# CHAPTER-2

## LITERATURE REVIEW AND OBJECTIVE

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2.1. INTRODUCTION

In any production process as in the industry, is the surface finish which has greater influence on the quality of the finished product. In such cases, the experience of the operator plays a major role, but even for a skilled operator it is very difficult to attain the optimum values each time. The quality characteristic of turned part depend on machining parameters are of cutting speed, feed rate and depth of cut etc. Optimizations of machining parameters not only increase the machining economics, but also the product quality. To achieve the above situation an effort has been made in the present work to estimate the machining parameters like surface roughness, material removal rate and power consumption by using experimental data.

2.2 REVIEW ON HARD TURNING

Hard turning has many advantages such as high flexibility, high productivity and ability to manufacture parts with complex geometries in one set-up Tonshoff et al [2] Hardturning. It has the potential to achieve low production cost, less process time and better surface quality, Sheehy et al [3]. Hard turning process is a fine or finish turning process to machine the material in hardened condition in the range of 40-60 HRC. The process is more flexible and productive, and hence fewer machine tools are required. Turning operation is more efficient cutting process than grinding, so less energy is required to
remove the same volume of material. In addition hard turning has the possibility of eliminating cutting coolant while cutting another substantial material which is the economic and environmental advantage of hard turning.

Development of new cutting tool materials, the precision and rigidity of machine tools have been improved to allow hard turning to become a viable process. The large negative rake angles on tools used for hard machining yield large dynamic thrust forces that require spindle power, and accuracy of motion along the axes of the machine Tonshoff and Hetz et al [4]. Conventional tools produce force twice that of chamfered edge tools, Bossom et al [5]. By poor stiffness setup during machining tools failed quickly due to edge fracture, Chryssolouris et al [6]. Advantages of the hard turning technology as identified by Konig et al [1] are as follows.

1. The lathe can perform soft turn and also hard turn leads to reduction of floor space and capital investment operations.
2. In hard turning, Metal removal rates are 4 to 6 times greater than equivalent grinding operations.
3. Single-point cutting tool can turn complex contours on a lathe machine, without going for costly form wheels.
4. The disposal of hard turned chips is cheap in comparison to grinding swarf.
5. Tooling cost is low compared to grinding wheels.
6. The surface finish in hard turning achieves 0.001 to 0.004mm.
In comparison to conventional turning during hard turning, the engagement of cutting tool and work piece must be limited, due to this small depth of cuts that take place during hard turning. For hard turning, tools are prepared with hard edges or chamfered edges to provide stronger edge which is less prone to premature fracture. Therefore, there is a need to develop a better understanding of the effects of process conditions on the behaviour of cutting tools and the surface quality that can be obtained by hard turning. With this background, the present research on Hard Turning under dry cutting conditions is considered.

2.2.1 Hard Turning Requirements

In hard turning process, the material is removed at hardened state so as to obtain longer tool life and desired surface finish during the application of constant cutting force, Ruey-Ying et al [8], for hard turning requires rigid machine tools, very hard and tough tool materials with optimum tool geometry etc.

2.2.2 Machine Tool Requirements

The precision and rigidity of machine tools have been improved to allow hard turning by using newly developed cutting tool materials with negative rake angles (the edge chamfer) on cutting tool edges.

2.3 VIABLE HARD TURNING PROCESS

In order to sustain above, it is necessary to adopt new technological solutions. New technology has played an important role in metal working industry to reduce production cost and improve quality. The conventional and hard turning operation are routine
metal cutting operations, which are very much operator dependent and also requires skill. CNC machine tools provide both consistency and reliability to become the biggest contributor to the part quality and cost.

The hard turning is defined as the process of single point cutting of part per piece that have harden values, Subrahmanyam et al [9]. To get the desired production rates and operating cost goals, the tooling choice will be most important. In such cases CBN is the most dominant choice for the more demanding applications of size, finish, Griffiths et al [10]. Carbide tools are available in a wide range of grades and with coatings it gives best matched application. The CBN with high content has higher toughness and longer tool life provided with low content insert.

