Development of Sustainable Roller Burnishing Process in terms of Surface Quality and Air Pollution

(Nghiên cứu phát triển quá trình lăn ép bền vững trong mối liên hệ với chất lượng bề mặt và ô nhiễm không khí)

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Faculty of Mechanical Engineering

MILITARY TECHNICAL ACADEMY

Contents

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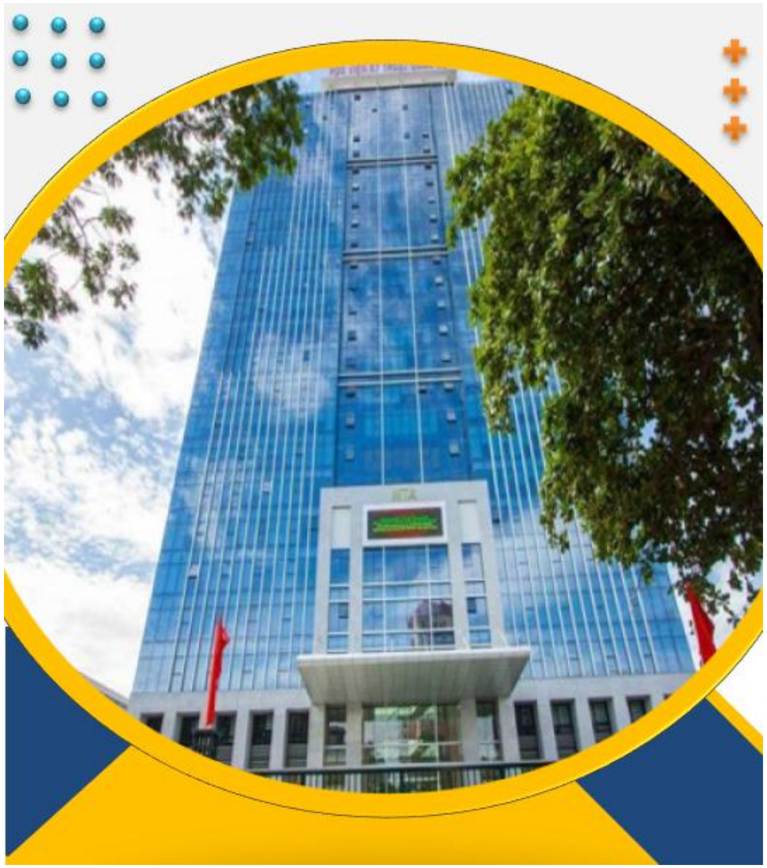
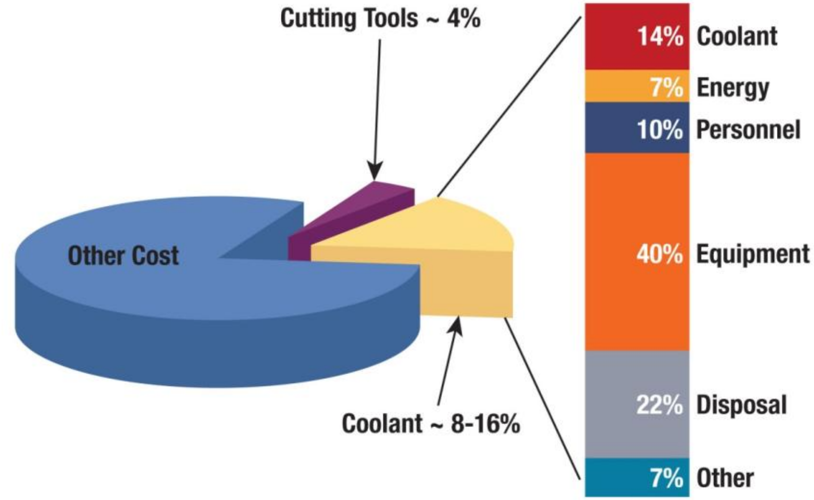


Outline

Importance of sustainable roller burnishing process

Traditional process with flooding condition



Lubricant role in manufacturing cost

The burnishing process is widely applied to automotive, aerospace, defence, medical industry, and power generation

