CHAPTER - 2

LITERATURE SURVEY

The literature survey covers all the aspects regarding optimization, design of feed using Electro mechanical, hydraulic, CNC etc., and cost, value, quality analysis, algorithm development and optimization of cutting conditions for fine boring operation.

2.1 OPTIMIZATION

The optimization of special purpose machine tool (fine boring machine) was developed from the fundamentals of optimization techniques. (James N.Siddall 1995 -1). Some of the industrial applications like the optimum design of moulded and cast parts were studied. Marc Weinstein and Souran Manoochiehri 1997 (2) presents a methodology for obtaining an optimum design of mould tool for an injection moulded or die cast part based on part geometry. Another paper by Hyeong – Soon Moon and Suck-Joo Na, 1997 (3) design based on mathematical model and Neural Network to predict weld parameters for fillet joints also deals with industrial applications of optimization. The paper deals with finding the reference of appropriate welding conditions by optimum design. Industrial application of optimization based on Mathematical modelling was studied. D. Srinivasan, R. Saravanan, S. Gopal and Dr.S.Sachihanandam 2001 (4) in their paper have taken effort to optimize machine tool gear box using genetic algorithm.
2.2 MACHINE TOOLS

The fundamentals of machine tool design is studied next. Machine tools are nothing but instruments which have been created for the purpose of manufacturing wide range of products of all categories.

All types of machine tools were developed from the beginning of the last century and remarkable advance has been made all over the world in the design and development of machine tool. This will be clear by mere critical comparison between a machine tool built today and a few decades back.

The types of machine tools used in metal processing in the last century are general purpose machines, special purpose machines & CNC machines. In this the machine taken for our study is a special purpose machine tool namely fine boring machine. This machine was developed by HMT Ltd., Bangalore.

2.2.1 A brief history of machine tools in India

Though manufacture of machine tools in India dates back to early twentieth century, planned production of the same started only after independence when the giant public sector undertaking Hindustan Machine Tools at Bangalore came into existence. Amongst the pioneers in the field, it is Mysore Kirloskar that produced conepulley lathe in 1941. Subsequently considerable emphasis was laid on the production of the indigenous machine tools during our first five year plan and the target production of machine tools in subsequent plans. In effect there was a rapid progress in building `mother machines' which could serve as infrastructure for manufacturing engineering and other commodities. Today the Hindustan Machine Tools which is the
biggest machine tools complex in India has opened up a new promise in the field of building indigenous precision machine tools in diversified field with up-to-date technological know how.

Fine boring machine was developed from the principle of horizontal boring machine. The factors to be considered for design is developed from F.Koenigsberger D.Sc J.Tlusty, 1990 (5). Whereas Horizontal boring machine is having only one spindle, fine boring machine is having 4 spindles. So the productivity is increased. Our concern is optimisation of feed drive of fine boring machine by modifying the system. So in literature survey I want to mention how drives were developed in machine tools.

The drives which were developed first was stepped drives.

2.3 DRIVES

2.3.1 Designing of stepped drives

1. There should be sufficient speed changes to divide the total range into increments between 10 and 15%.

2. Entire range of speed should be obtained without stopping the motor.

3. Any speed desired should be made without making all the intermediate changes between the present and the desired speed.

4. All changes should be obtained within the machine tool itself, without using any auxiliary countershafts.
5. Only the gears, through which the speed is actually obtained, should be engaged at one time.

6. Minimum possible number of shafts, gears and levers should be used.

7. As far as possible the control should be made centralized and to the advantage of the operators.

For the design of electro mechanical feed system based on stepped drives design, a complete study was made on different types of possible drives.

Gunter pritschow, Jochen Bretschneider 1999 (6) mention about the control systems used for Electro Mechanical servodrives in machine tools. Hermann Glockner (1999 - 7) points out using modern manufacturing methods Parallelism as little as 2μm can be consistently produced. Precision rail guides have proved to be a suitable guidance solution for high precision table design. Bernhard Bork and Hua Gao Darmstadt 1998 (8) point out growing requirements as to dynamics and accuracy of machine tool increasingly necessitate the use of linear direct drives.

