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Role of environmental friendly machining on machinability

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ARTICLE INFO

Article history:

Received 5 March 2021

Received in revised form 22 March 2021

Accepted 26 March 2021

Available online xxxx

Keywords:

Environmental friendly machining

MQL machining

Cryogenic machining

Dry machining

Sustainable machining

ABSTRACT

The present for supporting in market any industries need to bring the balance among ecological, social viewpoints and efficient. Environmental friendly machining e.g. high pressure cooling, MQL machining, cryogenic machining, dry machining is one of the latest approach which is economical and also eco-friendly that improve machinability. In present article main focus on understanding of environmental friendly machining techniques and investigate various experiences from the past writing which can help the better appropriation of ecological friendly machining approach. For study and examination of environmental friendly machining approach, roughly 100 papers are chosen. They chose articles are ordered dependent on climate of machining, year, diaries, distributor, and ecological friendly machining approach measurements. After the literature survey it was observed that in metal cutting operation heat are generated in the cutting zone due to tool chip interface so quality of surface finish are poor and tool wear. In any manufacturing industries two factors play important role in term of quality e.g. surface roughness and tool wear so in this situation some techniques are need which is environmental friendly and also improve machinability. So finally, it was observed that environmental friendly machining techniques are cost effective and eco-friendly machining compared to other convention machining approach. The main motives of this paper that studies and encourage environmental friendly machining approach.

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1. Environmental friendly machining

1.1. Introduction

Machining is quite possibly the main cycles in the assembling ventures which include an interaction of crude materials convert into final wanted item by utilizing subtractive cycle and joining measure. For the most part machining measure shows by subtractive cycle of materials. In machining measure friction are created between tool – work piece and apparatus chip so parcel of energy provided changed over into heat. Fig. 1 shown metal cutting operation.

This heat created, if not disseminated effectively, may influence the completed surface quality, and diminish the tool life and generally execution of interaction. Additionally these cycles are not eco-accommodating interaction. Basically, the traditional cooling method is utilized in metal cutting cycle which is neither affordable nor ecological well disposed [2]. Today, step by step incre-

ments of natural and medical issues which is brought about by utilizing customary cutting liquids in metal cutting activity, then environmental friendly machining approach procedures are created which is prudent and viable methodology. Furthermore, these strategies improve surface quality, eliminate developed edge, less tool wear compared to other and reduced friction between tool – chip interface. Environmental friendly are similar of sustainable machining. Fig. 2 showing layout of sustainable machining. Sustainable machining is method of changing the accessible assets into items with least negative ecological effect; give improved energy just as asset effectiveness along with least squanders [6]. Notwithstanding operational and utilitarian wellbeing it offers improved individual wellbeing too. Further keeping up item and interaction quality is likewise worried about plan of sustainable manufacturing. Advancement of Sustainable Manufacturing started twenty years prior with the requirements of climate assurance, lower wellbeing dangers, satisfying energy interest, environmental equilibrium and economy of assembling [3,4]. Customary assembling measure devoured more energy and got uneconomical alongside weakening impact to climate contrasted with current assembling frameworks [5]. In this relationship, from the start

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Nomenclature

TiAlN	Titanium aluminum nitride	TiN	Titanium nitride
Al ₂ O ₃	Aluminum oxide	AlCrN	Aluminum chromium nitride
CO ₂	Carbon dioxide	LN ₂	Liquid nitrogen
PVD	Physical vapor deposition	CVD	Chemical vapor decomposition
MQL approach	Minimum quantity lubrication	Cryogenic -MQL	Cryogenic cooling + MQL
nMQL	Nano fluid MQL	Ra	Surface Roughness
hBN	Hexagonal boron nitride	MRR	Metal removal rate
TW	Tool wear	ScCO ₂	Super critical carbon dioxide

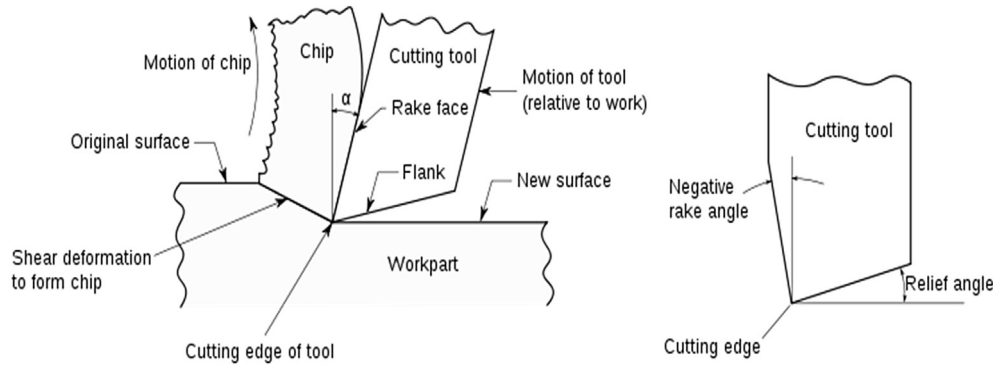


Fig. 1. shown generation of heat in metal cutting operation [1]

