Determination of Heat Transfer Rate on Machine Guide Ways Using Different Coolants by Convention Process

A.Guru Prasad
Post Graduate Student,
Department of Mechanical Engineering,
Global College of Engineering & Technology,
Kadapa, A.P.

G.V. Nagamani
M.Tech, MISTE, AMIE
Associate Professor,
Department of Mechanical Engineering,
Global College of Engineering & Technology,
Kadapa, A.P.

ABSTRACT:

A vertical machining center (VMC) is a machining center with its spindle in a vertical orientation. The guide way is one of the important elements of machine tool. The main function of the guide way is to make sure that the cutting tool or machine tool operative element moves along predetermined path. The machine tool operative element carries work piece along with it. The motion is generally circular for boring mills, vertical lathe, etc. while it is straight line for lathe, drilling, boring machines, etc.In this thesis, a box guide way with VMC is modeled in 3D modeling software Pro/Engineer. Heat transfer analysis is done on the guide ways to determine the thermal behavior of the guide ways using different coolants 68 Grade oil, organic solvent and brine solution as lubricants. Analysis is done in Annoys. The present used material is Cast Iron. In this project analysis is done by taking steel and copper for guide ways and compared for the better heat transfer rates to select better coolant and material.

Key words: VMC, Milling, Tooling.

1. INTRODUCTION:

Milling is the machining process of using rotary cutters to remove material from a work piece advancing (or feeding) in a heading at a point with the hub of the tool. It covers a wide mixed bag of distinctive operations and machines, on scales from little individual parts to expansive, substantial obligation group processing operations. It is a standout amongst the most normally utilized procedures as a part of industry and machine shops today to machine parts to exact sizes and shapes.

Processing should be possible with a wide range of machine tools. The first class of machine devices for processing was the processing machine (regularly called a plant). After the approach of PC numerical control (CNC), processing machines advanced into machining focuses (processing machines with programmed instrument changers, apparatus magazines or merry go rounds, CNC control, coolant frameworks, and walled in areas), for the most part named vertical machining focuses (VMCs) and flat machining focuses (HMCs). The coordination of processing into turning environments and of transforming into processing situations, started with live tooling for machines and the periodic utilization of factories for turning operations, prompted another class of machine tools, multi tasking machines (MTMs), which are reason assembled to accommodate a default machining system of utilizing any mix of processing and turning inside of the same work envelope.
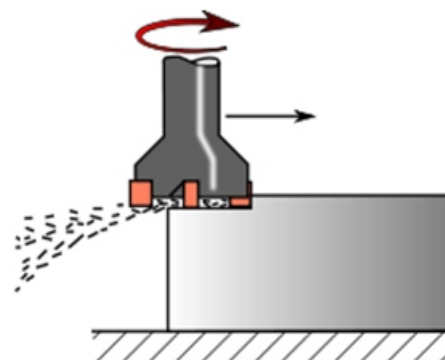
PROCESS :

Fig 1: Process

2. TYPES OF MILLING MACHINES:

» Knee-Type
» Plain Vertical and Horizontal
» Universal Horizontal Milling Machine
» Ram-Type and Universal Ram-Type Milling Machines
» Swivel Cutter Head Ram-Type Milling Machine

3. STRUCTURE OF MACHINE:

The model of any machine under review is now undergoing changes to the structure. The new design needs to be reviewed in the light of structural strength while subjecting the components/sub-assembly to Analysis using CAE. The geometry of the machine frame/ structure is amenable to the usage of 3D modeling. The design of the structure would necessitate knowledge of the fundamentals for Machine Design. The information like weight of the structure and the relative position with respect to other elements of the machine tool can be readily offered by the three dimensional CAD interface.

Sturdy Base Structure for a Vertical Machining Centre- VMC

Fig 2: VMV Study

Structure for a Vertical Machining Centre – VMC:

Vertical machining center are often used for high precision application such as mold making and graphite machining. The above structure shows the various parts like column, bed, box sideway and spindle. This structure is capable of withstanding the much better stress without deforming and provides the maximum vibration damping.

The column is ribbed to provide the strength:

and stability for vibration free, chatter free heavy machining. Wide at the bottom, to match the bed, the column stance assures the stiffness, rigidity and dynamic stability. The large symmetrically designed bed casting maintains machine basics geometric and uniform thermal characteristics.In case of end milling operation, metal is usually removed from a work piece by a single or multiple point cutting tool. For the efficient use of the machine tool it is important to find the optimum cutting parameters before a part is put into production. End mills are used in tracer controlled profile milling operations. They are employed for making deep grooves in base parts, profile recesses, steps, etc.