Gunter pritschow 1998 (9), in his article compares linear drives with Electro mechanical drive. This article gives us an understanding about Electro mechanical drive and linear drive Pritschow .G 1996 (10) in his article gives increasing accuracy of linear drives in manufacturing system.

Pritschow, G., 1996 (12) explains about the influence of the Velocity Gain Factor on the Path Deviation.


Karita, M., Nakagawa, H., Maeda, M., 1995 (15) in their article analyse High Thrust Density Linear Motor and its Applications.

Zirn, O., Glattfelder, H., 1997 (16) discuss Stability Analysis for the Design of Fast Axes Feed Drives

Pritschow, G., Phillip, W., 1990 (17) explain on the Efficiency of Feed forward Controllers in Direct Drives.

Van Brussel, H., van den Braembussche, P., 1998 (18) give out an article on Robust Control of Feed Drives with Linear Motors.

H.K.Tonshoff and C.Lapp 1999 (19) explain the design of machine tool structures for drives.

The design of fast machine tools which offer high manufacturing accuracy by employing high performance axis drives require careful design of not only of the individual components of the machine but of the entire machine structure.
The overall consideration of the machine tools with its critical components such as structure, frame and drives represents a viable approach to adhering a qualitative improvement with regard to increased dynamics and accuracy. During conceptual design phase of a machine tool for high speed machining, special attention has to be given to its structure and frame to take care of very high inertia loads as a result of high acceleration caused by the feed drives.

U.Heisel.F Ziegler and J.O. Hestermann 1999 (20) point out machine tools with parallel Kinematic structure are known as 3 Axis. 5 Axis machines. This type of machining necessitates high precision requirement.

Heisel, U; Richter, F; Wurst, K.H. 1997, (21) discuss Thermal Behaviour of Industrial Robots and Possibilities for Error Compensation.


Eiji Shamoto, Hirokazu Murase, Toshimichi Moriwaki, 2000. (27) explain Ultraprecision 6-Axis Table Driven by Means of Walking Drive.

Yonezawa.H et.al. 1990 (28) presents Table positioning with high accuracy and high speed.

Shamoto, E. and Moriwaki, T., 1997 (29) deal with Rigid XY0 table for Ultraprecision Machine Tool Driven by Means of Walking Drive,

Shamoto, E. and Moriwaki, T., 1992 (30) analyse Walking Drive-A New Precision Feed Drive.

Higuchi, T. et.al., 1988, (31) deal with Precise Positioner Utilizing Rapid Deformations of a Piezoelectric Element,

Shamoto, E., Shin, H. and Moriwaki, T., 1995 (32) discuss Ultraprecision Feed Drive System Based on Walking Drive.


The recent trend in machine tools is to develop high speed feed drives which lead to reduction in machining cycle times. In addition to the design of feed drives with acceptable structural dynamic and thermal performance the servo control system must maintain the contouring accuracy along complex trajectories at high feed & speeds. Conventional machine tool feed drives
employ proportional position control which leads to large tracking errors and thus contouring errors at high speeds. The tracking error is minimised by using high performance feed drive motors with a large band width. Ball screw drives with large motor constants and compensated dynamics or linear drives with large band width are preferred.


YaO.B. A1-Majed M.Tomizukma M. 1997 (41) give out an article which describes high performance robust motion control by machine tools.
Slotine, J-J., Li., W., 1988, (42) deal with Adaptive Manipulator Control: A Case Study, on Automatic Control,


Altintas, Y., Erol, N.A., 1998 (44) deal with Open Architecture Modular Tool Kit for Motion and Machining Process Control,

The gear box working under the principle of change gear drive has 1) Simplicity, 2) Low cost, 3) Safety in use and maintenance, 4) Accurate speed ratio. But this is not the ideal drive.

The ideal speed range is undoubtedly the one which gives an infinitely variable range between the maximum and minimum speed selected. This approaches as the number of speeds go on increasing towards "stepless drive".

In the field of machine tool drives we are more and more drifting towards individual drive that is to say each machine being driven by a separate motor. Every buyer of machine tool will like to have as many number of feeds as possible on his machine, even though the workers will be using only a few until and unless under strict supervision.