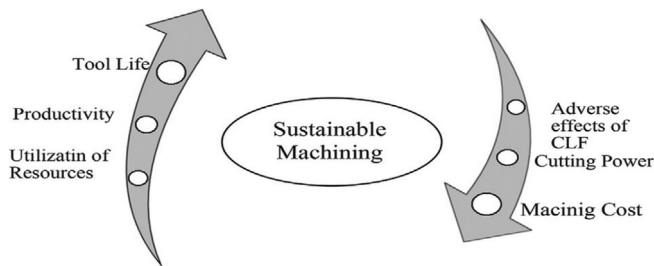


Fig. 2. Showing advantages of environmental friendly machining [6]

Lean Manufacturing system was seemed to lessen waste. So named as lean gathering followed by Green Manufacturing method. The later system utilized the possibility of 3R e.g Reduce, recycle and Reuse techniques. These successfully execute in organizations to address troubles of Sustainable machining. Present time sustainable machining weights on inventive collecting measure with development to extra 3R + 3R procedure e.g. reuse, recover, reduce, redesign, manufacturing and recycle.

1.1.1. Difference between environmental friendly machining and sustainable machining process

Ecological very much arranged cycles, or environmental agreeable cycles furthermore insinuated as eco-obliging, nature-obliging, and green while sensibility terms suggesting items and adventures, laws, decides and plans that case lessened, irrelevant, or no harm upon organic frameworks or the environment.

1.2. Background report

Various sorts of coolant have been utilized for improve machinability in traditional machining cycle like milling, grinding and drilling. Ordinary cutting liquids technique successfully decreases cutting temperature, lessens rubbing, improve tool life and

improve surface quality. Nonetheless, the expenses of utilizing regular cutting liquids are not restricted to the buy and arrangement, yet additionally comprise of keeps up and removal cost [7].

Growing legislative guideline and ecological concerns have expanded the expense related with the utilization of customary cutting liquids in metal cutting activity. The expense with cutting liquids could from 16% to 30% of the all out assembling cost, which is a lot higher than 2% – 4% tooling cost [8]. Dry machining is environmental friendly machining and also introduced improve machinability over the use of conventional cutting fluids method in material cutting [9]. But limitation of dry machining such as in drilling process lots of heat generated so some issue are raised e.g. more tool life and lower quality of surface [10]. In cryogenic machining, melted gases like CO₂, nitrogen and helium is utilized so this kinds of cooling strategy pulled in specialists to numerous years. Specifically, LN₂ is an unscented liquid which is lighter load than air and dissipates [11]. In metal cutting activity cryogenic coolant ingest the warmth produced at the cutting zone and improve machinability. Nitrogen is an idle gas, which frames over 78% of the world's climate. Thus, LN₂ can possibly be utilized as a natural cordial option in contrast to traditional cutting liquids. In the present article deal with environmental friendly machining approach e.g. MQL machining, dry machining, and cryogenic machining and high pressure cooling approach.

1.3. Classifications of cutting fluids

Various kinds of cutting liquids are used in metal cutting operation. Fig. 3 showing classifications of cutting fluids.

2. Environmental friendly machining techniques

Different types of environmental friendly machining techniques are available for metal cutting operation but in this article study on four types of environmental friendly machining approach e.g. minimum quantity lubrication technique, cryogenic cooling machin-

