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Some studies on Sustainable Machining : A Review

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Abstract: Machining plays an vital role in industrial economy and it contributes. more than 5% to the country's economy. The machining processes has gone through significant changes in the last decades. Competition has increased drastically to gain more profit. Machining processes are been used widely and attempts have been made to minimize the machining cost and the energy consumption. To achieve sustainability the machining parameters like speed, feed , depth of cut and the coolants used play an important role. Our main focus in this work is to increase the surface integrity and the tool life by making use of minimum resources and attain sustainability in machining to reduce the energy consumption.

Key words: Sustainable machining, energy consumption, resources, cutting forces.

1.0 INTRODUCTION

The implementation of sustainability principles in machining processes is needed to overcome the challenges facing the various sectors, it is vital that companies adopt sustainable manufacturing practices. Sustainable manufacturing consists of environmental protection, profitability and societal benefit for all industrial areas. Sustainable machining investigates the conflict and between economical and environmental considerations of system boundaries in determining optimum machining conditions. This research consists of the the study of various parameters in machining and its effects on the sustainability.

2.0 SUSTAINABLE MACHINING

The sustainability of a production process can be achieved by integrating all the small factors and thus achieving sustainable machining conditions. The real market demand has to be considered in dependence to cost, quality that has to considered while the delivery of the final product (short to avoid storage capacities and financial investment). Another important stage of manufacturing/machining is connection with economy is resource utilization and raw materials extraction. It is necessary to improve the proportion between incoming and outgoing raw materials in the production phase, what is basically represents wastes (producing same, while using less and reduce costs)[4].

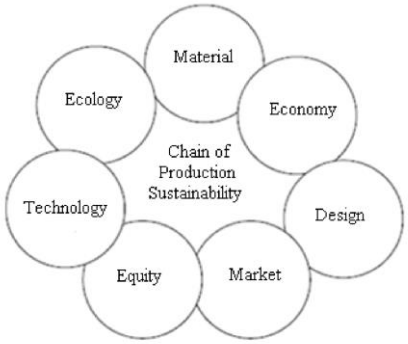

Fig.1:Model for sustainable machining (Source:Mustafa Gunay et al.).

Cryogenic machining presents an new method of cooling the cutting tool and part during machining operations. Cryogenic machining basically relates to delivering the cryogenic CLF (instead of oil-based CLF) to the cutting surface during the machining surface which experiences the highest temperature during the machining process and where there is change in the material characteristics and improve machining performance. The coolant is usually liquefied nitrogen fluid which is liquefied by cooling to –196°C (liquid nitrogen - LN). Nitrogen is a safe, noncombustible and noncorrosive gas which can be stored.

Fig. 2: Cryogenic Machining

HPJAM presents an method used most likely now-a-day for lubricating or cooling the cutting area during machining. More specifically, it relates to delivering the oil-based or water-based CLF in relatively small flow rates in comparison with the conventional flood type under extremely high pressure up to 300 MPa to the cutting tool tip and the cutting surface.

Fig. 2: HPJAM

In MQL machining, the medium used is generally straight oil, but in some applications even emulsion or water are used. The media are feed into cutting zone during machining operation in small quantity. Normal consumption of cooling and lubricating fluid in near-dry machining per machine hour is 10-120 ml as considered. The term "near-dry machining", generally presents machining with small amount of cooling lubricant used.

Fig. 2: Near dry machining (Source: cimindustry.com)

3.0 LITERATURE SURVEY

The methodologies used to reduce cutting forces in order to consume less energy and enhance surface integrity literature review of the authors who have made the research in the concerned area. Reputed journals from Science Direct, Elsevier and Springer were selected for literature survey. Keywords like "Sustainable machining, Energy consumption, Resources, Cutting forces" were given more importance in literature study. About 76% of research papers belongs to the year between 2006-2016. The below Pie chart shows the year wise distribution of literature review.

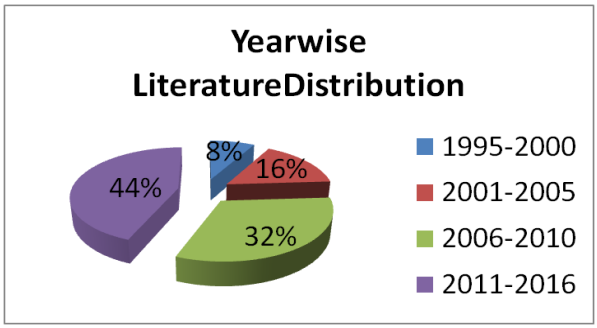

Fig 2: Yearwise literature distribution

Guoliang Liu et al (2016) used 17-4PH stainless steel, to replace the parts of jet engine made with titanium. Thus by using 17-4PH stainless steel. The fatigue life is the machined surface increased. Experimentations were conducted to analyze the impact of cutting operations on surface integrity and it's impact on fatigue life. This was achieved by considering the factors such as surface roughness, residual stresses and the work hardening determined by using these factors.