The tendency has a natural leaning towards stepless regulation.

2.3.2 Stepless drive

Stepless devices of speed and feed-rate regulation are generally more expensive than the devices providing stepped regulation. They, however,
possess certain features which make their application economically feasible in certain cases. These features are:

1. **Possibility of carrying out machining operations at optimum cutting speed**: This not only improves productivity, but also increases the tool life. This factor is particularly important in high-speed machining with carbide tools, because at cutting speeds exceeding the optimum value, the increased productivity is often offset by sharp decrease in tool life; on the other hand, machining at speeds less than the optimum reduces productivity as well as tool life.

2. **Ease of changing the speed or feed rate without stopping the machine tool**: This helps in increasing productivity as it cuts down the nonproductive time.

3. **Noiseless and more smooth rotation and absence of jerks which are characteristic of geared drives.**

These features explain why stepless devices are generally employed in high-speed machine tools.

2.4 **HYDRAULIC DRIVE**

Special correspondent of engineering advances 1998 (45), says that hydraulic and pneumatic technologies are largely complementary while hydraulic technology tends towards heavy engineering application and pneumatic technology is tilted towards light engineering. The major application of hydraulics include tractors, construction and earth moving equipment, machine tools, mining machinery and mechanical handling
equipment. Our design of hydraulic cylinder piston table arrangement, hydraulic valves, power pack are based on hydraulic design (CMTI Hand book, 1995 - 46).

Robert E. Koshi 1998 (47) mention about manually operated hydraulic valve will be displaced starting with large sophisticated equipment in future.

Michael Valenti, 1996 (48) points out Improving Hydraulic performance with intelligent valves.

Andrew Delaney 1996 (49) points out that in industrial situation where fluid power is routinely employed linear motion may be converted to rotary action by the use of rotary actuaters. These offer a safe cost effective alternative to mechanical and electromechanical options providing instant constant torque high external load capacity and long life.

Parker 1996 (50) says steel production is one of the most intensely competitive industries in the world creating a constant pressure to drive down operating costs. Technology can be used to great effort by reducing labour content improving reliability and increasing output. The same can be tried in machine tools also.

2.5 CNC DRIVES

CNC design is dealt in Mechatronis HMT Ltd. 1998 (51).

Hans Cross 1993 (52) deal with Electrical Feed drives for Machine Tool.

Y.C. Shin S.Hu and T.J. Choi (53) give out in their article that conventional computer numerical controllers used for machine tools are not
amenable to the adoption to dynamic changes in operation and environments due to the property of closed architecture. The paper presents the design and development of a distributed open architecture modularity and other desirable characteristic with application of object oriented, methodology. Fundamental agents related to machine tool system are identified and distributed system architecture is achieved.


Ardekani, R. and Yellowley, I., 1996., (55) explain "The Control of Multiple Constraints Within an Open Architecture Controller",

Gore, R., 1994, (56) discusses "Open Architecture Controllers for Advanced manufacturing",

Hu, S. and Shin, Y.C.k, 1998, (57) explain about "Simultaneous In-Process Roughness Control and Tool Wear Monitoring via a Distributed Open Architecture Controller".


Teltz, R., Urbasik, R., K. and Elbestawi, M.A., 1994, (63) analyse "Intelligent, Open Architecture Control for Machining Systems".

Wright, P.K. and Greenfield, I., 1990, (64) discuss "Open Architecture Manufacturing: The Impact of Open System Computers on Self Sustaining Machinery and the Machine Tool Industry".

Yellowley, I. and Pottier, P.R., 1994, (65) explain "The Integration of Process and Geometry Within an Open Architecture Machine Tool Controller".

H.K. Ton Shoff G. Gunther and H. Grandel 1999 (66) explain parallel kinematics are on their way to the market. Different parallel and hybrid systems were proposed and realized in recent years. Due to different structures and drive principles design possibilities are numerous. In order to be able to compare the different systems among each other there is a need to establish a comparison criteria.

In this paper different characteristics such as work space stiffness and isotrophy are used to evaluate the most used strut arrangement and drive system.