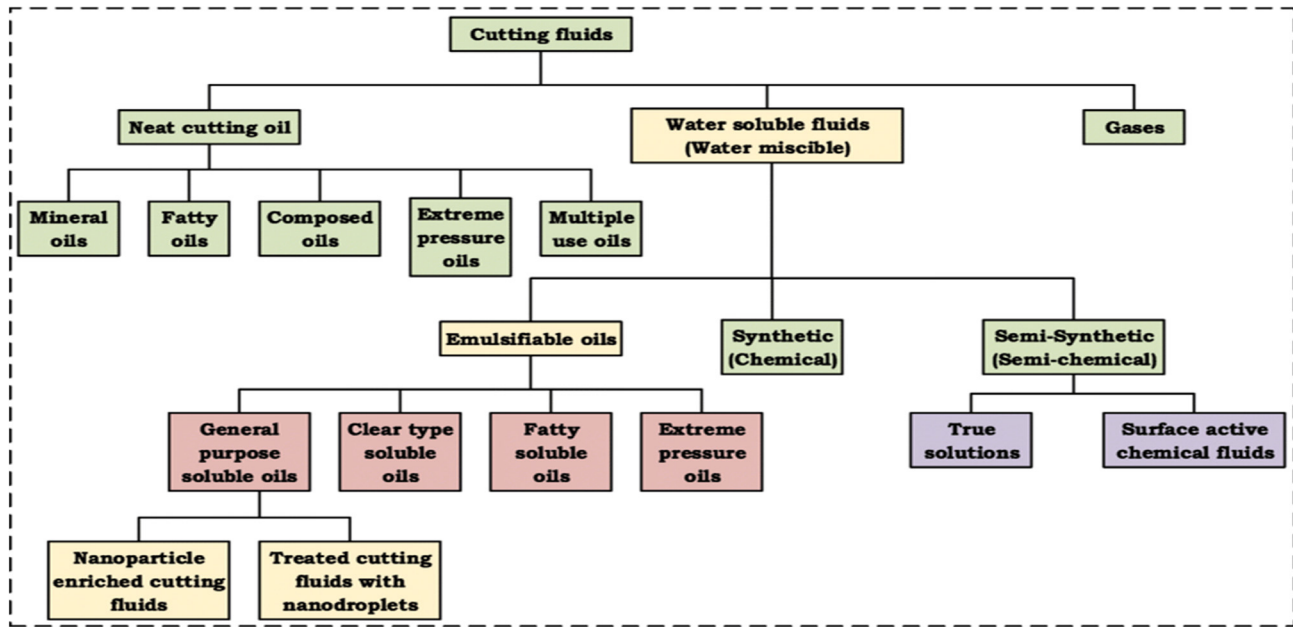


Fig. 3. Showing Classifications of cutting fluids [12]

ing, dry machining and high pressure cooling. Following types of environmental friendly machining are;

2.1. Dry Machining

Dry cutting method is cutting approach in which not used any lubricant in cutting operation. This mode is considered as the most efficient sort of machining condition, given that the machinability records are positive, and such halcyon execution is only sometimes found really. Clearly, dry cutting method is freed from coolant related issues. The places of dry cutting are on a very basic level two tasks: monetary achievement and ecologic. The shortfall of coolant restricts the creation's negative impact on the regular natural surroundings by avoiding of coolants' hurtfulness, similarly as decreases the creation costs by 16e20% through the removal of costs related to the cleaning of work-piece [13]. In like manner, nonappearance of coolant can raise the temperature that debilitates gadget execution and at the same time crumble the mechanical properties of work-piece. As course of action, agreeable coatings configuration can act like a glow prevention; reducing the temperature sway on the gadget wear, and lessening the pounding. In any case, more assessments are required considering the machining similarly as regular points of view dry cutting interaction. Fig. 4(a) showing dry machining process.

2.1.1. Benefits of dry Machining (See Fig. 5.)

2.2. MQL (minimum quantity lubricant)

MQL and MQCL show supply of unassuming amount of cooling/lubing up experts as airborne to the cutting area. This advancement is a sensible decision to dry similarly as flood cutting pondering the monetary and organic components. Its most noticeable benefits are energy saving, cost saving and cutting fluid saving to progress eco-kind cutting climate [16]. On account of dissipation nature of warmth move it is more feasible than convective warmth, move of high-pressure cooling [17]. Exactly when the liquid oils are applied as a medium and the impact is put on their extraordinary lubing up conditions, disintegration decline in the gadget chip interface, and reduction of warmth age by the crush-

ing, this mode is confirm as MQL. In any case, when the cooling sway is comparatively indisputable as like oil, the usage of cooling expert with MQL is suggested as MQCL. Consistently the stream speed of cooling/lubing up medium is in the arrive at 10e500 ml/h. Fig. 4(b) Shown MQL machining device calculation.

2.3. Cryogenic cooling

Cryogenic cooling is a system requested to clean creation headways, which other than the reduction of its negative environmental impact can profitably diminish the cutting temperature [18]. To show up at the significantly gainful cooling measure during the cryogenic cooling, the materials with very low temperatures are being applied as: liquid hydrogen [19]. In a certified condition, during the machining association the liquid nitrogen and dry ice are commonly being applied in view of their availability on market and by and large safe help. The cooling medium provided for the cutting zone during the cryogenic cooling disperses rapidly and gets back to the climate with no tainting. The utilization of LN2 as a coolant during such cycles, as turning or handling impacts well the course of action of machined surface by the diminishing of machining disfigurements and remaining weights, in light of practical control of cutting temperature [20]. Fig. 4 © Set-up of machining with cryogenic cooling framework.

2.4. High-pressure cooling

High-pressure cooling (HPC) development insinuates the utilization of fluid fly to the cutting zone at quick (350e500 km/h) and at high squeezing factor (5.5e35 MPa) [16]. This development stands better preposterous about the penetration of the infringed fluid. Inferable from the quick thought of jet(s), convincing pasageway of coolant to the unique cutting zone is represented. Along these lines, other than the improved machinability records, for instance, lower cutting force and surface brutality, HPC has preferred limit over cause breaking of chips (as opposed to dry, flood or MQL). [21] Reported improved warmth dispersal capacity of packed oil jets by convection mode and wild nature of fly in turning of Tie6Al4V. Coincidentally, talks about exist on HPC's ability to gadget wear issue: for instance, completions of [22]. On the contrary side, relatively few works have assessed the characteristic