2.3.1 Temperature and Hardness

During metal cutting localized heating occurs at the tool tip which tends to aid in the cutting action. Heat generated at the tool tip begins to anneal and soften the material just ahead of the tool, making it easier to shear. During hard turning turned surfaces experience white layer formation, Griffiths et al [10] and causes either severe plastic deformation that causes rapid grain refinement or phase transformations which result in rapid heating. For dry cutting operating the MRR is minimized and depths of cuts are in the order of 0.15mm.

1. The elevated workpiece temperature has to be considered and also gauging immediately after cutting.
2. Dry cutting leads to higher temperature at the tip of the tool and leads to lower tool life as compared to cutting with coolant.
3. Compare to coolant cutting the surface finish for dry cut operation is seldom.
4. High temperature chips are formed with temperature range of 925°C.
5. For dry cutting the correct tool material needs to be chosen. For example in case of cermite, which are prone to early failure under thermal shock condition.

2.4 APPLICATIONS OF HARD TURNING

The industrial segments use dry cutting for automotive, bearing, and marine, punch and die, mould, hydraulics and pneumatics, and aerospace. Commonly processed materials are bearing steels, hot and cold-work tool steels, high-speed steels, die steels and case hardened steels. Many researchers, industrialists and manufacturers have opted to develop the Hard Turning Process because of the above applications.

2.5. REVIEW ON CUTTING TOOLS

Cemented carbide tools are more popular and are higher production tool materials ASM Metals Handbook [11], with the achievement of a superior tribological achievement wear-resistance Bouzakis et al [12]. Therefore, the coated cutting tools have come into existence in present day metal cutting process.
2.5.1 Ceramics Tools

For machining hardened steel at higher cutting speeds with generation of high temperature ceramics tools are more appropriate. Ceramic tools can withstand high temperatures generated at higher cutting speeds in machining hardened steel. Due to high hot hardness, high heat resistance and low reactivity with the steel, ceramics are used without cooling lubricant supply. Narutaki et al [13] reported the performance of ceramic tools in machining Grey Cast Iron under dry machining. Tonshoff et al [14] evaluated the comparative tribological effects accompanying ceramic tool in finish turning process under dry and wet conditions. The strength and performance of ceramic tools are improved by reducing the grain size, mixing with non-oxide ceramic materials like TiC, TiN and whisker reinforcement like SiC, Subrahmanyam et al [15]. Alumina ceramic has the lowest toughness among the ceramics. By alloying it with TiC, the toughness, stability and thermal conductivity are improved without seriously compromising the hardness. Alloying with ZrO₂ also increases toughness, but at the expense of hardness, Konig et al [1]. In comparison to steel cutting tools, ceramics offer the advantages of increased resistance to abrasion due to increased hardness, Adams et al [16], improved chemical stability, Amin et al [17] and better hardness retention at the elevated temperatures typical in metal cutting Sibold et al [18].
2.5.2 Cubic Boron Nitride (CBN) tools

Ferrous alloy materials are machined using CBN tools which are chemically more stable than diamond. CBN tools are more thermally stable up to 800°C and stability under high temperature are further increment/improved by decreasing the impurities content by special processing techniques. CBN tools has longer tool life and higher MRR than carbide/ceramic tools. However, CBN tools are 10 to 20 times more expensive. CBN tools are available in tipped form and solid form and are classified into several grades based on the percentage of CBN, David and John [19], Oliveira et al [20]. The straight grade consists high percentage of CBN (>80%) and a metallic second phase, which have high fracture toughness and thermal conductivity. The composite grade consists lower CBN (<80%) and a ceramic second phase, which have higher compressive strength, Takatsu et al [21], Bossom et al [5] with less than 75% CBN produces better tool life and surface finish than the CBN content more than 90%. For machining tool steels with CBN cutting tools have more advantages than Al₂O₃+TiC Ceramic tools, Hodgson et al [22]. The main advantages of CBN tools are that they maintain hardness at very high temperatures (1800 HV at 1000°C), Tabuchi et al [24], have low solubility in iron and good fracture toughness for a ceramic, Bossom et al [5].