Hollingum, J.; 1997. (68) discuss about Hexapods to take over?, Industrial Robot.


Takeda, Y.; Funabashi, H.; 1996. (71) discuss Kinematic and Static Characteristics of In-parallel Actuated Manipulators at Singular Points and Their Neighbourhood.

2.6 COST ANALYSIS

Over one hundred year ago Queen Victoria was still in the throne of England then the fourth bridge in Scotland was under construction George Pepler Norton had his book entitled "Textiles Manufacturer's book keeping" published.

The book devoted a whole chapter to what he described as the stock and cost books plus illustrations of specimen forms. After careful investigation and various modification he designed a number of forms for recording costing purposes (e.g) inventory stock and cost records, product costs production fixed assets etc.
A book published in 1924 by ICS (International Correspondence schools) describes a costing system as simply a method of accounting which makes it possible to ascertain cost. However it then goes on to point out that costing system does have other objectives namely to.

* Point out the way to economical working of the factory.
* Produce evidence of waste in terms of time or materials.

The eleventh edition by ICS, published in 1965 included several topic areas not covered by the two books said earlier. This edition included a comprehensive coverage of budgetary control, standard costing, marginal costing and profitability and mechanised accounting backed by wealth of worked examples.

A review of more today's leading tests on the subject provides us with an insight into what is regarded as cost and management accounting and also with an indication of the changing role of cost and management accountant.

Introduction to management accounting is referred from Gary.L.Sundem William O.Stratton, 1998. (72)

Cost of component manufactured from each type of drive is calculated using Lawrence Matthews 1983 (73). Return on investment is calculated using various methods with James C.Van Horne John.M. Wachowicz. Jr. 1996 (74) Break even chart is made for 3 type of feed system. Lawrence P. Bentz 1978(75) in his article points out manufacturing firms of all sizes are adopting modern technique for analysing optimizing costs. Direct labour cost is optimised using linear programming to find the breakeven point at which the
total cost of a two shift operation would equal the total cost of one shift with a given amount of over time.

Pravin P. Shah 1981, (76) discuss about cost control and information system.


Kaminskaya, V.V. et al., 1975. (78) explain Computer aided calculation of optimum dimensions of machine tool components and assemblies.

Levin, A.I. 1979. (79) gives out Structure and organisation of an automated sub-system.

Kim, E.N. 1979. (80) discusses Set of programs for automated design of milling machine gearboxes.


J. Todorovic 1982 (83) points out that the cost effectiveness refers to all stages of product life cycle among which the highest importance is attached to research and development, production and product usage. Various costs have impact on cost effectiveness. In a number of cases maintenance costs is of highest influence. All types of costs were analysed. Deyi Xue 1987 gives a multilevel global optimization approach considering product realization process.
alternatives and parameter of these alternative is proposed to improve manufacturability measures. This approach is helpful in optimization based on cost analysis.

The overall cost is calculated based on direct labour direct material and overhead. J.Richard P. Martin M.Veron, B.Mutel 1978 (84) mention. "The optimal working point is a function of the cutting rate and tool life for obtaining optimum cost of machining".

After comparing the feed system based on cost analysis, next the feed system are compared based on theory of value.

2.7 THEORY OF VALUE

Parker, D.H. 1957 (85) provides possibly the most pragmatically useful definition to Engineers on theory of value. He defines value as the objective desire. It is that experience which would satisfy desire.

Cohen, J.B. 1972 (86) in his book has written about motivation personality and learning with seven chapters of articles but different authors many of which gives ideas about theory of value.

Edwards W. and A. Tversky 1967 (87) explains the relation between utility and value. A typical economics definition for utility is (Samuelson 1964) "Total utility refers to the entire amount of satisfaction from consuming various quantities of commodities".

Stark R.M. and R.L.Nicholls 1972 (89) have given about the final approach in Theory of value the money criteria. They have explained the money criteria is measured by minimum first cost, minimum annual cost, maximum annual profit and maximum return on investment.