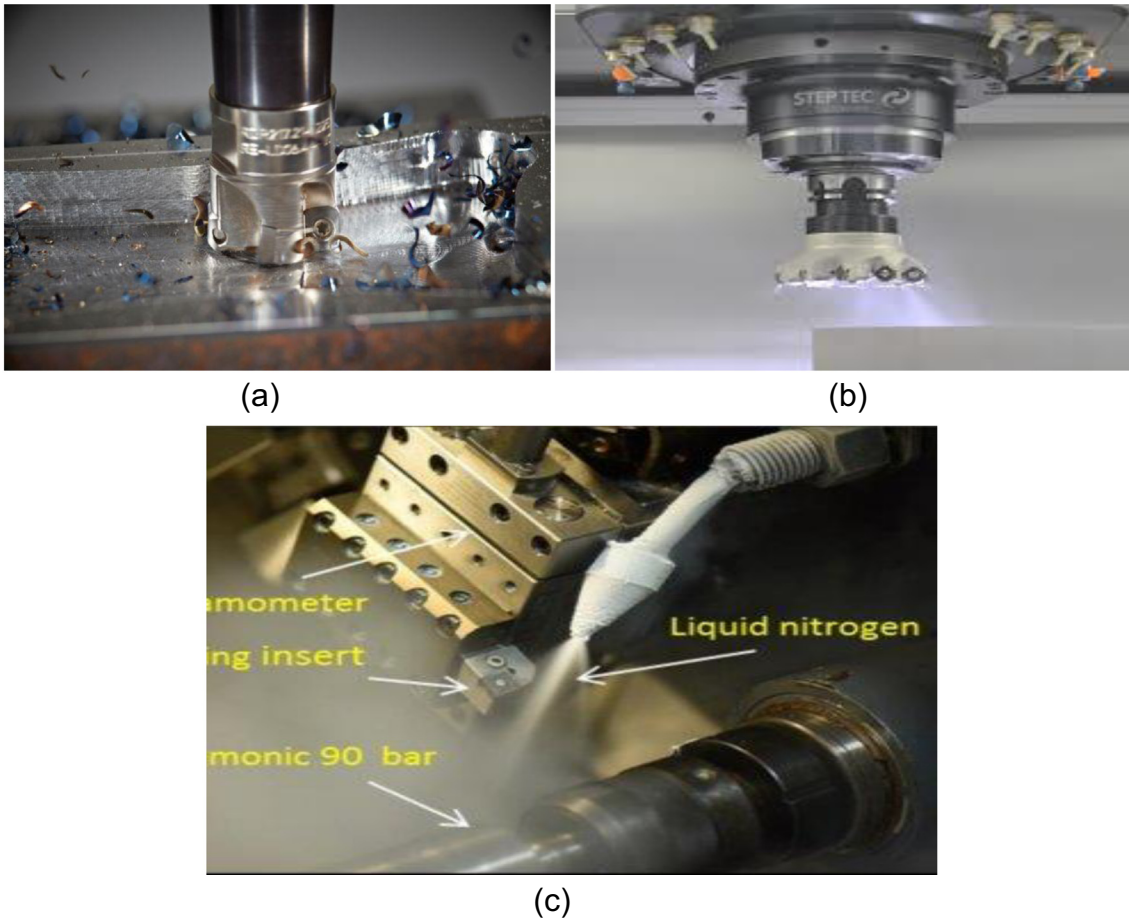


Fig. 4. (a) Dry machining, (b) MQL machining and (c) Cryogenic Machining [14]



Fig. 5. Shown benefits of dry machining [15]

impacts of HPC, for instance, life cycle examination or organic examination. Fig. 6 shown heading of infusion in high-pressure stream helped machining approach.

3. Literature review on Machinability of Ti alloy, stainless steel, Mg alloy, aluminum alloy and Inconel under machining with environmental friendly machining techniques

In this section, literature survey carried out on machinability influence with environmental friendly machining techniques of

materials e.g. Ti alloy, Inconel stainless steel, Magnesium alloy, Aluminum alloy. This section divided into four sub-sections based on materials. These sections are following;

3.1. Literature survey on Ti and its alloy

Titanium composite has, heavenly properties for example strength maintenance, erosion obstruction at high temperature because of these properties it is generally relevant in biomedical, aviation, petrol and auto enterprises.

Titanium and its combination difficult to cut materials because appeared differently in relation to aluminum, carbon, solidified steel. Cryogenic, MQL and high pressing factor machining is used for improve machinability of hard to cut material. In this way, these cooling approaches are considered as a possible response for machining of different to cut materials [24]. In term of surface improvement, [25] experiment carried out on Ti-6Al-7Nb with dry, flood and cryogenic environment and found that surface roughness (Ra) improved by 35%, 6.6% with cryogenic cooling environment. Fig. 7 shown micro structure of work piece. Also, this supported by [26] that experiment work carried out on Ti-6Al-4 V with oil based coolant, cryogenic compressed cooling environment after these experiment result found that cryogenic cooling system improved surface roughness and machinability. Additionally, on behalf of tool wear [27] experiment work carried out Ti-6Al-4 V with dry, cryogenic compressed air and found that tool wear reduction with cryogenic compressed air compared to dry machining.