End mills can be used on horizontal milling machine, but it is better to use them on vertical milling machine. Their diameter varies from about 3mm to 50mm. End mills are those tools which have cutting teeth at one end, as well as on the sides. The words end mill are generally used to refer to flat bottomed cutters, but also include rounded cutters (referred to as ball nosed) and bull nose cutters. They are usually made from high speed steel (HSS) or carbide, and have one or more flutes. They are the most common tool used in a vertical mill. Schematic diagram of End milling operation is shown in Figure.
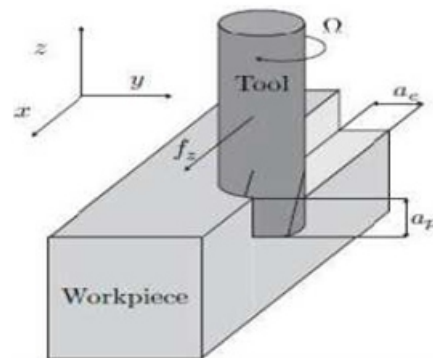

Figure3: End Milling Operation

Where,

1. ae is radial depth of cut in mm

2. fz is feed per tooth in mm/tooth

3. ap is axial depth of cut in mm.

Table1: Chemical composition of OHNS Steel:

S No	Element	percentage
1	carbon	0.9 to 1.3
2	Manganese	1
3	Chromium	0.5
4	Tungsten	0.4 to 0.8
5	Nickel	0.5
6	Iron	Balance

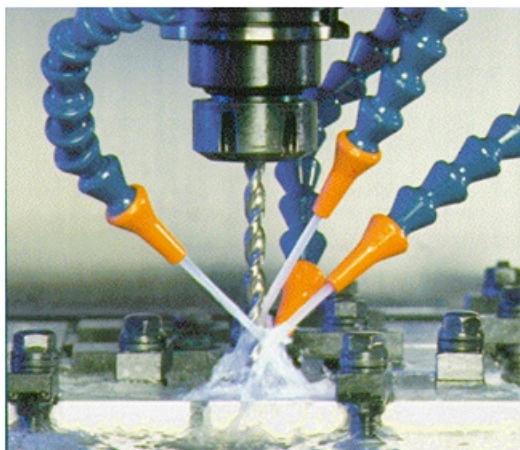## 3.1. INTRODUCTION TO CUTTING FLUIDS:

Fig 4: TYPES OF COOLANTS

4. INTRODUCTION TO CAD:

Computer Aided Design (CAD) is a technique in which man and machine are blended in to problem solving team, intimately coupling the best characteristics of each. The result of this combination works better than either man or machine would work alone , and by using a multi discipline approach, it offers the advantages of integrated team work.

4.1. INTRODUCTION TO PRO/ENGINEER:

Pro/ENGINEER Wildfire is the standard in 3D item outline, including industry-driving efficiency apparatuses that advance best practices in configuration while guaranteeing consistence with your industry and organization guidelines. Incorporated Pro/ENGINEER CAD/CAM/CAE arrangements permit you to outline quicker than at any other time in recent memory, while expanding development and quality to eventually make remarkable items. Client necessities may change and time weights may keep on mounting, yet your item outline needs continue as before - paying little mind to your venture's degree, you require the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

4.2. INTRODUCTION TO FEA:

Limited Element Analysis (FEA) was initially created in 1943 by R. Courant, who used the Ritz strategy for numerical examination and minimization of variational math to acquire surmised answers for vibration frameworks. In the blink of an eye from that point, a paper distributed in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp set up a more extensive meaning of numerical investigation. The paper fixated on the "firmness and avoidance of complex structures". FEA comprises of a PC model of a material or configuration that is focused on and broke down for particular results. It is utilized as a part of new item plan, and existing item refinement. An organization has the capacity check a proposed configuration will have the capacity to perform to the customer's details preceding assembling or development. Adjusting a current item or structure is used to qualify the item or structure for another administration condition. If there should be an occurrence of basic disappointment, FEA may be utilized to assist focus the outline alterations to meet the new condition.

4.3 TYPES OF ENGINEERING ANALYSIS:

Structural examination comprises of direct and non-straight models. Direct models use straightforward parameters and accept that the material is not plastically twisted. Non-direct models comprise of focusing on the material past its versatile abilities. The burdens in the material then shift with the measure of distortion as in.

