Design and Development of Honing Tool

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Abstract – *The objective of this research work is on achieving a greater surface finish on the internal diameter of a guide. This guide is a part of the gate valve assembly. We have focused on eliminating the grinding process and replacing it completely with honing in order to achieve a mirror like finish on the concerned surface. In order to attain the set goal, a vertical honing machine has been put to work. In this study we investigated how to obtain the highest productivity with minimal to no rejections of the final product. Here, an oil cooled vertical honing machine (VMC) is used as an alternative for the outgoing grinding machine which helps in less chances of the product to fail in its life. This study concluded that the use of a renewed shaft with proper l/d ratio will allow a higher production rate with the least failures.*

Key Words*: *Honing, Vertical honing machine, Shaft, surface finish, rotary motion, translatory motion.

1. INTRODUCTION

In Today's era of the highly competitive environment, there is an increasing demand of high quality products which will fulfil customer's requirements. Manufacturing company has to maintain balance between quality & quantity of the product. In certain areas of applications such as oil & petroleum industry for environmental safety, quality of the product is major concern. Hence to improve the quality certain finishing operations like honing & super finishing are carried out on the component.

Basically Honing is an abrasive machining process that produces a precision surface on a metal work piece by scrubbing an abrasive stone against it along a controlled path. Honing is used to improve primarily the geometric form of a surface, but may also improve the surface texture. Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles, hydraulic valves and gears. There are so many types of hones but all of them consist of one or more abrasive stones.

Honing is carried out on horizontal or vertical honing machines equipped with hydraulic or pneumatic cylinders. The limitation on geometric accuracy is thus overcome in honing because the honing stone follows a complex path.

1.1. Objective

The list of Objectives to be achieved are as follows:

1) To avoid deep line marks on the internal surface of the guide
2) Avoiding indentation marks on the surface
3) Reducing ovality of the guide within suitable limit
4) To avoid rejection of the guide
5) Reducing the cost due to rejection of guide

1.2 Root Causes & Solutions

Causes:
- Weight of the shaft
- Increased L/D ratio
- Selection of material

Solutions:
- Increasing the weight of the shaft
- Optimizing the L/D ratio
- Selecting suitable material

1.3 Methodology

As per the analysis of the problem, we observed that the l/d ratio and weight of the shaft was a crucial factor in the shaft design. Hence we made modifications in the shaft design keeping the l/d ratio as low as possible.

Also we used different material having higher strength than mild steel i.e., medium carbon steel. Also it has high density, so ultimately weight is also increased.

As due to misalignment of shaft, the tool was also deviating from the center line so we provided guiding stick to the tool such that it will remain along the center line.

2. Theory:

2.1. Honing

Honing process is a low velocity abrading process in which stock gets removed from metallic or non-metallic surfaces with the help of bonded abrasive sticks. It is one of the finishing operation employed not only to produce high finish but also to correct out-of-roundness, taper and axial distortion in work piece. In honing, because there is a simultaneous rotating and reciprocating motion is given to the stick, the surface produced will have a characteristic cross-hatch lay pattern. Depending on size and shape of work pieces honing can be performed by following two methods.

2.1.1. Manual Stroking:

Manual stroking is used in preference to power stroking for large verities when tolerances are extremely close and when the size and shape of the work piece permit the operation. One of the main advantage of manual stroking is that the work pieces need not be fixture and this reduces tooling investment and permits immediate changeover from one job to another. The techniques which are used to obtain the required accuracy during manual stroking include end to end reversal of work-pieces, change of stroke length and quick 'hone and try'. Also there are various areas where a given part require differing degrees of correction because of bell mouth, taper or other irregularities, the operator can make the necessary corrections as stroking proceeds.

2.1.2. Power Stroking:

Power stroking method can be used for honing virtually all types and sizes of work-pieces. Here mass production power stroking is better than manual stroking. In power stroking method, fixturing is required for work pieces that exceed the size or weight that can be handled manually. An example of this category is the long bore hydraulic cylinder. Reducing the cost due to rejection of guide

2.2. Honing Stone

Honing stones which are sometimes known as honing stick consist of particles of aluminum oxide, silicon carbide and diamond bounded together with play, resinoid, corn, carbon etc. Following is the porosity of the structure of the stick, depending on the mixture of grit and bound, methods and pressure used in the forming the sticks, facility cheap clearance, thereby minimizing the generation of heat.