Similarly environmental friendly machining approach provides better machinability compared to other. According to [28],

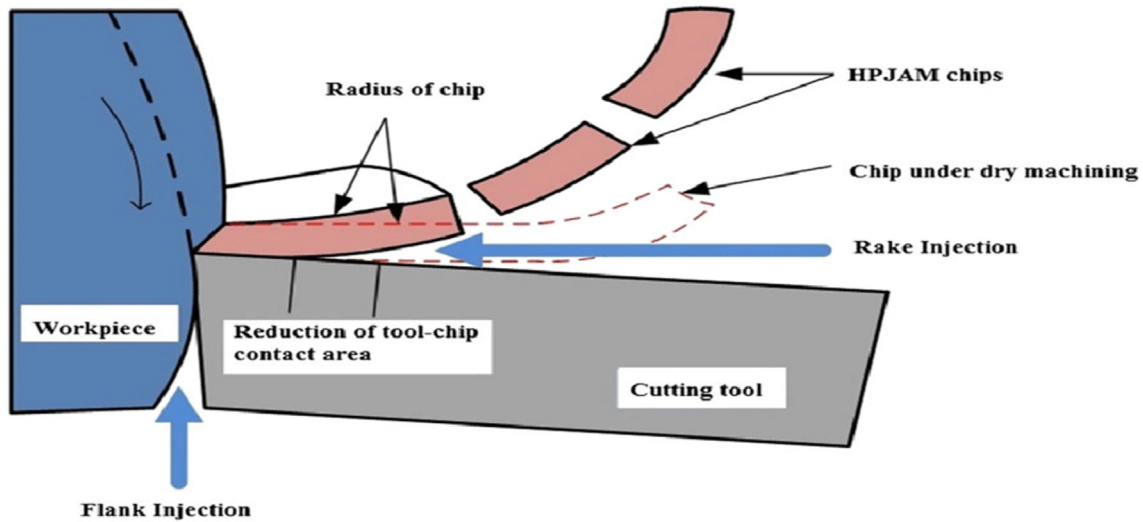


Fig. 6. direction of injection in high-pressure jet-assisted machining [23]

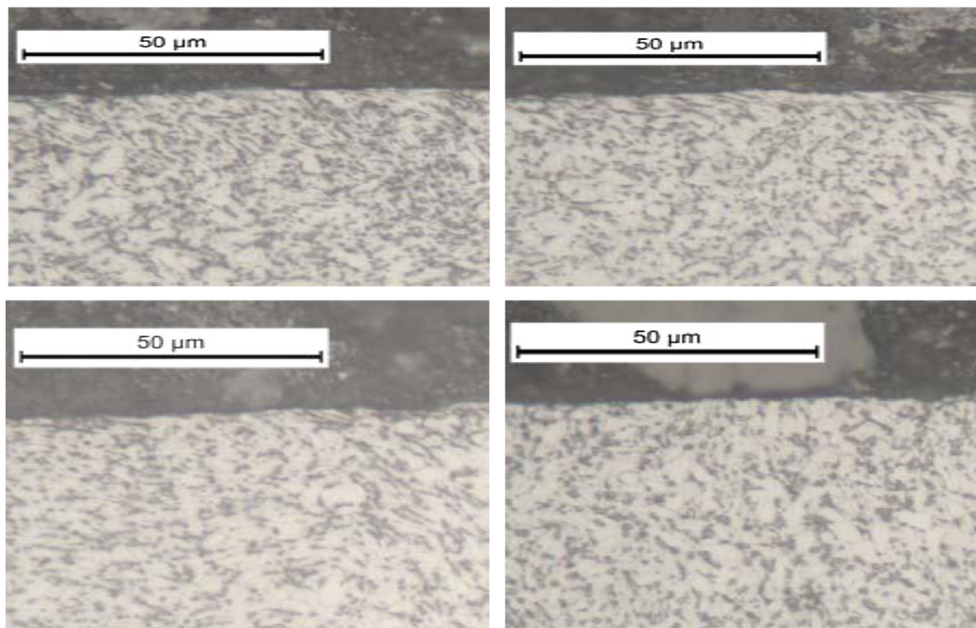


Fig. 7. The microstructures of the machined surface and sub-surface in: (a) cryogenic machining; (b) flood-cooled machining; (c) dry machining; and (d) as received material [25]

experiment carried out on Ti-6Al-4V with flood, ScCO₂, and MQL + ScCO₂. After this experimental work, it was observed that the machinability improve with ScCO₂ + MQL at V_c -60 m/min., feed rate- 0.5 mm/tooth. Also in term of tool life [29], machining work completed on Ti-6Al-4V with coated with AlCrN tool under different cooling environment e.g. flood, MQL + Nano particles, internal cryogenic cooling, MQL + external cooling approach and MQL + internal cryogenic cooling approach. And found that MQL + indirect cryogenic cooling system tool wear improved to 90% compared to the conventional flood coolant strategy. Fig. 8(a and b) showing MQL + indirect cryogenic machining setup and tool wear respect to these machining environments.

As indicated by Fig. 8 that tool wear is decrease contrasted with flood cooling framework. Thus, it was seen that environmental friendly machining techniques is giving better outcome and eco-accommodating machining. References [24–36] address writing

survey on titanium compound. These writing reviews present in even structure, Table 1 showing writing overview of machining on Ti and its amalgam with various cooling climate.

