turning of AISI 52100 bearing steel.	Philippe Revela, Nabil Jouini, G Thoquenne, F Lefebvre.	Precision Engineering, Elsevier , 2015	AISI 52100 Bearing Steel , 61±1 HRC	210	50	5	CBN- cutting tool insert.
					210	100	10	
					260	50	5	
					260	100	10	
17	To investigate the effects of process parameters on surface integrity with longitudinal turning (hard turning) under dry conditions.	Bordin, S. Bruschi, A. Ghiotti	Procedia CIRP 13 (2014) 219 – 224.	ASTM F1537 CoCrMo, 35 HRC.	40	0.1	0.5	PVD coated Ti AI N carbide tool having designation CNMG - 120404 SM 1105
					60	0.15	0.5	
18	To study about white layers induced during hard turning through formation mechanisms and also study the mechanically induced white layers (M-WL) and thermally induced white layers (T-WL).	S.B. Hosseini, U. Klement, Y. Yao and K. Ryttberg.,	Acta Materialia 89 (2015) 258–267.	AISI 52100 Steel, 715HV30	30	0.5	0.2	Cubic boron nitride (CBN) cutting tool having designation DCGW11T308
					110	1.5	0.2	
					260	2	0.2	
19	To study the tool wear and tool geometry with different cutting edges combination.	C.E.H. Ventur, J. Köhler, B. Denkena	Journal of Manufacturing Processes 19 (2015) 129–134.	16MnCrS5 Steel, 60±2 HRC.	200	0.05	0.05	SNMA120408- CBN inserts 90%CBN, TiCN and Co as bond materials.
20	Performance evaluation of solid lubricants in terms of machining parameters in turning.	P. Vamsi Krishna, D. Nageswara Rao,	International Journal of machine tools & manufacture 48 (2008) 1131-1137	EN8 Steel, 30±2 HRC, Heat treated.	110	0.25	1.0	Carbide, SNMG 120408.
21	Effect of magneto rheological fluid on tool wear during hard turning with minimal fluid application.	P. Sam Paul, A.S. Varadarajan, S. Mohan	Archives of civil and mechanical engineering (2014).	AISI 4340 Steel, 46HRC.	100	0.12	1.2	Multicoated hard metal inserts, SNMG 120408MTTT5100 coated with TiC &TiCN.
22	Influence of the direction and flow rate of the cutting fluid on tool life in turning process of AISI 1045 steel	Anselmo Eduardo Diniz , Ricardo Micaroni	International journal of machine tools & manufacture 47 (2007) 247-254	AISI 1045, 96HRB.	490	0.15	1	Coated carbide tool SNMG 120408-PF, Coated of TiCN and TiN.

III.LITRATURE REVIEW

Srithar, Palanikumarb and Durgaprasad [1], discussed the various cutting parameters such as depth of cut, feed rate, and cutting speed; used in hard turning and the analysis revealed that these parameters has a impact on surface roughness. With increase in cutting speed from 135 to 325 m/min and surface roughness slightly decreases. It indicated that the cutting speed decreased and surface roughness increases with lower cutting speed and when the feed rate and depth of cut increased, the surface roughness also increases.

W. Grzesik, Krzysztof Zak, Piotr Kiszka [2], studied the various surface textures with different techniques. Compare the quality and functional properties of material finished by precision hard turning and gentle grinding operations. 41Cr4 (AISI 5140 equivalent) steel, hardness of 57±1 HRC and the initial surface roughness of about 0.4 µm was used to investigate the experiments. With hard turning tool CBN tools containing about 60% CBN, grade CB7015 by Sandvik coromant. TNGA 160408S01030 chamfered inserts with brazes -CBN tips were used and cylindrical grinding cylindrical grinder using mono crystalline Al_2O_3 ceramic wheel 350×25×12732A and water soluble emulsion as a coolant used. According to experimental results the measured values of SA and Sz parameters were equal to 0.28 µm and 1.6 µm for hard turning and 0.27 µm and 4 µm for grinding. According to 2D values of Rz, it is equal to 1.2µm and 2.4 µm for hard turned and ground surfaces respectively. Ground surface contains high sharp peaks as compared to hard turned surface.