1. Grit size :- The size of grit may range from 36 to 600, but the size raging 120 to 320 is most widely used. Selection of particular grit size mainly depends on the desired rate of material removal and required finish. In this the course grit removes the metal faster but results in rougher finish.

2. Abrasive :- i) Selection of the abrasive depends mainly on the composition, hardness of the metal being honed, finish required and the cost ii) Normally aluminum oxides for the steel and silicon carbide for CI and nonferrous materials are used as abrasives. iii) Diamond is used for honing extremely hard and wear resistant materials such as tungsten, carbide or ceramics.

3. Designation of honing stones :- i) The marking system employed for designation of grinding wheels is also applicable for honing stones. ii) The marking normally specifies types of abrasive, grit size, hardness and type of bond.

2.3. Honing Tool

It is basically a cylindrical tool which is used for finishing of the components like Hydraulic / pneumatic Cylinders Liners, Diesel Engine Connecting Rods, Hydraulic Valves, Crank Cases, cylinder Body for 2 & 3 Wheelers, compressors cylinders etc. on batch & mass production basis.

Fig -1: Honing Tool

2.4. Abrasive Honing Stick

Honing stick is bonded abrasive stone made in the form of a stick. Silicon Carbide is used for stick material.

Fig – 2: Abrasive Honing Stick

2.5. Honing Machine

The honing process can be done on many general purpose machines also, such as lathes and drilling machines. In production work where the honing is to be done on a large scale, such machines will fail to give satisfactory and economical results. In such cases, the use of regular honing machines will give the desired results. These honing machines are made in various types and sizes. The most common classification of these is as follows:-

2.5.1. Horizontal Honing Machine

These machines are mostly used for honing comparatively longer jobs, such as gun barrels. All such machines carry a horizontal spindle, on which honing tool is mounted.

Fig -3 : Horizontal Honing Machine

2.5.2. Vertical Honing Machine

Vertical honing machines hold the work as well as the tool in vertical positions. They are available in both single and multiple spindle types. In D-HONER-DHV 100 the honing cycle is fully automobile. Here the operator of machine has to put the job on fixture and give the clamp command for automatic clamping and press cycle start button. The honing tool will start to rotate, reciprocate and servo expansion will start as per settable program. At the same time mechanical gauge will try to enter inside the job during this honing process. When gauge is entered inside, machine will automatically transfer to the finishing cycle. In this cycle servo will make it to count a settable pulses for final size of the job. When counting is complete the pulses cycle will stop and machine will goes home as per the program. This operation thus improves the geometrical accuracy like Taper, Ovality, Roundness and thus improves surface finish by removal of tool chatter marks etc. and increasing of the bearing contact area and maintained the CP/CPK of the job size is thereby done. D-HONER DHV 100 is vertical Honing machines capable of honing heavier components like Hydraulic / pneumatic Cylinders Liners, Diesel Engine Connecting Rods, Hydraulic Valves, Crank Cases, cylinder Body for 2 & 3 Wheelers, compressors cylinders etc. on batch & mass production basis. The range covers from 10mm - 300mm in diameters and 150mm - 1000m m in length. This machine is operated hydraulically and Honing cycle is fully automatic.