Vibrational investigation is utilized to test a material against irregular vibrations, stun, and sway. Each of these occurrences may follow up on the normal vibrational recurrence of the material which, thus, may bring about reverberation and resulting disappointment. Weariness investigation helps planners to anticipate the life of a material or structure by demonstrating the impacts of cyclic stacking on the example. Such investigation can demonstrate the zones where split proliferation is well on the way to happen. Disappointment because of exhaustion may additionally demonstrate the harm resistance of the material.Heat Transfer investigation models the conductivity or warm liquid elements of the material or structure. This may comprise of a consistent state or transient exchange. Relentless state exchange alludes to consistent thermo properties in the material that yield direct warmth dispersion.

4.4 RESULTS OF FINITE ELEMENT ANALYSIS :

1.FEA has turned into an answer for the assignment of showing so as to foresee disappointment because of obscure anxieties issue regions in a material and permitting planners to see the greater part of the hypothetical hassles inside. This strategy for item plan and testing is far better than the assembling expenses which would collect if every example was really fabricated and tried.

2.By and by, a limited component investigation generally comprises of three essential steps

3.Preprocessing: The client builds a section's model to be broke down in which the geometry is separated into various discrete sub locales, or components," associated at discrete focuses called hubs." Certain of these hubs will have settled removals, and others will have endorsed burdens. These models can be amazingly tedious to get ready, and business codes compete with each other to have the most easy to use graphical "preprocessor" to help with this somewhat dull task. Some of these preprocessors can overlay a cross section on a previous CAD record, so that limited component investigation should be possible helpfully as a major aspect of the mechanized drafting-and-configuration process.

4.Analysis: The dataset arranged by the preprocessor is utilized as info to the limited component code itself,

which develops and explains an arrangement of direct or nonlinear logarithmic comparisons

Kijuj = fi

Where u and f are the removals and remotely connected powers at the nodal focuses. The K's development grid is reliant on the sort of issue being assaulted, and this module will layout the methodology for truss and straight flexible anxiety investigations. Business codes may have extensive component libraries, with components proper to an extensive variety of issue sorts. One of FEA's important favorable circumstances is that numerous issue sorts can be tended to with the same code, only by indicating the proper component sorts from the library.

5.Postprocessing: In the prior days of limited component investigation, the client would pore through reams of numbers created by the code, posting relocations and hassles at discrete positions inside of the model. It is not entirely obvious essential patterns and problem areas along these lines, and present day codes use graphical showcases to help with imagining the outcomes. A common postprocessor presentation overlays shaded forms speaking to push levels on the model, demonstrating a full field picture like that of photograph versatile or moiré exploratory results

6.Introduction to annoys

7.ANSYS is universally useful limited component investigation (FEA) programming bundle. Limited Element Analysis is a numerical strategy for deconstructing an intricate framework into little pieces (of client assigned size) called components. The product actualizes comparisons that represent the conduct of these components and fathoms every one of them; making a far reaching clarification of how the framework goes about overall. These outcomes then can be exhibited in classified or graphical structures. This sort of investigation is normally utilized for the configuration and advancement of a framework unreasonably complex to dissect by hand. Frameworks that may fit into this classification are excessively unpredictable due, making it impossible to their geometry, scale, or representing mathematical statements.

8.Generic Steps to Solving any Problem in ANSYS

9.Like taking care of any issue logically, you have to characterize (1) your answer area, (2) the physical model, (3) limit conditions and (4) the physical properties. You then take care of the issue and present the outcomes.

In numerical strategies, the fundamental contrast is an additional step called lattice era. This is the stride that partitions the intricate model into little components that get to be reasonable in a generally excessively complex circumstance. Underneath depicts the procedures in wording somewhat more adjust to the product.

10.Build Geometry

11.Build an a few dimensional representation of the item to be demonstrated and tried utilizing the work plane direction framework inside ANSYS.

12.Define Material Properties

13.Now that the part exists, define a library of the necessary materials that compose the object (or project) being modeled.This includes thermal and mechanical properties.

14.Generate Mesh

15.At this point ANSYS comprehends the part's cosmetics. Presently characterize how the demonstrated framework ought to be separated into limited pieces.

16.Apply Loads

17.Once the framework is completely planned, the last errand is to trouble the framework with limitations, for example, physical loadings or limit conditions.

18.Obtain Solution

19.This is actually a step, because ANSYS needs to understand within what state (steady state, transient… etc.) the problem must be solved.

20.Present the Results

21.After the arrangement has been acquired, there are numerous approaches to exhibit ANSYS' results, look over numerous choices, for example, tables, diagrams, and form plots.