B. Varaprasad, R.C. Srinivasa, P.V. Vinay [3], studied the effect of machining parameters (feed, speed, depth of cut) on tool wear (flank wear), during hard turning of AISI D3 steel having hardness 62HRc with mixed ceramic insert (CC6050). It was found that the excessive temperature directly influences the temperatures of tool face and tool flank, and this leads to thermal damage of machined surface. Tao Chen., Suyan li., Bangxin Han and Guangjun Liu [4], studied the effect of cutting parameters on cutting forces and surface micro-topography during the hard turning operation. The surface roughness parameters (2D and 3D) are also investigated. It has been found that the cutting force decreases with increasing cutting speed from 100 to 200 m/min and also increases when cutting speed varies 200 to 300 m/min. due to increase in cutting speed the cutting temperature gradually increased and come closer to the melting point of work piece material. Feed rate also increases the cutting force and it has greater influence on cutting force as compared to cutting speed. The feed rate increases the surface roughness. When feed rate was low the surface roughness was low. As the feed rate increases gradually the surface roughness increases unto 5.51 µm maximum height. When cutting speed increases unto to 200m/min. the surface roughness increases and when it increases to 300m/min the surface roughness decreases.

H-J Hu., W-J Huang [5], studied the tool wears and compares the tool materials like common ceramic and ultra-fine grained ceramic tools for better hard turning results with the help of different techniques. FEM (finite element modeling) approaches & lagrangian increment method were used for 3D metal turning. DEFORM -3D V6.0 software for simulate the turning process. Flank wear measured by scanning electron microscope (SEM) JSM 6460 LV. Wear rate calculated by using Archard empirical wear mode. As turning proceeds the amount of wears increases gradually for common ceramic tool and ultrafine-grained ceramic tool. The wear depths of common ceramic tool are bigger than that of ultrafine-grained ceramic tool.

Roland Meyer, Jens Köhler, Berend Denkena [6], found that the corner radius geometry of cutting tool reduce the tool wear performance. It was also revealed that the size of corner radius was an important parameter, which affects the tool wear behavior. Small corner radii of main cutting edge, the wear progression was higher as compared to large corner radii. Tool life increased when the corner radius increased. It also affects the process forces, with the increase of corner radius process forces also increased. Small the corner radius leads to lower process forces.

Jinming M. Zhou, Stefan Hognas and Jan-Eric Stahl [7], discussed that the water based coolant through a pipe with nozzle diameter of 2mm remove the thermal distortion generated due to heat during machining and improve the waviness of bore with the help of pressurized coolant. Thermal distortion induced when the temperature of bore is increased. When the flank wear is over 0.1 mm the temperature of cutting area increases faster. The distance between jet nose and cutting edge is 5mm.

Singh Dilbag, P. V. Rao [8], used graphite and molybdenum disulphide in powder form having 2 µm average particle sizes as solid lubricants. The solid lubricant was supplied from 0.5 gm/min to 15 gm/min through the designed apparatus. It was found that the molybdenum disulphide shows better result as compared to graphite. Surface roughness value decreased 8% to 10% when graphite is used and 13% to 15% decreased due to molybdenum disulphide. Cutting forces were reduced when lubricants were applied from 1gm/min. to 2gm/min flow rate.

Dilbag Singh and P. V. Rao [10], discussed about surface finish, and it was found that it varies when the cutting parameters varies. Statistical analysis of the experiment processed using ANOVA (analysis of variance). Surface roughness increases with the increase of feed rate and depth of cut and decreases with the increase of cutting speed.

Yong Huang, Steven Y. Liang [11], used AISI 52100 bearing steel with hardness 62 HRC (Rockwell hardness) as a work piece to develop a methodology to model CBN tool crater wear rate. CBN tool inserts (Kennametal KD050) was used with rake angle -20º and 0.1mm wide edge chamfer 0.8 mm nose radius. Crater wear takes place where the chip thickness value is maximum and during the experiments the iteration go on, until micro chipping or breakage happens and it reached the tool flank wear creation. With the increase in cutting speed from 1.52 m/sec. to 2.29 m/sec., feed rate decreased from 0.076mm/rev to 0.061 mm/rev and increase in depth of cut from 0.102 to 0.203 mm crater wear rate increased and it reaches its maximum value around the midpoint of tool/chip contact length.