3.2. Literature survey on stainless steel

Stainless steel [37–39], is part of iron based compounds that contain at least 11% chromium [40–41] an arrangement that consider the iron from rusting [42] similarly as giving warmth safe properties [40,41,43–47]. Table 2 address contain of tempered steel. Various types of stainless steel consolidate the segments carbon (from 0.03% to more conspicuous than 1.00%), nitrogen, aluminum, silicon, sulfur, titanium, nickel, copper and molybdenum and so on Express sorts of tempered steel are much of the time allocated by a three-digit number for example 304 immaculate.

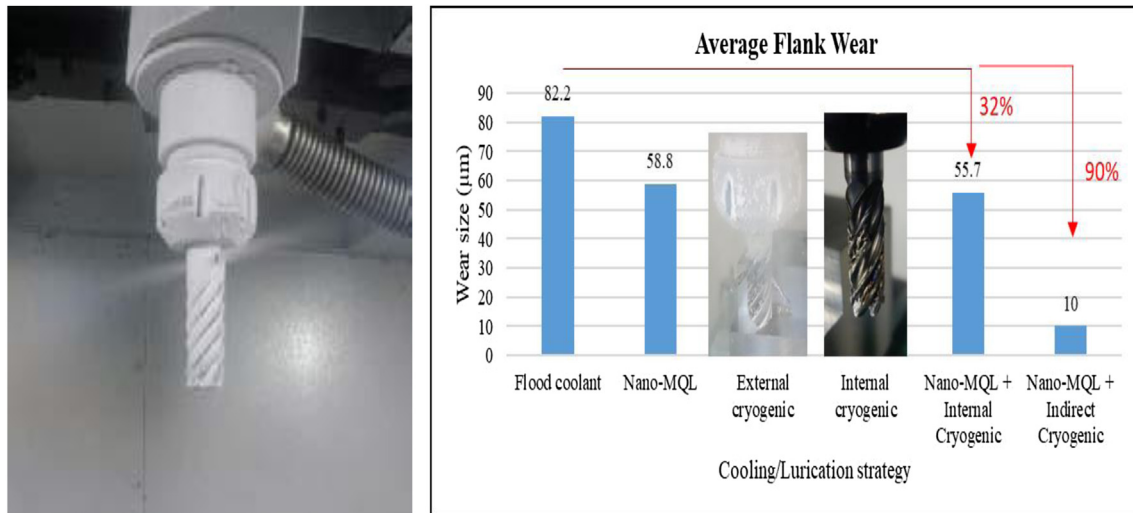


Fig. 8. (a) MQL + indirect machining setup, (b) Tool wear with respect to different cooling system [29]

Table 1

Literature Review of Machining on Ti and its alloy.

	Cutting Tools	W/P	Environment	Outcomes
[24]	TiAlN Coated inserts	Ti-6Al-7Nb (W/P)	Dry machining, Cryogenic machining, flood machining	In term of Ra, it was observed that surface roughness improved upto 35%, 6.6% with cryogenic machining compared to both others.
[25]	Coated carbide insert CNMG 120,412	Ti-6Al-4 V	Machining with Cryogenic cooling system, oil based coolant	As s results, cryogenic machining effectively improve machinability and reduced tool wear.
[26]	Carbide inserts CNMX120408A2S	Ti-6Al-4 V	Machining with compressed air and dry machining method	Test work did on Ti-6Al-4 V work piece plate under dry machining and compacted air and it was acquired that apparatus wear is decreased by machining with packed air.
[27]	SANDVIK 419 R-1405E-MMS 407 (insert)	Ti-6Al-4 V	Machining with flood, super critical CO2 and MQL with super critical CO2	After experimental work it was obtained, machinability improve if machining carried out with ScCO2 + MQL at Vc 60 m/min., feed rate 0.5 mm/tooth.
[28]	Coated insert with AlCrN	Ti-6Al-4 V	MQL with Nano particles, MQL + Internal, MQL + indirect, internal cryogenic cooling and flood machining	Experimental work carried out under different cooling environment such flood, MQL + Nano particles, internal cooling , MQL + Internal, MQL + direct. After experimental work result was found that MQL + direct cooling approach effectively improve tool life up to 90%.
[29]	Uncoated carbide inserts tool ISO-CNMG 120,408	Ti-6Al-4 V	Untreated condition and treated condition with 12H, 24H, 36H	In this article test work did under treated condition and un treated condition. Furthermore, result tracked down that profound cryogenic treated (36H) is best boundary contrasted with other machining boundary.
[30]	SANDVIK432 MM tool with TiCN coating tool	Ti-5553	Flood machining technique, Cryogenic cooling system and MQL machining	In term force, it was seen that thrust force diminished by 30% contrasted with both other machining condition.
[31]	Cemented carbide CNMG120404	Ti-10 V-2Fe-3Al	Cryogenic machining with carbon dioxide and emulsion	In this article tool wear is output parameter and after trial work it was seen that tool wear is decreased by if machining work completed with carbon dioxide (cryogenic cooling approach).
[32]	Cemented carbide with uncoated insert	Ti-6Al-4 V	Wet machining with MQL approach, MQL approach with 0,-15,-30,-45 degree, dry machining	In term of machining performance it was observed that MQL with - 15 degree cooling approach give better results compared to other machining conditions.
[33]	Microcrystalline with uncoated ISO K20 insert	Ti-6Al-4 V	High pressure cooling approach, conventional cooling approach	In this article, exploratory work did on Ti-6Al-4 V and it was seen that instrument life and other machining execution boundary are improve if machining done by high pressing factor cooling framework.
[34]	Tungsten carbide with PVD coating insert	Ti-6Al-4 V	Untreated condition, treated condition with 24H,48H.	Essentially in this article test work did under two unique sorts of cooling approach for example untreated condition and cryogenic treated condition. After the Experimental work it was seen that 48H demonstrated better outcomes in term of machining execution contrasted with other machining condition.
[35]	Diamond coated cemented carbide insert	Ti-6Al-4 V	ScCO2, ScCO2 + WMQL, ScCO2 + OoWMQL, dry cutting	In term of tool wear, surface trustworthiness result was tracked down that overly basic CO2 + Oo MQL give successful outcomes contrasted with other machining condition.
[36]	Carbide insert with uncoated	Ti-6Al-4 V and Inconel 718	Cryogenic cooling (CO2), MQL, CMQL	As results, in term of machining performance that CMQL provide most favorable cooling method compared to other cooling method.