5. THERMAL ANALYSIS OF VERTICAL MACHINING CENTER GUIDE WAYS
CAST IRON
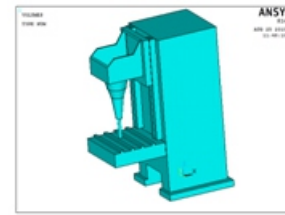## COOLANT – WATER + SERVO OIL

Fig 5: Imported Model from Pro/Engineer.
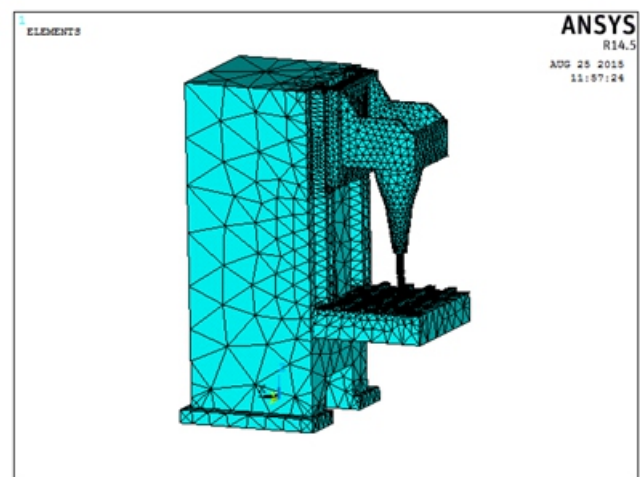
Meshed Model:

Fig 6: Meshed model

Material Properties: Thermal Conductivity –53.3w/mk
Specific Heat – 1.853 j/kg k
 Density - 0.00000715 kg/mm3
Apply Loads
Loads – Define Loads – Apply – Thermal – Temperature
Temperature – 380k
Loads – define Loads – Apply – Thermal – Convection – on areas
Bulk Temperature – 303k
Film Coefficient – 851.745 W/m2K (water + servo oil)
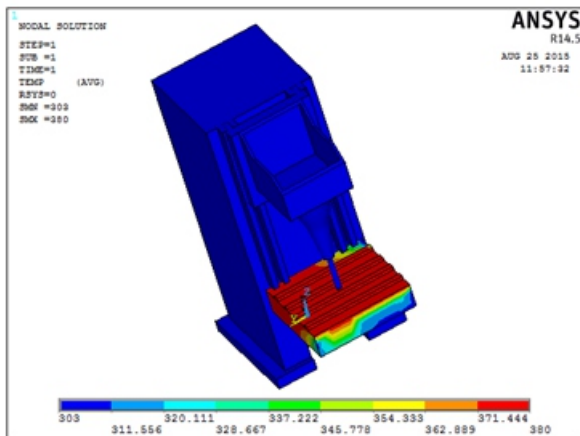Solution
Solution – Solve – Current LS - ok
Post Processor
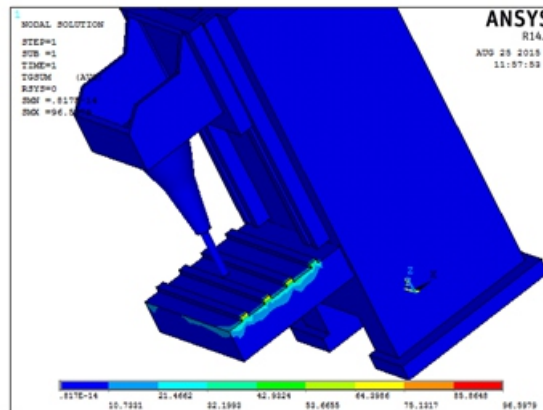General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Nodal Temperature Vector sum

Nodal temperature

Thermal gradient

6. RESULTS TABLE
CAST IRON

	Nodal Temperature(K)	Thermal gradient(K/mm)	Heat flux(W/mm²)
SERVO OIL	380	96.5979	5148.67
ORGANIC SOLVENT	380	83.1361	4431.15
BRINE SOLUTION	380	95.8017	5106.23

COPPER

	Nodal Temperature(K)	Thermal gradient(K/mm)	Heat flux(W/mm²)
SERVO OIL	380	73.6531	28356.4
ORGANIC SOLVENT	380	49.2467	18960
BRINE SOLUTION	380	68.0591	26202.8

STEEL

|	Nodal Temperature(K)	Thermal Gradient(K/mm)	Heat Flux(W/mm²)
SERVO OIL	380	263.637	11336.4
ORGANIC SOLVENT	380	87.7746	3774.31
BRINE SOLUTION	380	93.2345	4009.09