Kang He, Qingsong Xu [12] developed modeling technique for predicting surface roughness with the use of new HMM-SVM (hidden markov model and least squares support vector machine) model based on Bayesian in hard turning. AISI 4340 steel and

AISI D2 steel are used as the work piece materials with average surface hardness value of 50, 55 and 60 HRC respectively. According to the GB/T1031-2009 standard, the range Ra 0.2 to Ra 0.4 is denoted as accuracy grade [Ra 0.4], Ra 0.4 to Ra 0.8 as accuracy grade [Ra 0.8], and Ra 0.8 to Ra 1.6 as accuracy grade [Ra 1.6]. It is found that HMM-SVM estimates the surface roughness with the highest accuracy as compared with MR and LSSVM. According to MR 6 were misjudgment found and according to HMM-SVM with probability comparison 4 misjudgements were found. HMM-SVM model reduces the risk of accuracy grade misjudgement of surface roughness and improves prediction accuracy. The mean absolute error for HMM-SVM, LSSVM and MR are 0.0504, 0.0969 and 0.1635 respectively.

B. Anuja Beatricea, E. Kirubakaranb, P. Ranjit Jeba Thangaiahc, K. Leo Dev Winsd [13], discussed about the surface roughness in terms of cutting parameters with the use of cutting fluid through the ANN model (artificial neural network) in hard turning . cutting fluid parameters used, pressure at injector is 100 bar , rate of cutting fluid application 8ml/min. , composition of cutting fluid - 20% oil in water and frequency - 500 pulses/min. in the present investigation , surface roughness (RA) was considered as performance parameter . When the feed rate was 0.05 and cutting velocity was 115, the experimental result was 1.45 µm and according to ANN prediction 1.35 µm, the % error was 6.89. In model analysis, coefficient of determination is used as a measure to consider how better the prediction. In this study, the coefficient of determination was found is 0.95962 for 3-7-7-1 configuration and standard error of 0.0950. According to ANN model the accuracy is possible with smaller number of turning data.

Suha K. Shihab, Zahid A. Khan, A Mohammad, A Noor Siddiqueed [14] , AISI 52100 hardened alloy steel was used as a work material with chemical composition, C- 0.98 , Si-0.28 , Man- 0.39 , S- 0.024 , P- 0.023 , Ni- 0.141 , Cr - 1.302 , Mo - 0.081 , Cu - 0.042 , Fe - rest to investigate the effect of cutting parameters (cutting speed, feed and depth of cut) on the cutting temperature in hard turning with the use of RSM (response surface methodology) and multilayer coated carbide insert. RSM (response surface methodology) is used for data collection and analysis. Tool chip thermocouple is used to measure the cutting temperature. Results shows that, optimized value of cutting temperature from 566.593 ºC - 592.028 ºC at particular parameters. Cutting speed and feed rate are the major parameters for increasing the cutting temperature.

A Pal, S.K. Choudhury and S. Chinchanikar [15] studied the effects of cutting parameters on cutting forces, chip-tool interface temperature and surface roughness during the hard turning and soft turning. During this study effects of cutting parameters on cutting forces (axial force Fx, radial force Fy and tangential force Fz) are observed when the depth of cut is 0.3 mm and feed value is 0.113 mm/rev. at three different levels of hardness. The cutting forces decreases with the increase of cutting speed and increases with increase of depth of cut and feed rate. Radial force magnitude is 15-20% higher than tangential force and 102- 112% higher than axial force during experiments. Surface roughness increases with the increase of feed and depth of cut and decreases with increase of cutting speed. The tool-chip interface temperature increases with the increase of all cutting parameters.

Philippe Revel, Nabil Jouini, G Thoquenne and F Lefebvre [16], used AISI 52100 bearing steel rings thermally treated to average hardness of 61±1 HRC to study the surface roughness and residual stresses. Full factorial experimental design was performed to analyse the effect of cutting parameters. Surface roughness measurements were carried out with profilometer. Surface roughness strongly affected by feed rate and it was found that when feed rate decreases surface roughness decreases and with the increase in cutting speed the surface finish increases. Both the circumferential and tangential residual stresses become more compressive with an increase in cutting speed from 260 to 360 m/min.

Bordin, S. Bruschi and A. Ghiotti [17], investigated the effects of process parameters on surface integrity with longitudinal turning (hard turning) under dry conditions. The CoCrMo alloy with PVD coated Ti AIN carbide tool were used for the study. The effects of cutting speed and feed rate on surface integrity were evaluated in terms of surface topography, surface roughness, residual stresses, micro hardness measurements. The feed rate plays a major role on surface roughness. For smoother surface low feed rate is required. When cutting speed is 60 m/min. then the uniform surface profiles resulted. XRD analysis showed that high compressive stress resulted on surface for all the cutting conditions and small reduction of stress level observed at depth of 50µm. Surface hardening increases with increase of cutting parameters.