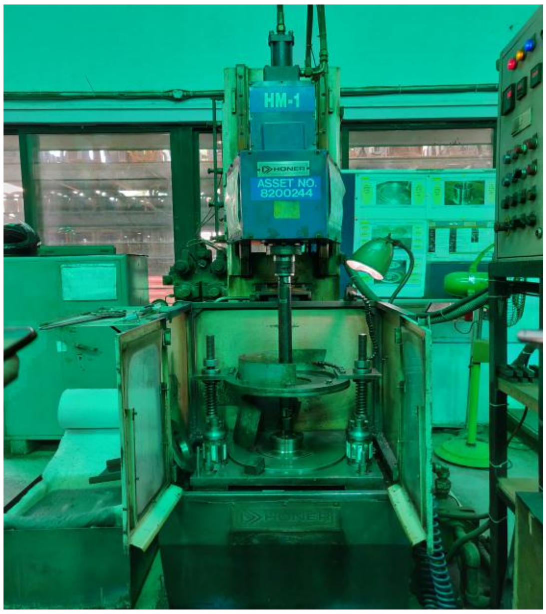

Fig – 4: DHV-100 Vertical Honing Machine

2.6. Working Principle

The principle of operation of honing consists in having rotary motion as well as its translator motion using a heavy feed rate. It requires an allowance of 0.2 mm in the hole size so that the bore can be finished fast using initially medium grit honing stick followed by fine grit honing sticks. The process requires continuously flushing out of the used abrasive grain from the honing sticks so as to avoid the abrasive grains get embedded in between the grain & result in glazing the honed surface.

Fig – 5: Working of Honing process

3. Design, Analysis and Manufacturing :

3.1 Introduction

This chapter gives detailed description of theoretical design of various components of the project. Software modeling is used for products assembly & details for further analysis. Analysis shows the results of stresses, deflection, etc used for study of assembly before manufacturing and testing of components.

3.2 Design steps

Designing a new machine component, there is no rigid rule. The problem may be solved in various ways. However the general procedure to solve design problems is as follows:

Recognization of need: First of all make a complete statement of the problem indicating the need, aim or purpose for which the machine is to be design.

Synthesis: Select the possible mechanism or group of mechanisms which will give the desired motion.

Analysis of forces: Find the forces acting on each member of the machine and the energy transmitted by each of the machine.

Material selection: Selecting the best material suited for each member of the machine.

Design of element: Find the size of each member of the machine by considering the force acting on the member and the permissible stresses for material used.

Modification: Modification of the size of the member to agree with the past experience and thus judgment of it to facilitate manufacture. The modification of shaft may also be necessary by consideration of manufacturing and to reduce overall cost.

Detailed design: Draw the detail drawing of each component and assembly of the machine with complete specification for manufacturing process suggested.

Implementation: The component as per drawing is manufactured in the workshop.

Testing: The components are tested for various parameters such as strength, stress, stiffness.

3.2.1 Material Selection

45C8

Advantages

- It has high toughness & high strength
- Coefficient of thermal expansion is less
- It is cheaper than high carbon steel
- It is easily available in the market
- No special tools required for machining

Element	**Content**
Carbon, C	0.42-0.50%
Silicon, Si	0.15-0.35%
Manganese, Mn	0.60-0.90%
Phosphorus, P	0.040 Max
Sulphur, S	0.050 Max

Physical Composition

Density	7.87 g/cc

Mechanical Properties

Mechanical property	Metric
Tensile strength, Ultimate	680MPa
Tensile strength, Yield	380MPa
Modulus of elasticity	206GPa
Bulk modulus	163GPa
Shear modulus	80GPa
Poisons ratio	0.29

Table-1: Chemical composition and properties of 45C8

EN8

Advantages

- It has high tensile strength than mild steel
- It is readily machinable in any condition
- It is easily available in the market
- It can be brought closer to the finished machine size, reducing machining cost
- It has high endurance strength

Chemical Composition

Element	Content
Carbon, C	0.36-0.44%
Silicon, Si	0.10-0.40%
Manganese, Mn	0.60-1.00%
Phosphorus, P	0.050 Max
Sulphur, S	0.050 Max

Physical Composition

Density	7.85 g/cc

Mechanical Properties

Mechanical property	Metric
Tensile strength, Ultimate	560MPa
Tensile strength, Yield	469 MPa
Modulus of elasticity	200GPa
Poisons ratio	0.29

Table-2: Chemical composition and properties of EN8

For above mentioned advantages & properties we have selected 45C8 and EN8 material for the manufacturing of honing machine shaft.

3.2.2 Design of Shaft

Available Data

Power = 5 HP = 5 × 746 = 3730 watt
- Speed = 550 rpm
- Internal Diameter = 20 mm
- Length = 381 mm
- Outer Diameter =?