Tim Richards 1997 (90) points out components for generating linear motion begin with lead screw. This is comparatively a cheap option as it lacks sophistication of rolling element resulting higher torque & less efficiency. Ballscrews cover a wide range of possibilities from low cost to fairly accurate ground screws for machine tool use. They employ the same principle but with a ball rolling element that improves durability. This article is used for comparing Electro- mechanical feed with CNC feed.

James Haigh, 1996 (91) in his article explains Direct Torque control (DTC) drives have been designed to produce full torque at zero speed. This is achieved by overcoming the limitation of flux vector by controlling the flux and torque directly. Also says about safety of drives. A semiconductor fuse is better than standard fuse as the semiconductor's response time is much faster and can prevent the power surge reaching the drive.

Bruce W.Main and Kristern, J.McMu 1999 (92) says safety through is a process or an approach to safety that relies heavily on engineering controls rather than employee behaviour interventions. These controls include analysis developed to identify and reduce hazards with design changes before problem emerge. Safety through design seeks to minimise hazards. There are several key reasons why safety through design process attracting interest including cost competition, international influence, risk assessment, advance legal requirements.
This article help in analysing safety aspect of feed system.

Roland and Moriarty, 1990, (93) deal with System Safety Engineering.

Main. B.W., Ward, A.C., 1992, (94) deal with safety aspects of machines and education and training for safety.

Dembe, Allard E., 1996, (95) explain future of safety.


Robotics Industries Association, Ann Arbor, MI, Stanmdard R15.06 Safety Requirements (under review). (97) in this article deals with safety requirements.

Compendium of the 1996 (98) discuss Integrating Safety Through Design.


Hammer, W., 1989, (100) deal with Occupational Safety Management and Engineering,

1997 Design safe... the hazard analysis and risk assessment guide, (101) deals with design safety
Different functions of 3 feed system are compared. Robert B. Stone and Kristin L. Wood (2000) state functional models represent a form independent blue print of a product. As with any blue print of schematic a consistent language or coding system is required to ensure other can read it. This paper introduces such as a design language called a functional basis where product function is characterized. This article is useful in our analysis to compare the functions of feed mechanism.

2.8 QUALITY ANALYSIS

The earliest records of the beginning of quality control go back to 1924. when Walter A. Shewhart of Bell Telephone Laboratories first applied a statistical quality control chart to manufactured product. Subsequently Shewhart authored a book Economic Control of Quality of Manufactured product published in 1931 by D. Van Nostrand Inc., New York. The early 1940 saw development and use of sampling tables for acceptance inspection plus publication of military sampling tables and endorsement of their use by the armed services.

Stone, R., Wood, K., and Crawford, R., 1998, (103) have developed "A Heuristic method to identify modules from a Functional Description of a Product."


Pimmler, T., and Eppinger, S., 1994, (105) discuss about "Integration Analysis of Product Decompositions,"

Collins, J., Haga, B., and Bratt, H., 1998, (107) point out "The Failure-Experience Matrix-a Useful Design Tool,


Malmquist, J., Axelsson R., and johansson, M., 1996, (109) have done a comparative analysis.

Details of quality analysis is explained in the thesis. Statistical quality control aspects are dealt in the thesis. Frequency polygon, barchart, Histogram, process capability for 3 feed mechanisms were discussed in Bertrand and L.Hansen Prabhakar M.Ghare 1993(110) and Bharat Wakhlu 1994 (111).

Vinod Bhat, Edward C, De Meter, 2000 (112) point out geometric error of machined features.

ANSI Y144.5 M-1994 (113) discuss about Dimensioning and Tolerancing,

J.Hurt,1980, (114) Compare several plain fit algorithm.

X.Zhang, U.Roy, 1993 (115) have developed Criteria for Establishing datums in manufactured parts,

X.Li, M. Yeung, Z.Li, 1996, (117) have developed an algebraic algorithm for workplace localization.


E.J.Salisbury, F.E.Peters, 1998, (120) explain about The impact of surface errors on fixture workplace location and orientation.