In automotive and allied industries, hard turning is carried-out using CBN tools for finishing and semi finishing of transmission axles, drive trains, brake discs and brake rotors. In air craft industry, this
technique is used to make flap gears and landing struts. The tools with higher CBN content are recommended for high speed turning while those with low CBN content are to be used for interrupted cutting. In the case of machining hardened steel with CBN tool as the cutting speed and workpiece hardness increases the shear zone thickness and chip thickness decreases, Eu Gene and Aspinwall et al [25].

Recent improvements in the carbide tools like restricted contact and use of various coatings on carbides make the Carbide cutting tools suitable in machining of hard materials under dry conditions, Kurimoto and Barrow, [26]. The carbide tools with honed edges provide shorter edge geometry and it is less prone to premature fracture, Santosh Ranganath et al [27]. In hard turning process, the wiper inserts perform better with reference to surface roughness and tool wear, while conventional insert is useful in reducing the machining force Gaitonde et al [28]. Krzysztof Jemielniak et al [29] compared with the performance of cemented carbide, CBN and whisker tools in rough turning of Inconel-718, and indicated that machining conditions play vital role in tool performance. Cutting force is the most important parameter influencing the residual stress followed by feed and depth of cut Batalha et al [30]. The errors in precision hard turning process are analysed and proved that within the certain range of flank wear geometrical accuracies are good, Zhou et al [31], Jacobson et al [32] have reported that in hard turning process without using the cutting fluid Better surfaces can produced
by increasing the feed and tool nose radius with decrease in cutting speed, Diniz and Micorani et al [33]. In hard turning of chromium steel with CBN tool it is observed, that the cutting conditions in turning with CBN tools influence the depth of hardness layer on machined surface and surface finish, Liu et al [34] and indicated that large edge hones result in higher average surface roughness values than small edge hones, Thiele and Melkote et al [35] and the surface roughness valleys in machining hardened steel with CBN tools and also stated that large edge hones result in higher forces Subrahmanyam et al [15]. If hard turning is to replace any grinding operation, it must be capable of producing surfaces of acceptable quality. Therefore, it has to meet the “extended surface integrity data set”, consisting of: - surface finish, fatigue resistance, microstructure, micro hardness, residual stress state and frictional characteristics, Field et al [36].

2.5.3 Cemented Carbides tools

The basic ingredient of most cemented carbides is tungsten carbide which is extremely hard. To allow machining at higher cutting speeds (and increased production rates), carbide tools were developed in the 1930s, Kalpakjian and Steven et al [37]. These tools now consume an estimated 70% of the machining market. Because the tools are typically pressed and sintered from ceramic powders (often with a cobalt binder material), they are sometimes called sintered carbides or cemented carbides. There are two basic subsets of carbide tools: Tungsten Carbide (WC) and Titanium Carbide (TiC). WC tools
are being the most prevalent, DeGarmo et al [38]. Pure WC is very hard, but also brittle. To improve toughness, WC powder is mixed with 5-15% cobalt (weight percentage). Hardness and wear resistance can be improved by reducing the grain size of the WC particles, which are typically in the range of 0.5-5 µm, Edwards [39].

Cemented carbide tools generally have Tungsten Carbide (WC), Titanium Carbide (TiC) / Tantalum Carbide (TaC) with Cobalt (Co) as binder. Conventional Cemented Tungsten Carbides (WC + Co) are not suitable for machining high hardened steel, particularly at elevated temperatures due to the presence of cobalt binder. The properties of cemented carbides are mainly based on the ratio of Tungsten Carbide to cobalt binder and the grain size of the compound Leyandecker et al [40]. The hardness of cemented carbide decreases with increase in the binder content, Ducros and Sanchette et al [41]. By reducing the grain sizes of the tungsten carbide powders to submicron levels (0.5 to 0.8µm) and ultra fine grain (0.2 to 0.5 µm), cemented carbide tools are made suitable for dry machining of high alloy steel or high strength steels, Tavares et al [42], Holleck and Schier, [43]. The tribological behaviour of cutting tools for dry machining can be improved using coatings. Coatings are classified based on the method of deposition (e.g. CVD or PVD) and by their structure (monolayer or multi layer).

