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Comparison of Energy Consumption in the Turning Process on CNC Lathe Machine

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Abstract

Manufacturing process is energy extensive at each and every stage during the process energy is used. Energy can be classified into electrical energy or energy from fossil fuels. In this study we present a method to comparing the energy consumption in the turning process as calculating the science based formulae. In this work method would be developed to determine energy consumption from the science based formulae calculations and compared with two different diameters conditions.

Keywords

Machining, turning process, CNC

Introduction

Turning is a frequent unit process in manufacturing as a mass reduction step, in which the major motion of the single point cutting tool is parallel to the axis of rotation of the rotating work piece thus generating external surfaces. Facing is a special case of turning in which the major motion of the cutting tool is at right angles to the axis of rotation of the rotating work piece. Industry has wide use of energy for processing raw material to final product. Turning is one of the most used machining processes in many manufacturing industries these are considered to be the most essential parts of energy consumption. Reduction in the energy consumption by machine tools helps the companies to achieve green production. Actually the increasing the cost of energy has made energy efficiency become one of the key factors of intelligent manufacturing as well as manufacturing industry.

Literature review

Ong S K et al. ((2002) This paper presents a web-based, open, and modularized system architecture for constructing a virtual CNC machining system, consisting of a resource support subsystem, CNC controller, simulation service and environment, user control interface, and machining parameters simulation models. As a prototype, aweb-based virtual CNC milling system is implemented usingVRML and Java. This virtual milling machine is constructed with VRML. Java, as the animation engine, makes the virtual milling machine controllable via Script node and EAI. In the graphic simulation, the implementation of the real-time work piece removal process simulation, the G-code interpreter, and the collision detection module are explained in detail. In the simulation of the machiningparameters, the prediction of cutting forces, torque, power consumption and tool life models are implemented using an empirical method.Gutowski T. et al. (2006) relate literature is presented thatrequirement of energy in manufacturing process is not constant as many life cycle analysis tools assume. The most important variable for estimating this energy requirement is the process rate, and the trend in manufacturing process development is toward more and more energy intensive processes.Lupak M (2008) obtained that increase in cutting speed produces an insignificant increase in energy consumption and specific energy consumption for electrochemical grinding and a much more pronounced increase for mechanical grinding. Increasing the depth of cut results in an increase in energy consumption of both types of machining and in a decrease in specific energy consumption. An increase in longitudinal feed speed produces an increase in energy consumption for both types of machining and a decrease in specific energy consumption. Increasing inter-electrode voltage results in an increase in energy consumption (more pronounced) as well as in specific energy consumption e for electrochemical grinding.He Y et al. (2009) depicted that understanding and estimating the energy consumed by machining are essential as the energy consumption on machining is responsible for a substantial part of environmental burdens in manufacturing industry. Energy consumption of each component is calculated by multiplying the power with the corresponding time of energy consumption component. Total energy consumption can be estimated as sum of the energy consumption of each component. The energy consumption of NC machining greatly depends on the operational states of energy-consuming components controlled by NC codes. The correlation between energy-consuming components of machine tools and NC codes is analyzed to identify the corresponding operation behaviors of energy-consuming components.Taha Z et al. (2010) obtained that every machining parameter has impact to power consumed in machining process. Combinations of machining parameters need to be optimized in order to get minimum power consumption. However, machining time is the most influencing factor in power consumption. When calculating the energy consumption obtained that if work piece has fewer diameters then energy consumption is less.Guo Y et al. (2012)obtained that an approach which incorporates both energy consumption and surface roughness is presented for optimizing the cutting parameters in finish turning. Based on a new energy model and a surface roughness model, derived for a machine tool, cutting parameters are optimized to accomplish a precise surface finish with minimum energy consumption.

Concept of Study

In CNC turning process various operations are done. The unit process consists of the inputs, process and outputs of a operation. In input process requires work piece process parameters cutting tools cutting fluid energy after turning process obtained final product, chips, coolant waste, Mist

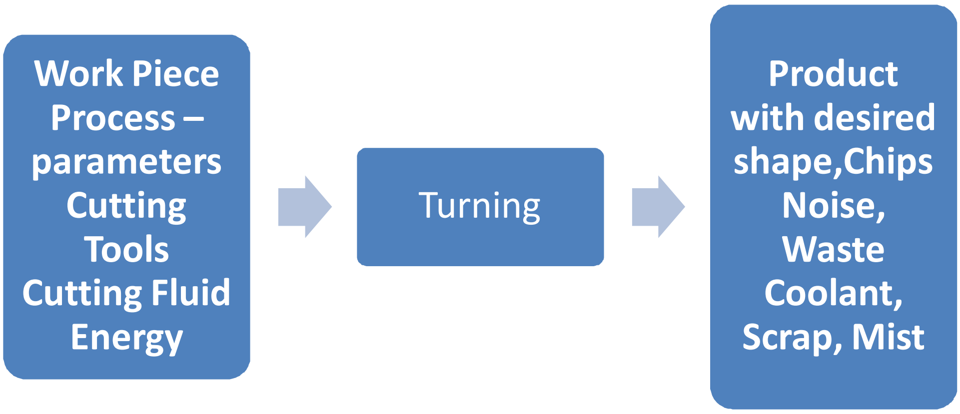

Figure 1.1Input Output diagram of turning process.