Barbara J. Hoopes and Konstantinos P. Triantis 2001(121) say that data development analysis provides an assessment of the efficiency of performance of production process by including in its modeling frame work technologically critical input/output variables. In order to create the conceptual linkage to traditional control charts, input/output production specifications may use the concept of design, process and product characteristics. Process control charts track the variability and central tendency of production processes by studying the stochastic behavior of a single product characteristic. On the other hand efficiency measurements approaches include, as part of their evaluation, the entire set of critical product and/or process characteristics simultaneously. This research shows that these two approaches can be used in a complementary manner to identify unusual or extreme production instances, benchmark production occurrences, and evaluate contribution of individual design and product characteristics to the overall performance of the production process.

2.9 ALGORITHM DEVELOPMENT FOR PREDICTING OPTIMUM DESIGN AND OPTIMISATION OF CUTTING CONDITIONS FOR FINE BORING OPERATION.

Gowri Sankar 2002, (126) in his article explains about Deterioration A statistical quality control analysis.

V.C. Jacob, T.R. Natesan V. Rhymend, Uthariaraj 2002, (127) have developed Analysis of Hybrid Heuristic model reduction algorithms for solving linear programming problem.


M. Week, O. Broemsen 2002, (129) have developed Computer System for tooth root optimization of case hardened gear wheels.

Chung T.S., Hwang S.M. 2002, (130) have solved design problem by genetic algorithm.

Pal. D.K., Patkar M.R., 2003, (131) in their article Multi objective optimization of machining parameters in turning operation have developed an optimisation model for turning operation with objective function as
production time and constraints as surface finish, power, tool life, tolerance, maximum minimum speed, feed, depth of cut etc. The second objective function is taken as machining cost.

A.Thillaivanan, A. Ashokan, G.Prabahaharen 2003, (132) in their article present Determination of optimal cutting parameters for the wire EDM process using Non Traditional Optimization Techniques.

Y.S Tarng S.C.Ma and L.K. Chung 1995, (133) also in their article present Determination of optimal cutting parameters in wire electrical discharges machining.


EI – Gizway, AS; EI-Sayed, J.J. 2002 (136) have developed multiple objective based strategy for process design of machining operations.

QU; T.Shih, AJ; Scatter Good, RO 2002, (137) have done optimisation analysis on Development of the cylindrical wire electrical discharge machining process. Pt1 concept design and material removal rate.

Wang.J; Kuriyasawa, T., Wei, Xp; Guo, DM 2002, (1‘38) have done optimization of cutting conditions for single pass turning operations using a deterministic approach.
Jordaan, JP; Ungerer, C.P 2002, (139) discuss about optimization of design tolerance through response surface approximations.

Reyer, J.A; Papalambros, PY 2002, (140) discuss combined optimal design and control with application to an electric DC motor.

Gadallah, MH; El-Mounyri, H 2002 (141) in their article explain about Exhaustive Search approximations in design optimization; An algorithmic implementation.

His – Yung Feng; Ning Su 2000, (142) have developed Integrated tool path and feed rate optimization for the finishing machining of 3D plane surfaces.

Mahmoud Shalta, Christian Kerk, Taylon Altan, 2001 (143) discuss about Process modeling in machining part 1, determination flow stress data.

Kaan Erkorkmaz, Yusuf Altintas 2001, (144) in their article explain about High speed CNC system design Part -II modeling and identification of feed drive.

Neelesh K.Jain Vijay K.Jain 2002, (145) have developed a model on material removal rate.

Jinsoo Kim Sangkee Min David A.Dornfeld 2001, (146) discuss about Optimization and control of drilling burr formation of AISI – 304L and AISI 4118 based on drilling burr control charts.

E.J.A. Armarego, A.B. Herath 2000, (148) discuss about predictive model for machining with multi edge form tools based on generalized cutting approach.

James B. Taylor and Andres L. Carrano 2000, (149) explain about parametric design and optimization for nonlinear precision X-Y micro stage.


Arvind K. Sridharan and Sanjay Joshi 2001, (151) have developed an algorithm for the optimization of extraneous material removal in laminated object manufacturing.

Y.X. Chu, J.B. Gouad Z.X. Li. 1999, (152) have developed workpiece localization algorithm performance evaluation and reliability analysis.