2.5.4 Silicon Nitride based Tools

Silicon nitride (Si₃N₄) are used as a cutting tool, but does not sinter easily to full density. Additions are often made to assist
sintering, but hot pressing is typically required to achieve good strength. Similar to sialon tools, diffusion into iron makes $\text{Si}_3\text{N}_4$ tools unsuitable for machining steels. They are generally restricted to grey cast iron and some **nickel-based alloys, Jack et al [44]**.

### 2.6 INDEXABLE INSERTS

The inserts are also known as throwaway or disposable inserts. A good proportion of single point tools use cemented carbide or oxide inserts. Most modern cemented carbide milling cutters and a wide variety of special tools also used as indexable inserts, **Devitt et al [7]**. The American National Standards Institute (ANSI) identification system for inserts uses about 10 Alphanumeric characters to specify the shape, relief angle, tolerance, type, size, thickness, cutting point configuration, cutting point definition, other conditions and left / right hand operation. A typical example for designation of the tool is SAEN 120408FR, the respective places of symbols are given in the Table-2.1, **Juneja et al [45]**.

**Shape of insert:** The first character indicates the shape of the insert, e.g., A for $85^0$ parallelogram, D for diamond, P for pentagon, R for round, S for square and T for triangular, etc. Figure - 2.1 gives the standard (ISO) shapes.

**Clearance Angles:** The second character is for denoting relief or clearance angle, e.g. A for $3^0$, B for $5^0$, C for $7^0$, P for $11^0$, N for $0^0$.

**Tool-Holders:** The tool-holder is mounted on the cross-slide which is fixed to the carriage of the lathe. The tool post is suitable for holding a single tool or four-way tool post.
Lathe Tools: The main types of turning tools are the straight-shank turning tools, bent-shank turning tool, small nose radius turning tool or broad-nose finishing tools, facing cut-off or parting tools, thread cutting tools and boring tools are generally made out-of HSS. Now a days, the throw away, standard carbide inserts are quite popular and such tools mounted on tool holders are shown in Figure-2.2.

Table - 2.1:ISO Designation of cutting tool [Juneja et al., (45)]

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Figure 2.1: Shapes of inserts Juneja et al [45]
2.7 COATED CUTTING TOOLS

The coated cutting tools enhance the performance of cutting tools during cutting operations. It was introduced in 1969, Soderberg et al [46]. By consuming several materials with Inconel different properties were improved by using composite composition, Satyanarayana, et al [47]. To improve mechanical properties such as stiffness, strength, toughness and resistance to fatigue many class of composites. For improved tribological chemical functions coating composites are designed for improving their friction and wear resistance properties, Hogmark et al [48]. The combination of substrate along with composites will improve hard wear resistance, PalDey and Deevi et al [49]. Wide usage of coated and uncoated carbide tools are the best alternative for most turning operations, Haron et al [50]. PVD and CVD cutting tools are used to improve further the cutting performance of the cutting materials, Bouzakis et al [12].
In high speed turning, it is possible to increase the cutting speed by 25 to 50% without reduction in tool life Trent et al [51]. The performance of the coated tools has further improved with multilayer coatings, Grzesik et al [52]. Multilayer coatings are designed to improve mechanical properties like hardness, toughness and high thermal stability, Grzesik and Nieslony et al [53]. The top layers provide high hardness or reduced coefficient of friction Sung et al [54], Maria et al [55]. It has been established that performance of multilayer coated tools is superior to that of monolayer ones, Hsieh et al [56], Bull and Jones et al [57]. Coated carbides have one or more thin layers of Chemical Vapour Deposition (CVD) or physical Vapour Deposition (PVD) coatings are best applied at high speeds where dynamic force and with minimum thermal shocks, Mats Larsson et al [58].

The coating can extend the tool life by 2 to 3 times with reduction in the rate of wear. The hard coating materials of cutting tools are classified into four major groups, Klocke and Krieg et al [59]. For machining hard ferrous materials high temperature alloys, grey cast iron and CBN coated tools are suitable, Prengel et al [60].