GRAPHS
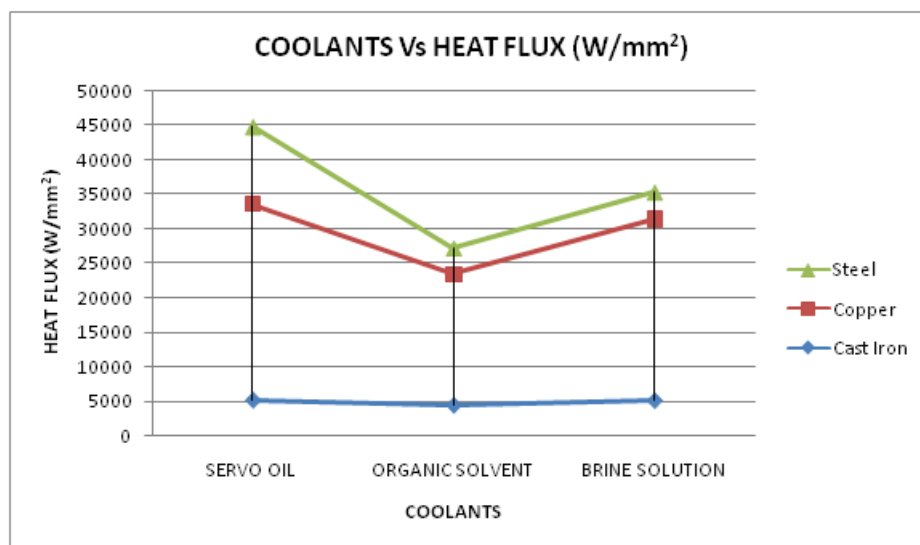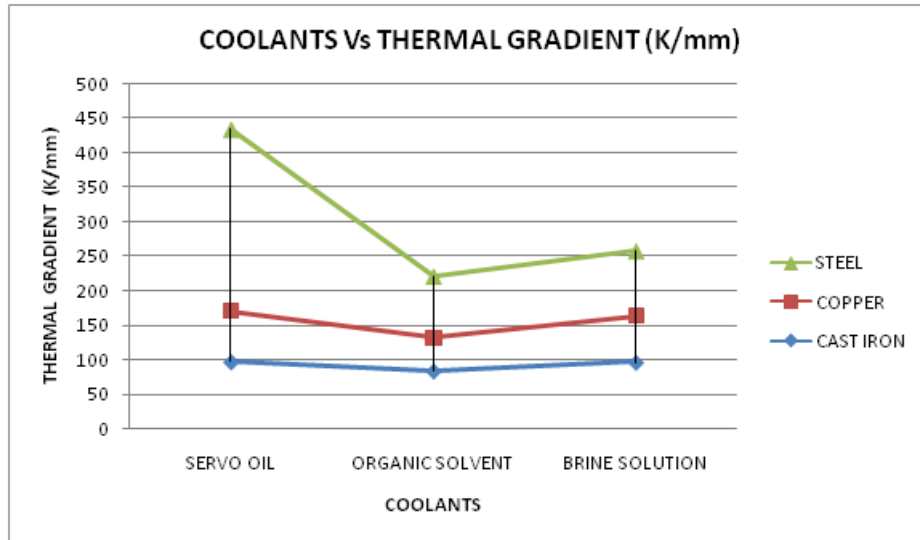
7. CONCLUSION:

In this thesis, a box guide way with VMC is modeled in 3D modeling software Pro/Engineer. Heat transfer analysis is done on the guide ways to determine the thermal behavior of the guide ways using different coolants 68 Grade oil, organic solvent and brine solution as lubricants. Analysis is done in Annoys. The present used material is Cast Iron. In this project analysis is done by taking steel and copper for guide ways and compared for the better heat transfer rates to select better coolant and material.By observing the thermal analysis results, the heat transfer rate is more when servo oil is used than organic solvent and brine solution since heat flux and thermal gradient are more.

The heat transfer rate is increasing by 14% when servo oil is used when compared with that of organic solvent and increasing by 0.8% when servo oil is used when compared with that of organic brine solution for Cast Iron material. The heat transfer rate is increasing by 33% when servo oil is used when compared with that of organic solvent and increasing by 8% when servo oil is used when compared with that of organic brine solution for Copper material. The heat transfer rate is increasing by 67% when servo oil is used when compared with that of organic solvent and increasing by 64% when servo oil is used when compared with that of organic brine solution for Steel material. When compared the results for materials of guide ways, steel is better.
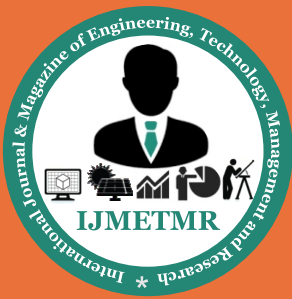
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