Stainless steels security from ferric oxide game plan results from the presence of chromium in the compound, which shapes a detached film that shields the key material from dis-

integration attack and self-recover inside seeing oxygen. Along these lines, stainless steel is by and large used in machining measure.

Table 2
Contain of Stainless steel and its alloy.

Element	Weight Percentage
Carbon	0.008 max.
Sulphur (S)	0.030 max
Chromium (Cr)	20 max.
Nickel	12 max.
Manganese (Mg)	2.00 .max.
Phosphorus	0.045 .max.
Silicon	0.75 .max.
Nitrogen	0.10 .max
Iron	67–71

Table 3
Literature Survey on Stainless Steel and its alloy.

Reference	Cutting Tools/Inserts	W/P	Environment conditions	Outcomes
[48]	HSS T-42 S-400 Insert	AISI 4340	LN2	After the experimental work it is observed that Ra only 5.32% machining with LN2.
[49]	TiN coated ISO-P30TN450XPDT	AISI p20	Dry machining, flood machining, machining with LN2	It was observed that 15–17% of tool wear is reduced compared with LN2 compared to dry and flood.
[50]	Nano-Multilayer TiAlN insert with PVD Coated	Duplex stainless steel (DSS)	Dry environment and machining with cryogenic (LN2)	After the exploratory work, results found that machining with cryogenic framework improve surface quality and furthermore diminished tool wear.
[51]	CBN TCGW16T304S105MT	AISI52100	Cryogenic (LN) and dry machining	As results, that machining with LN2 helped machining of solidified AISI52100 has a huge outcome contrasted with dry machining.
[52]	Carbide insert with CVD coated (TiCN/Al2O3)	AISI 4340	Dry cutting environment machining, cryogenic machining(LN2)	it was obtained that all cryogenically machined surface
[53]	TiN coated carbide insert ISO-DNMG150608 MM	AISI304	Dry machining, machining with liquid nitrogen, MQL machining, MQL + LN2, MQL + CO2 (Cryo.)	As a result, that these all techniques improve surface quality but MQL + CO2 provide most effective cooling environment approach.
[54]	Tungsten carbide insert with AlTiN PVD coated KC 5010	17–4 HSS	Dry cutting machining, wet machining, MQL machining, machining with liquid nitrogen	In term of surface quality, it was seen that cryogenic cooling give fulfills bring about term of surface quality contrasted with dry machining, wet machining and MQL.
[55]	HSS twist drill	SS310	Untreated condition, cryogenic treated condition	After trial work it was seen that cryogenic treated with addition gives better surface completion and decreased of mistake.
[56]	TiN & TiAlN with coated insert	AISI D2 (W/P)	Dry machining, wet machining and LN2 machining	Subsequently, in term of cutting temperature and cutting power 13%, 18% decreased with LN2.
[57]	Tungsten carbide insert with TiCN/Al2O3/TiN coated	AISI H11	Dry machining, Liquid nitrogen cooling untreated condition	It was seen that DCT 24 give successful outcomes contrasted with other.
[58]	Uncoated SNGA 120,408 TO1020AB30	AISI D2(W/P)	DCH (36) & DCTT (36), CHT	As outcomes, in term of Ra and Tool wear DCTT (36) give better outcomes contrasted with CHT, DCH (36).

Table 4
Literature review on Magnesium alloy, nickel alloy, Inconel alloy and aluminum alloy.