The wear of the tool while turning TiN coated and uncoated TiC based cermets mainly depends on diffusion between tool work interfaces, Novak and Komac et al [61]. Coated tool prevent the diffusion and resulting extended tool life. The adhesion of the coating on cutting tools depends on the internal stresses whereas the high internal stresses cause poor adhesion, EijiKusano et al [62].
Majority of the PVD or CVD coatings are carbide cutting tools, Lux et al [63]. The machining performance and tool life are improved by high hardness, chemical stability and wear resistance of the coated tools, Layyous et al [64]. In the CVD process the deposit of thin films on the cutting tools through various chemical reactions, Prengel et al [60], Childs and Maekawa et al [65]. The characteristic of a CVD process is the high substrate temperature about 1100°C with increase in toughness and transverse rupture strength of the substrate, Prengel et al [66]. Whereas the PVD process is usually carried out at low temperature around 500°C, which has no impact on the transverse rupture strength of the substrate. By sputtering and evaporation PVD is deposited. The main advantage of PVD over CVD is becoming increasingly favourable over the fact that the cutting process occurs under much lower temperature. The high temperature during the CVD process causes deformation and softening of many cutting tool substrates, Mori et al [67]. With PVD coated cutting tool processes are having the ability to form smooth, fine grained, crack free coatings over sharp edges and featuring favourable internal residual stresses. Sputtering is one of the PVD processes found to be suitable for deposition of multilayer Nano-coatings, Tavares et al [42], Kustas et al [68].

2.7.1 Function of coating in Metal Cutting

At high speed machining the Machining efficiency is improved by reduction of machining time when cutting steels, cast iron and super alloys, softening temperature and the chemical stability of the
tool material limits the cutting speed, Akcan et al [69]. Ceramic materials like TiC, Al₂O₃ and TiN possess high temperature strength than conventional tool materials such as high-speed steels and cemented tungsten carbides. At high speeds the necessity of hard chemical reaction material is imported by depositing single and multi layer coatings on conventional tool materials, Cho and Komvopoulo et al [70], Schintlmeister et al [71], the effect of coating are as follows:

1. At lower cutting speeds, can be prevented.
2. The coating acts as a diffusion barrier between the chip and the surface of the tool at higher speeds.

2.7.2 Types of Coating Technology

Surface coating of tribological applications is associated with deposition temperatures ranging from room temperature to over 1000°C. Some methods involve high deposition temperatures that may give undesired phase transformations, softening or shape changes of the coated component. An important benefit of PVD and CVD processes is the high flexibility as to composition and structure of the coatings.

With high temperature and medium temperature processes in complex cycles that modern CVD coating produces excellent wear resistant coatings with a thickness of 4-20 µm Prengel, et al [72]. Diffusion of chemical elements from the carbide substrate occurs at higher temperature (980-1100°C) during CVD, Soderberg et al [46]. For carbide metal cutting inserts the PVD coatings with deposition
temperatures of 400-600°C are gaining greater acceptance, Prengel et al [72]. The advantage in applications involved interrupted cuts, for sharp edges, and also for finishing, Santhanam et al [73]. Electron beam evaporation, sputtering and arc evaporation are used depending on the intended applications. Pre-treatment processes like as plasma etching, chemical etching influence adhesion, and grain growth and coating structure. Whereas post-PVD processes influence smoothness of coating surface and better chip flow, Tonshoff et al [14]. Cemented carbide with PVD coatings attribute excellent cutting performance, Bouzakis et al [12]. Previous studies have shown that cemented carbide cutting tools coated by PVD technology offer proven performance over their CVD coated counterparts, Jindal et al [72].

2.7.3 Materials used in Coatings

The combination of TiC, TiN and Aluminium Oxides (Al₂O₃) coats on cemented tungsten carbide (WC) inserts reduces the rate of flank wear during cutting process, Dearnley et al [76]. The first PVD coating material with commercial application was TiN, Soderberg et al [46]. To improve the wear resistance of cutting tools of TiN coating at temperatures above 600°C TiO₂ layer is formed. Wahlstrom et al [121]. Dissolution/diffusion and discrete plastic deformation are the principal wear mechanisms for TiN coating Dearnley and Trent et al [122].