This information is contained from the research papers.The total turning process is illustrated in Figure 1.2. The cutting speed, V (m/min), is the peripheral speed of the work piece past the cutting tool. The rotational speed of the spindle, N, (rev/min) (set on the machine), N= V/(π×Di). Where V = cutting speed, mm/min and Di = Initial diameter of the work piece, mm.The feed rate, fr (mm/min) is the rate at which the cutting tool and the work piece move in relation to one another. The feed rate, fr (mm/min), is the product of f×N. . For turning, the area removed is an annular ring of initial diameter Di and finished diameter*Df* Thus, the expected cut area is π(Di2 -Df2)/4. The rate at which the tool is fed, *fr* (in unit distance per minute), is *f*×*N*. Therefore, the volume removal rate (VRR) for turning isVRR = (π(Di2 -Df2)/4) × fr (mm3/min). Time for turning tturning = (l) ÷ f×N = l÷fr = l ÷ [f× (V/π×Di)]

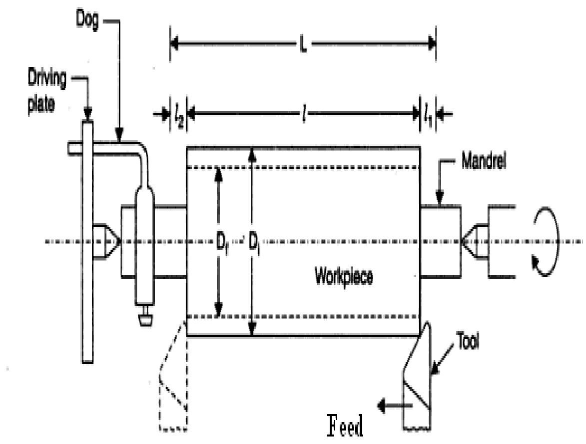

Figure1.2:schematic diagram of turning process

Case study

For the Case 1: for case study we are taking Aluminum as the work piece. The work piece is a cylindrical bar that is 55 mm diameter and 250 mm long, where 4.5 mm is to be removed up to 100 mm length from the end of the bar.Case 2:The work piece is a cylindrical bar that is 48 mm diameter and 250 mm long, where 4.96 mm is to be removed up to 100 mm length from the end of the bar. The objective of the study is to analyze the energy consumption in turning process. From the dimensions and the density from Table 1.1, the weight of the work piece is 5.71 kg (assuming density as 2712 kg/m3).

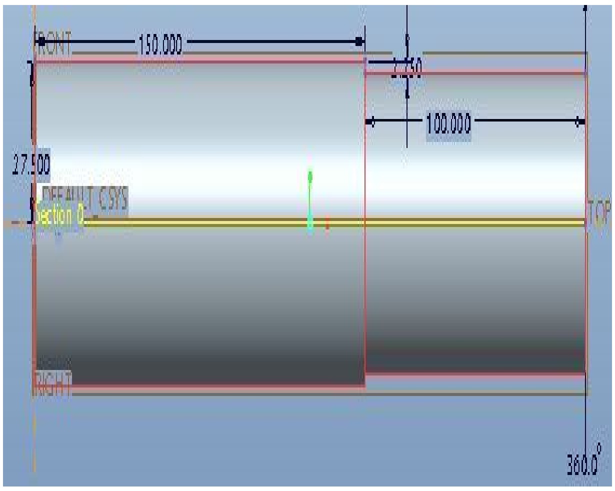

figure1.3: for case 1

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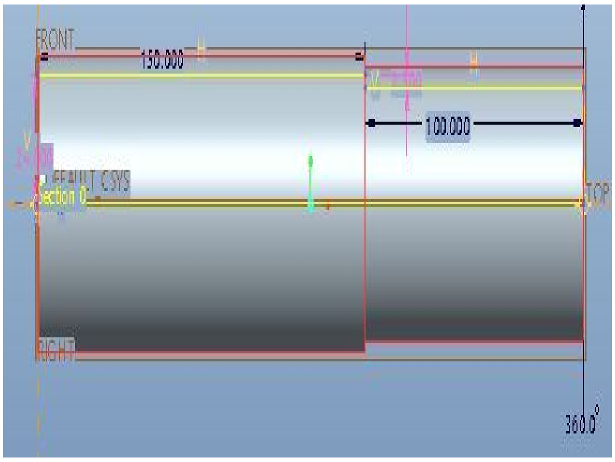

Figure1.4: for case 2

Table 1.1Determination of energy consumption on the basis of science based formulae

Conditions	Case 1	Case 2
Initial diameter (Di)	55 mm	48 mm
Cutting speed (V)	150 m/min	110 m/min
Feed (f)	0.3 mm/rev	0.4 mm/rev
Spindle speed (N)	868 rpm	729 rpm
Feed rate (fr)	260.4 mm/rev	291.6 mm/rev
Machining length (l)	100 mm	100 mm
Volume of material removed	37286.77 mm3	37286.77 mm3
Depth o cut (d)	4.5 mm	5 mm
Final diameter (Df)	50.5 mm	43 mm

VRR	103273 mm3/min	104205 mm3/min
Time (s)	101.75 s	99.19 s
Power (kw)	10.38 kw	10.188 kw
Energy	1054.38 kJ/cut	1010.6 kJ/cut

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