Reference	Cutting Tools	W/P	Environment	Outcomes
[59]	Carbide insert	AA6063 aluminum alloy	Dry & machining with LN2	In term of Ra and MRR, result found that better machining condition was obtained under LN2 machining with 120 m/min., 0.4 mm, and 1400 rpm.
[60]	Carbide insert CNMG	Inconel 718	Dry machining, LN2 machining, MQL machining and MQL + LN2 machining	In term of surface integrity that cryogenic cooling approach improves Surface quality and overall machining performance.
[61]	Two flute helical PVD	AZ31 magnesium alloy	Dry machining, liquid nitrogen machining	After the test work, it was seen that cryogenic machining with Liquid nitrogen improve machinability adequately contrasted with dry machining.
[62]	PVD TiAl/AlCrN grade ACK 300	Inconel 718	Cryogenic cooling system and dry machining	In term of tool wear and Ra, cryogenic cooling machining give better machining execution contrasted with dry machining.
[63]	Carbide tool with PVD TiAlN/TiN coated	Nickel alloy	Cryogenic machining, machining with MQL and MQL with Cryogenic machining	Accordingly, it was seen that Cryogenic + MQL improved surface by 24.82% more than cryogenic cooling approach. At long last it was seen that MQL give better outcomes contrasted with other.
[64]	Carbide tool with uncoated	AZ31B magnesium alloy	Dry machining & machining with LN2	In term of surface quality, that machining with LN2 increase surface quality compared to another method.
[65]	Tungsten insert with AlTiN coated	Nickel alloy	Machining with liquid nitrogen & machining with MQL + Nano particles	In term of machinability result was found that liquid nitrogen give better results e.g. reduced flank wear, reduced tool wear and also improve machinability.
[66]	Coated carbide tool	Inconel 625	Machining with MQL, dry machining, Cryogenic machining (by LN2), machining MQL with LN2 machining, NMQL + LN2	After exploratory work saw that in term surface 0.5 vol% hBN cooling technique utilized related to fluid nitrogen gave the best outcomes as far as machining execution.
[67]	PVD coated tool	Inconel 718	Machining with dry method and machining with cryogenic (Through CO2)	Cryogenic machining through CO2 is novel machining and effectively improves machinability compared to dry machining.

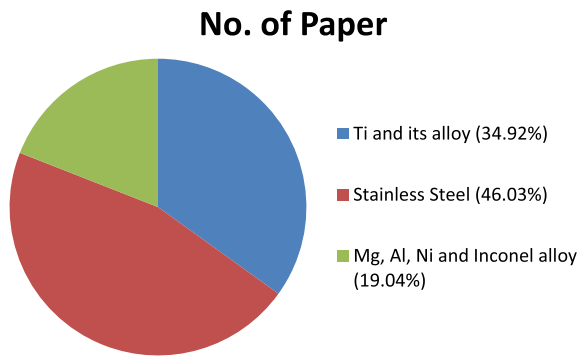


Fig. 9. literature review between No. of paper to types of materials.

Table 5

Comparative examination for execution and biological parts of machining under various cooling-oil conditions.

Parameters	Dry Machining	MQL Machining	Cryogenic Machining
Tool Life	2	4	5
Surface Quality	2	4	5
Cost	3	5	4
Sustainability	3	4	5

Scale 1–5 (1- bad, 5-best).

cryogenic machining and tracked down that natural amicable machining give better machining execution contrasted with show cooling methods All the literature survey which carried out on stainless steel shown in Table 3.

3.3. Literature survey on magnesium alloy, nickel alloy, Inconel and aluminum alloy

In this section represent literature review [59–67], on different types of alloys e.g. magnesium alloy, nickel alloy, Inconel and aluminum alloy. These literature review showing tabular because easy for reading and conclusion of paper. Table 4 showing literature survey on Magnesium alloy, nickel alloy, Inconel alloy and aluminum alloy.

4. Summary of literature review

This segment address of rundown of all writing survey dependent on two term, for example, number of paper to sorts of materials and Comparative investigation for execution and biological parts of machining under various cooling-grease conditions.

- In this section graphical representation of all reviewed paper by using Fig. 9. In Fig. 9 graphical representation between literature review between No. of paper to types of materials.
- Comparative examination for execution and biological parts of machining under various cooling-oil conditions. Table 5 showing these analyses.

5. Conclusion

Because of the ecological concerns, defilement and contamination guideline the interest of environmental friendly machining method expanding step by step [11]. In this article, investigation 85 papers which is connected by environmental friendly machining techniques and the current examination has stressed on how environmental friendly machining research has grown in the last ten years by conducting a comprehensive descriptive study

through a systematic literature review of 85 selected articles. The conclusions of article are following;

- In primarily, conventional cutting fluids are utilized in machining operation. But due to environmental problems and health issue, these techniques are not suitable in machining operation. Because these techniques are nor economical and neither eco-friendly approach. After literature survey it was observed that environmental friendly machining such as dry machining, high pressure cooling approach, MQL machining and cryogenic machining are eco-friendly and cost effective approach in machining operation.
- Dry machining is environmental friendly machining and furthermore improves machinability. However, a few limits of dry machining in penetrating machining measure in light of the fact that in boring more warmth created in cutting zone so machining execution are decreased.
- Other environmental friendly machining techniques e.g. high pressure cooling method, MQL machining and cryogenic machining is improves machinability; minimize environmental issues and health issue.

In present article, completely study on environmental friendly machining and impact of environmental friendly machining on manufacturing industries.

CRedit authorship contribution statement

Rajeev Sharma: . **Binit Kumar Jha:** . **Vipin Pahuja:** Supervision. **Sagar Sharma:** .

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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