Micro- cracking and micro chipping are also major wear modes of TiC coatings, Chubb and Billingham et al [109]. A thin Al₂O₃ coating on top of an inner TiC coating was introduced in the 1970,
Layyous et al [64]. Retention of hardness even at higher temperatures is very important, Paulo Davim et al [77]. Micro hardness values of different coatings measured at different temperatures are shown in Figure 2.3. They all exhibit a decrease with an increase of temperature, and the decrease of hardness was much more pronounced in the case of TiC. Al₂O₃ prevents diffusion of oxygen into the coating and its low thermal conductivity allows dissipation of a considerable amount of heat via chip removal, Jindal et al [72]. Oxidation rate of hard coatings is shown in Figure 2.4.

![Figure 2.3: Temperature dependence of micro hardness](image1)

![Figure 2.4: Oxidation rate of hard coatings](image2)
Earlier studies have shown that surface plastic deformation is the dominant wear mechanism of Al\textsubscript{2}O\textsubscript{3}. Dearnley and Trent et al [122], Dearnley et al [76]. The surface plastic deformation is the dominant wear mechanism of Al\textsubscript{2}O\textsubscript{3} and a TiN outer-layer shows that almost invisible wear land produced in the early stage of cutting. Compared to two-layer coated tools three-layer coated tools have higher wear resistance, Cho and Komvopoulos et al [70], Dearnley et al [76] and it shows that wear rate in the order of TiN> Al\textsubscript{2}O\textsubscript{3}>TiC. At higher temperature the softer TiN outer layer helps in reducing the propagation of cracks. PalDey and Deevi et al [49].

2.8 REVIEW SON SURFACE ROUGHNESS

There are two major types of surface damage that can be caused by hard turning. The first is white layer, which has generally been assumed to result from temperatures generated at the work piece surface that exceed the austenite temperature of the material, followed by rapid cooling. The second type of damage is the formation of undesirable residual stress profiles at, and just below, the work piece surface. Mechanical loading, plastic flow, and phase transformation can affect residual stresses, but negative effects are primarily due to the elevated temperatures during machining. Thus, the two types of damage (white layer and tensile residual stress) are related and have generally been investigated together.

Several publications have proposed that white layers may have increased hardness relative to the bulk material Tonshoff et al [78], Brinksmeier et al [79], Akcan et al [69]. Others have reported
nearly identical hardness in the white layers compared with the bulk material, **Chou and Evans et al [80]**. Micro-hardness and residual stresses are used to identify mechanical and thermal influences on the work piece and then relate to functional behavior, **Tonshoff and Brinksmeier et al [81]**. The hard machined fatigue samples exhibited slightly increased endurance limits compared to ground samples during the machining of AISI 4340 at 58 HRC Steels, **Matsumoto et al [82]**. The axial fatigue tests on hard turned bars revealed that the bars turned with PCBN tools performed better than bars machined with alumina tools and also better than ground surfaces, **Abrao and Aspinwall et al [23]**. The hard turned and super finished components had comparable or improved fatigue life with other similar materials, **Matsumoto et al [82]**.

### 2.9 MODELING OF MACHINING PROCESS

**Subramhanyam and Rambabu et al [83]** explained the modeling to predict the surface roughness in turning operation. To meet the technical specification initially in any manufacturing process is to determine the values of the process parameters that would yield product quality. Finally to maximize the manufacturing system performance within the available resources, **Dong Youn Jang, et al [84]**. By the use of computer controlled machine tools, with more predictive models have brought up the machining process more productive, **Gopal and Rajmohan et al [85]**. Prediction and identification of surface roughness has been the subject in the
manufacturing field. The available methods are briefly explained in the following.

- **Classification of approaches**

  The classification of surface roughness prediction models are

  (i) Machining theory based approach.

  (ii) Experimental investigation approach.

  (iii) Designed experiments approach.

  (iv) Artificial Intelligence (AI) approach.