M.A. Saroosh et al (2007) has discussed about the fatigue life for high cycle operations, for this they focused on the material property of the workpiece. Four different materials were used for experimentations based upon the strength coefficient k and the strain hardening coefficient n which were used to derive a relation between the fatigue life and the property of the workpiece materials. The local stress and strain approach was uses for the experimentations. The tool life data was collected from different industries for the fatigue life consideration. Thus the fatigue life properties were obtained based on the Morrow's equation.

Ibrahim Deiab et al. (2014) proposed the use of vegetable oils in as a sustainable element for the conventional coolants. The use of the techniques like dry machining and cryogenic machining were introduced along with minimum quantity lubrication MQL and minimum quantity cooled lubrication MQCL. The effect of different strategies of the tool flank wear, energy consumption and surface roughness were studied on titanium using uncoated carbide tool at an appropriate speed and feed. The MQL and MQCL methods using rapeseed vegetable oil was founded as an sustainable alternative.

Isuamfon F. Edem et al (2016) described methods to calculate the energy supplied based upon the weight of the feed axis and the material placed on the worktable. Thus, by placing the various weights of material and cutting at various section of the axis the actual energy demand was calculated depending upon the axis direction. Thus the observations showed that along the X -axis the milling machine consumed less energy than in the Y-axis. Thus the high mass components and long components are placed along the top table axis.

Xiaona Zhou at al (2015) described ECA which stands for Energy consumption allowance, thus, increasing the energy consumption efficiency of the manufacturing system on the basis of complexity and energy consumption varieties. A new concept of energy consumption step ECS used to establish a discrete manufacturing system. This helps in solving the complex energy consumption problems in machining systems which include the refinement of energy management and thus increasing the energy efficiency of the machining system.

Sunil Dambhare et al. (2015) described the effects of different process parameters like speed,feed,depth of cut,dry and wet Mql and the type of cutting tools used for machining the job.in this paper is applied analysis of variance (ANOVA) was

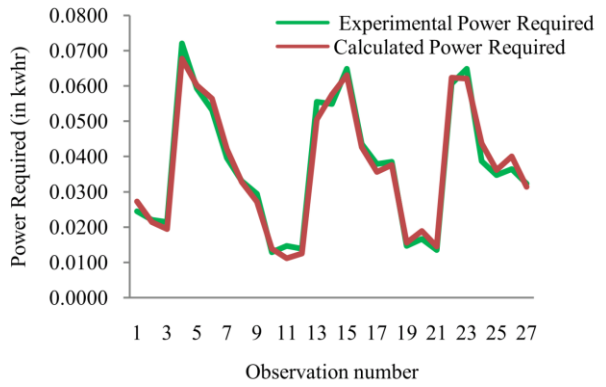

Fig. 3: Validation of model for surface roughness (Sunil Dambhare et al)

applied to test the parameters.This process was analyzed by using response surface methodology.the result of his work helped to understand the effect of different cutting parameters and to reduce the power consumption.

Vincent A Balogun et al. (2016) described in this paper about specific energy based on evalution of machining efficiency in which a side milling tests were conducted on milling maching tools to investigate specific energy pon AISI 1045 steel alloy.he gave the relationship between swept angle and the specific ploughing energy used during machining process and it was found that it's adopted as 39.74 degree.

R Suresh et al. (2012) described the correlation between cutting parameters such as cutting speed, depth of cut,different maching forces,tool wear and surface roughness on work piece. In this paper he used taguchi methods to understand the effects of this parameters on job. he gave response surface graph based on research data.

Mohamed Elbah et al. (2013) decribed that surface roughness effect on wiper and conventional ceramic tools with help of ANOVA and RSM used to evaluate different parameters. He obtained surface roughness values namely arthimetic mean roughness,mean deoth roughness,tool roughness from RSM model.

Saurabh Singhvi et al. (2016) described effect of machining and tool parameters on cutting force in orthogonal turning processes on different materials for optimizing the cutting forces. He conducted experiment by considering different cutting parameters also nose radius with the help of different mathematical formules and techniques.