Selection of material
- 45C8
- Tensile strength, Ultimate (S_{ut}) = 680 N/mm2
- Tensile strength, Yield (S_{yt}) = 380 N/mm2

- Page no. 1.12 from D.D.B
- τ_{all} = 0.18Sut = 0.18 × 680 = 122.4 N/mm2
- τ_{all} = 0.3Syt = 0.3 × 380 = 114 N/mm2

Selecting minimum value of τ_{all}
i.e, τ_{all} =114N/mm2
K_b = 2
K_t = 1.5

- Page no. 1.12 from D.D.B
- Mean torque

T_{mean} = P × 60 /(2πN)
= 3730 × 60/ (2π × 550)
= 64762 Nmm
- Max torque

T_{max} = 1.2×T_{mean}
= 1.2× 64762
= 77714Nmm
- Cutting force

F_t = T_{max} × 2/ D
= 77714 × 2 /152.4
= 1019.87 N
- Bending moment

M_b = F_t × L
= 1019.87×381
= 388.57× 103Nmm
- Equivalent torque on shaft

$T_e = \sqrt{(K_b \times M_b)^2 + (K_t \times M_t)^2}$
$= \sqrt{(2 \times 407.94 \times 1000)^2 + (1.5 \times 77714)^2}$
=7.86× 105Nmm
- Max shear stress

$\tau_{max} = 16T_e / [\pi \times D_o^3 \times \{1 - (D_i \div D_o)^4\}]$
$114 = 16 \times 7.86 \times 10^5 / [\pi \times D_o^3 \times \{1 - (20 \div D_o)^4\}]$
D_o = 34.41mm
D_o = 35 mm (Std) - Page no. 7.25 from D.D.B

3.2.3 Design of Pin

- S_{ut} = 560 Mpa

S_{yt} = 469 Mpa
- τ_{all} = 0.18S_{ut}

= 0.18× 560
= 100.8 N/mm²
- τ_{all} = 0.3S_{yt}

= 0.3 × 469
= 140.7 N/mm²

Selecting minimum value of τ_{all}
i.e, τ_{all} = 100.8 N/mm²
- $T = 2 \times (\pi/4) \times \tau \times Do \times d_p^2$

$7.86 \times 10^5 = 2 \times \pi/4 \times 100.8 \times 35 \times d_p^2$
d_p = 9.52
d_p = 10 mm

The dimensions of the tool holder are taken as per the standard dimensions of the tool to attach it properly.
- Tool holder inner diameter = 25 mm
- Tool holder outer diameter = 38 mm
- Machine holder upper diameter = 50 mm
- Machine holder lower diameter = 60 mm

3.2.4 3D-CAD Model

The 3D-CAD model of the shaft is as shown in the following figure.

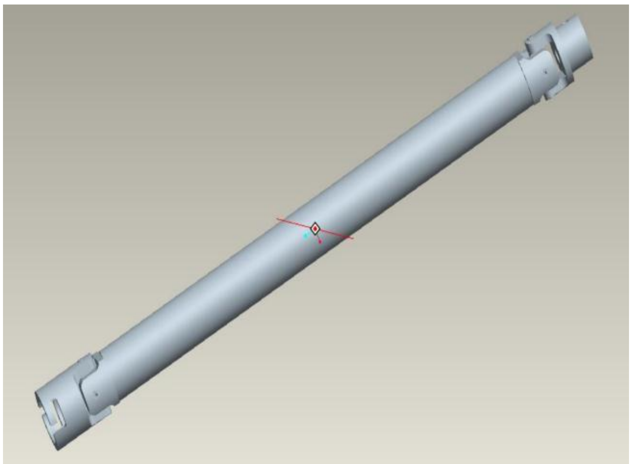

Fig – 6: 3D-CAD model of the shaft

3.3 ANALYSIS

3.3.1 ANSYS

ANSYS is a general purpose software which is used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers.

ANSYS software enables to simulate the tests or working conditions, enables to test in virtual environment before manufacturing prototypes of products. Hence after, determining and improving weak points, computing life and foreseeing probable problems are possible by 3D simulations in virtual test environment. This software with its modular structure as shown in the fig. gives an opportunity for taking only the needed features. It can work integrated with other engineering software on desktop by adding CAD and FEA connection modules.