2.9.1 **Machining theory based approach**

There are some theoretical models that relate surface roughness to cutting conditions such as the feed rate. The models are generally not accurate so their improvement with the introduction of additional parameters is examined by researchers. The integration of these factors to the already existing models is estimated to increase their accuracy, especially in cases of finishing procedures where their influence is greater.

**Grzesik et al [86], predicted surface roughness in turning by using the minimum under formed chip thickness.** Mathematical models are developed for tribological effects at the chip cutting tool interface. The approach was based on the assumption that the difference between the theoretical and measured surface roughness values due to adhesion at the chip cutting tool interface. The output of the model for predicting the surface roughness of a turned surface was improved with reduction in predicted values.
2.9.2 Experimental investigation approach

Rozario Jegaraj and Ramesh Babu et al [87] explained that the important factors consider for experimentation and the results obtained are used to investigate the effect of each factor as well as the influencing mechanism on the observed quality characteristics. Based on the experimental data regression model was developed. The experimental approach is used where there is no analytical formulation of the cause and effect relationships between the various factors.

Abouelatta and Madl et al [88] reported the relationship between tool life, surface roughness and vibration. On-line roughness measuring technique was developed for studying the effects of cutting vibration during hard turning, Jacobson et al., [32]. A detailed investigation was carried-out concerning the effects of the cutting edge geometry and work piece hardness on the surface finish and cutting forces in the finish hard turning of steel, Thiele et al [90]

2.10 DESIGN OF EXPERIMENTS BY TAGUCHI

Designed experiments approach constitutes a systematic method concerning the planning of experiments, collection and analysis of data with near-optimum values. The Response Surface Methodology (RSM) and Taguchi techniques for design of experiments (DOE) seem to be the most wide spread methodologies for the surface roughness prediction problems, Choudhury and El-Baradie et al [91], Paulo Davim et al [77].
2.11 REVIEWS ON OPTIMIZATION OF MACHINING PARAMETERS

Farhad Kolahan, and Mahdi Abachizadeh et al [92]. Simulated annealing algorithm is developed to optimize machining parameters for cylindrical part. The objective is to achieve minimum total cost with seven different constraints for non-linear model. Results revealed that proposed optimization procedure has considerably improved total operation cost by optimally determining machining parameters.

Y. J. Cao and Q. H. Wu et al [95]. Presented an attractive approach for a teaching genetic algorithm with an illustrative example. And revealed GA is capable of finding global or near-global optimum solutions of multi nodal function.

F. Cus, U. Zuperl et al [97]. Particle swam algorithm effectively used to optimize multiple conflicting objective. The results revealed that the objective function maximization of cutting force surface by considering cutting constraints.

Lixin Tan et al [74]. Proposed using genetic algorithm to optimize the PI regulator parameter in simulation system. In this study the dynamic characteristic of the prime mover simulation system compared the step characteristics under the conditions of the genetic algorithms and traditional method by MATLAB simulation. The results revealed that genetic algorithm can optimize PI parameters quickly.

C. Natarajan, S. Muthu and P. Karuppuswamy et al [98]. With a suitable optimization method for minimizing surface roughness is
applied and to predict the surface roughness an ANN model is designed with back propagation network.

G. Krishna Mohana Rao, G.RangaJanardhana, D. Hanumantha Rao, and M. Srinivas Rao et al [99]. Developed a hybrid model in EDM and optimizing the MRR using ANN and GA. By using neuron solution package multiceptron neural network model were developed. For optimizing weights of the concept of genetic algorithm is used. The developed model is within the limits of agreeable error.

V.N. Gaitondea, S.R. Karnikb, J. Paulo Davim et al [28]. To determine optimal amount MQL for turning of brass using K10 carbide tool with appropriate cutting speed and feed rate. For minimization of surface roughness and cutting force Taguchi technique with utility concept, a multi response optimization method was proposed. For determining the optimal parameter level and identifying the level of importance of the process parameter ANOM and ANOVA on multi response signal-to-noise (S/N) were employed.

Palanikumar, k. And karthikeyan et al [126]. For turning of particulate metal matrix composite for maximizing metal removal rate and minimizing surface roughness were evaluated using Taguchi and response surface methodologies.