Yuan-Jye Tseng et al. (2015) described in this paper, concept of closed-loop design. By integrating forward design and reverse design closed loop model is developed. Fuzzy logic is used for integrated evaluation of forward design model, reverse design model and green manufacturing model. Forward design model is linked with forward supply chain which is considered as traditional supply chain chain which maintain sustainability. This model is useful for sustainable manufacturing objective[1].

S. J. Mason et al. (2008). Described the simulation based sustainable manufacturing system design. Taking account of both economic and ecological constraints sustainable manufacturing system design form. To design sustainable manufacturing system design optimized multitude of system used. It uses simulation tool for optimization. The most needed element for this are lean manufacturing, identification and elimination of waste, production losses and environmental consideration. This paper link between lean manufacturing environmental -impacts

Mustafa Gunay et al (2013). Described about the sustainable machining. In this paper various lubrication processes are seen. Lubrication process is used to reduce the tool life as well as cost with increased sustainability. sustainable machining shows synergy between economical and environmental considerations. It shows the effect of system boundaries in determining optimum machining conditions. There is mechanism like near-dry machining (NDM) which is also called minimum quantity lubrication (MQL). Thus paper compares recent trends and new concepts that are important from the point of evaluating the sustainability contents.

Rajesh kumar bhushan et al (2015) described the paper of optimization of cutting parameters for minimizing power consumption and maximize tool life during machining of composites of Al alloy. Using ANOVA identification of optimum level is done and contribution of parameters are determined. During turning with values at cutting parameters reduces the power consumption by 13.57% and increased tool life by 22.12%.

Nikolaos. I. Galanis et al (2014) in this research work basically finite element modelling where used on machining of metal which has wide area of application in aircraft engineering and industry.the high speed machining on AISI 316L were used as process for turning.since the sigh speed machining has application in various industries the evaluation of result obtained by FEM and then by actual process were significant to compare.

O. Pereiraa et al (2015) the study were carried out on two different turning processes.one with conventional dry hard turning and another was co2 cryogenic turning.the ASP23 were used as working material for both turning operations.the result obtained were based on the value of roughness parameter,which was more stable in cryogenic rather than conventional type.The tool life was more affected it was improved over 60% in cryogenic machining.

Youngsik Choi (2015) in this work the influence of cutting parameter which is feed rate on fatigue and fatigue life were obtained. some experimental work indicated that the high rate of feed improves the crack initiation and crack propogation life by 45% and 149% respectively.

R. Robinson Gnanadurai et al (2016) it was based on the application of heat pipe for reducing the amount of coolant used in machining.when the heat pipe is used the heat transfer in interface were by convection and evaporation. main objective was ti reduce the wear of tool due to excess heat generated.

M.F. Rajemi et al. (2010) the work was done to optimise the energy used by the machining component to finally reduce the energy footprint.the parameter which were the crucial while obtaining optimum tool life was the different power usage rates by machining either in start to end or in between idle period also the energy footprint

Taoyuan Zhang et al (2015) the recent non- linear multi-objective optimization techniques were reviewed in this work.the problems on optimisation and its solution by pareto scenario for multi-objective optimisation were estimated or predicted.the optimisation is need of fulfilment of environmental as well as economic requirements.

4.0 METHODOLOGY

To reduce cutting forces, energy consumption and also to enhance surface integrity the methodology in figure 4 will be followed.

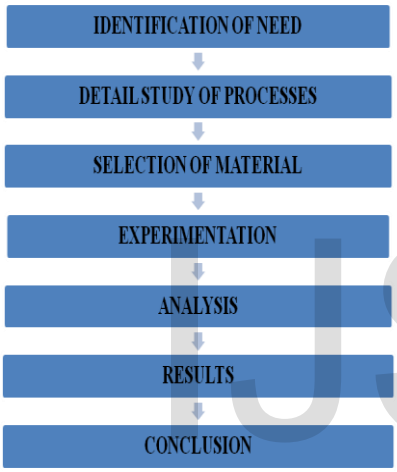

Fig. 4: Methodology

5.0 CONCLUSION

The surface integrity, cutting forces and the tool life can be improved by varying the parameters like speed, feed, depth of cut and by adopting modern advanced machinery to reduce the wastage of resources. A systematic process has to be followed to obtain sustainability and minimize the energy consumption. We also studied the effect of machining parameters like feed axis, cutting angles and tool geometry for getting better results.

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