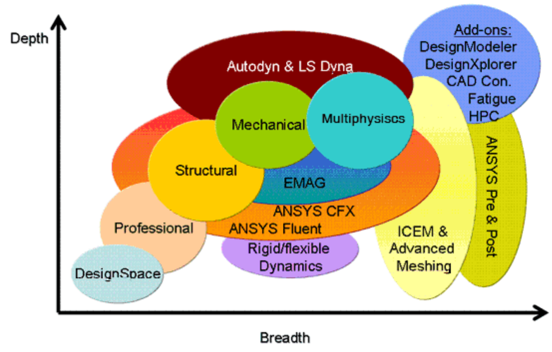

Fig-7: Features of ANSYS

ANSYS can also import CAD data and so enables to build geometry with its “preprocessing” abilities. ANSYS also carries out advanced engineering analysis quickly, safely and practically by its variety of contact algorithms, time based loading features nonlinear material models.

ANYS Workbench is one the best platform which integrates simulation technologies and parametric CAD systems with unique automation and performance of the product. The objective of ANSYS workbench is to verify and modify the product in virtual environment.

We have done the analysis of shaft by applying the cutting force in which we observed that the total deformation as shown in the fig. was decreasing from the tool holder to the machine holder. The maximum deformation occurred at the bottom and at the top it was minimum.

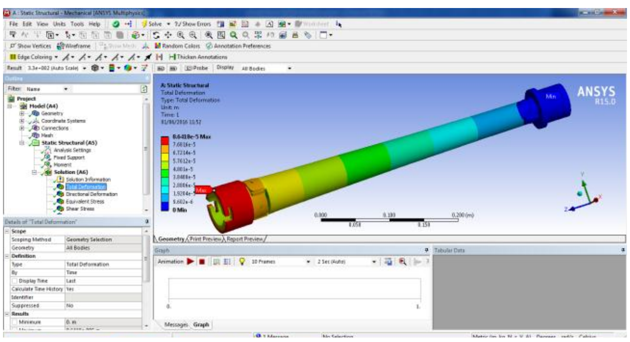

Fig-8: Total deformation in the shaft

In the following fig. equivalent (von - misses) stress is shown. The stress is maximum on the inner side, while it is decreasing on the outer side. The red region indicates the maximum stress and blue indicates minimum stress.

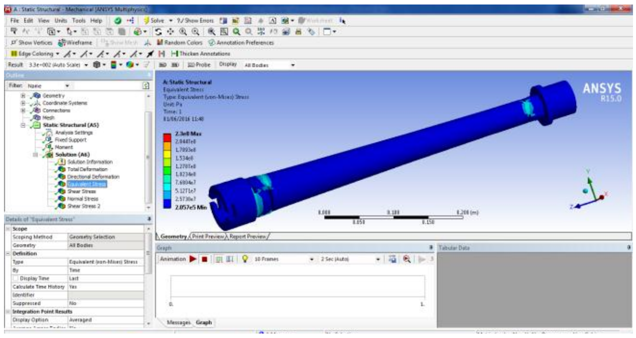

Fig-9: Equivalent stress in the shaft

3.4 Modification after Manufacturing

After manufacturing the new shaft and by providing guiding sticks on the tool we have overcome uneven contact of abrasive sticks.

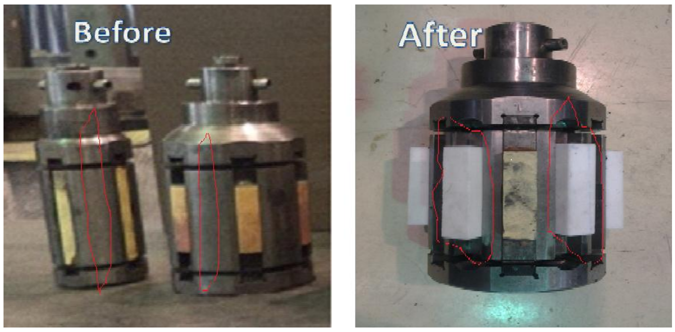

Fig-10: Modification after manufacturing

4. CONCLUSION

We conclude that the surface roughness of the guide has been reduced below permissible limit, ovality of the guide has been also reduced, Deep line marks are eliminated and the surface texture has been improved. Ultimately the rejection of the guide has been avoided.

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