V. Gecevska a, f. Cus b, f. Lombardi c, v. Dukowski a, m. Kuzinowski et al [101]. Proposed optimal determination of the cutting parameter by using deterministic method and genetic algorithm formulated a complex mathematical model for designing of
the cutting conditions for machining process. In the second stage a numerical algorithm for optimization with software OPTIMAD (optimization of milling and drilling) by using deterministic method.

**Yue Jiao, Shuting Lei, Z.J.Pei, E.S.Leeusee et al [102].** Modelled fuzzy adaptive network in machining process to predict surface roughness. The results revealed that the feed rate is most significant also the approach is more powerful than the classical regression approach.

**Farhad Kolahan1, A. Hamid Khajiavi et al [103].** Taguchi method and Regression modeling are used to establish the relationship between input and output parameters for machining 6063-T6 Aluminium alloy. In first stage ANOVA is applied and the proposed model developed is embedded into a Simulated Annealing algorithm to optimize process parameters and to set objective process parameters such as depth of cut etc.

**Sanjeev dhawan, kulvinder s. Handa, rakeshkumar et al [104].** Tested for optimization of software testing using genetic algorithms. Study of optimization of software testing techniques by using Genetic Algorithms (GA’s).

**UrosZuperl and Franc Cus et al [105].** For a complex optimization of cutting parameters a neural network based approach was proposed. In this technological, economic organization and organizational limitations a multiobjective optimization is developed for cutting conditions. A neural optimization algorithm is developed to predict for higher precision.
Indrajit Mukherjee, Pradip Kumar Ray et al [106]. Said that application of optimization techniques in metal cutting is essential in manufacturing to withstand severe competitions and to produce quality product to meet the required demand. Application of potential of several modeling and optimization techniques in metal cutting has been centrally examined for the benefit of selection of an appropriate model a generic framework for parameters optimization in metal cutting process is suggested.

S. M. Ali, and N. R. Dhar et al [107]. In machining tool wear and surface roughness prediction plays a major role in machining industry and optimizations of the parameters are more significant. ANN with feed forward back propagation network with 25 hidden neuron selected for the optimization network.

A. Kohli · U.S. Dixit et al [108]. Proposed ANN methodology for predicting surface roughness in turning process. The upper and lower estimates of surface roughness are predicted. By using the back propagation algorithm the network model is trained with trained data. It is found automatically the learning rate, the number of neuron in the hidden layer, the error goal is an adaptive manner.

2.12 OBJECTIVES

Based on the literature review on metal cutting, tool materials, surface roughness and metal removal rate etc., the following objectives are formed by selecting the work material as AISI 4340 and cutting tool materials CVD and PVD.
1. To study the influence of cutting parameters on AISI 4340, with CVD and PVD tools.

2. To study the effect of Surface roughness, Metal removal rate and power consumption on AISI 4340 work piece with CVD and PVD tools.

3. To study the influence of strength factor along with cutting parameters between work piece and tools.

4. To simulate experimental data on Surface roughness, metal removal rate, power consumption using ANN and GA.

5. A multi objective GA is used for minimization of surface roughness, maximization of MRR and minimization of power consumption by assigning weight functions for each objective.

The chapter deals with applications of hard turning and the requirements for hard turning cutting are also discussed. Hard turning and coating tools such as ceramic tools, CBN, carbides, silicon nitride based are discussed and presented precisely. It is found that cemented carbide tools generally are not suitable for machining high hardened steel. There are recent improvements of carbide tools like restricted contact and the use of various coatings on carbides. A short introduction on indexable inserts is also discussed with ISO designated cutting tools. Many researchers in the present decade are showing much interest on coated cutting tools. In the present study the selection of CVD & PVD tools, cutting parameters and objective of present work is given in detail.
Based on the literature review, it is observed that most of the researchers presented their work by implementing statistical analysis (ANOVA), simulation techniques by Artificial Neural Networks (ANN) and optimization technique by Genetic Algorithm (GA). The methodological procedure is explained in the next chapter.