S.B. Hosseini, U. Klement, Y. Yao and K. Ryttberg [18], discussed the white layers concept during hard turning through formation mechanisms and studied the mechanically induced white layers (M-WL) and thermally induced white layers (T-WL). Chromium - containing high carbon steel of grade AISI 52100 (DIN100Cr6) work material used. Water based containing 5% oil, applied to rake face with pressure of 5 bars. In this study the formation mechanism of white layers induced at 30m/min compared with WLs generated at 110m/min and 260m/min. The difference is observed due to the absence of FCC-austenite reflections. White layers formed at 30m/min with BCC- ferrite and orthorhombic. The average grain size of WLs is 10 nm and submicron grain up to 200nm it was noticed that the grain size is increases with the increase of cutting speed from 30m/min.to 260m/min.

C.E.H. Ventura, J. Köhler, B. Denkena[19], 16MnCrS5 steel having hardness 60 ± 2 HRC and length 200mm turned without cutting fluid . In this study the influence of cutting edge geometry of high content CBN insert in interrupted hard turning was investigated. Tool performance with different edge geometries was discussed. The contact length between cutting edge and work piece chip was minimum when sharp cutting edge is considered due to this, bluntness increases with the increase of contact length and an increase of forces were observed. Lower increase for first three geometrics (sharp, chamfer and K = 2.0), and higher increased values can be seen for the last two (K = 1.0 and K = 0.5) due to the vibrations related to the higher force components. A small effect on tool wear was observed when the forces acting parallel after the cutting time of 16 min. due to higher temperature involved. Flank wear was observed in comparison to sharp and chamfered edges and with form factor K=2.0, 1.0 and 0.5 deeper grooves were noted in micro geometries.

P. Vamsi Krishna, D. Nageswara and Rao [20], studied the tool wear and surface roughness when solid lubricants were applied and compare with dry and wet machining. Graphite and boric acid in proportions of 5%, 10%, 20% and 30% by weight are mixed with SAE 40 oil. Work piece EN8 steel hardness 30±2 HRC with carbide tool used. Surface finish is improved compared with dry machining. Due to solid lubricants the kinematic viscosity increases and thermal conductivity decreases with increase in solid lubricant content in SAE 40 oil.

P. Sam Paul, A.S. Varadarajan and S. Mohanasundaram [21], studied the tool wear with the use of magneto rheological fluid with minimal fluid application. AISI 4340 steel was used as work material with is used in automobile, air craft engine, gear shafts etc. Magneto rheological (MR) fluids belongs a class of controllable fluids which consist of fluid impregnated with ferromagnetic particles. Viscosity of fluid increases as strength of magnetic field increases. It was found that the tool wear is reduced due to magneto rheological fluid with 75 µm size Ferro particles. Cutting forces also reduced up to 22.3% and 44.4 % improvement in surface finish.

Anselmo Eduardo Diniz and Ricardo Micaroni [22] used AISI 1045 steel bars with an average hardness 96 HRB along with the vegetable oil as cutting fluid with 6% water concentration. Cutting fluid used at different flow rates, (91 and 111 min^{-1}) and pressure 0.04 Mpa. Due to lubricant application on tool, the tool life improves as compare to dry cutting and also reduce the temperature formed during turning.

IV. CONCLUSIONS

This study has overviewed the hard turning with different materials, hardness value and different parameters and it was found that it is a good alternative technique of cylindrical grinding because its cost is lower, less time required for set up, flexible geometry and high surface finish.

Effect of cutting parameters on cutting forces, surface roughness and tool wear were studied through this review. It has been found that the feed rate is important parameter to increase & decrease the surface roughness and cutting forces and for tool wear cutting speed is the main factor. Hard turning can become very useful with right machine, right tool and with optimum cutting parameters.

It has been found that to improve the thermal distortion, tool life, surface roughness and performance of hard turning cutting lubricants can be applied during hard turning. Surface roughness decreased, when solid lubricant (graphite and molybdenum disulphide) used in powder form. The use of solid lubricants has also been successful in reducing the cutting forces.

AISI 4340 steel finds its applications in aerospace, automotive and crane shafts. The effect of solid lubricants on AISI 4340 steel and comparison in terms of dry or wet lubricant was not experimentally done in previous work. It will be interesting to know the effect of different parameters with solid lubricants on cutting forces and surface roughness in hard turning.

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