Due to the limitations of domestic natural energy resources, decreasing and/or limitation of lubricant becomes an important consideration

Sustainable roller burnishing process is extremely important

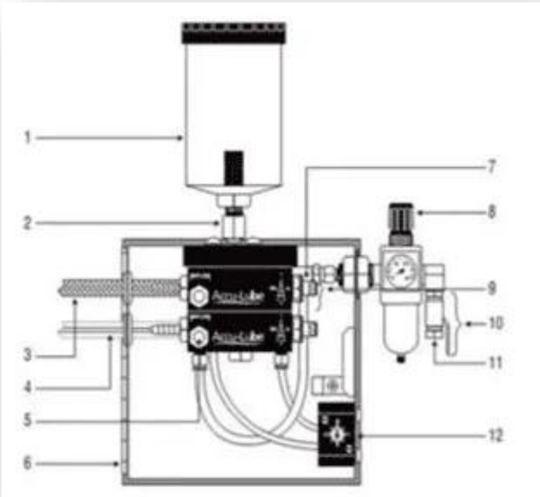
- Obtaining sustainable development
- Resolving ecological issues
- Saving manufacturing cost
- Increasing competitiveness

Conceptual design of sustainable roller burnishing process

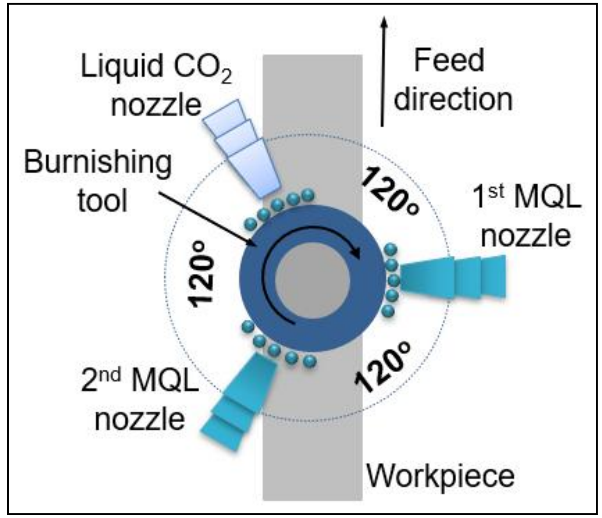
Minimum quantity lubricant system

Sustainable roller burnishing process

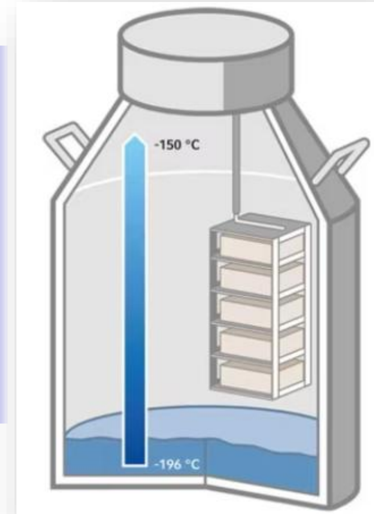
LN_2 and/or LCO_2 supply system



Oil mist



LN_2 and/or LCO_2



- Ultra-low fluid consumption
- Aerosol delivery method
- Precise control mechanisms
- biodegradable/high-quality lubricants
- Dry chip production

- Extreme cryogenic temperatures
- High expansion ratio
- Rapid heat absorption
- Inert and non-flammable
- Asphyxiation risk

Process parameters and burnishing responses considered

Liquid CO_2-assisted MQL flat burnishing parameters

- Air pressure
- Lubricant flow rate
- CO_2 flow rate

Preparation

Specimens
Burnishing tool
MQL
Liquid CO_2
CNC machine

Burnishing experiment

Post burnishing

Burnished specimen
Experimental data
Microstructure analysis

Burnishing responses

- Maximum height roughness in defined area
- Particulate matter 2.5 concentration
- Vickers hardness

Implementation of sustainable roller burnishing process

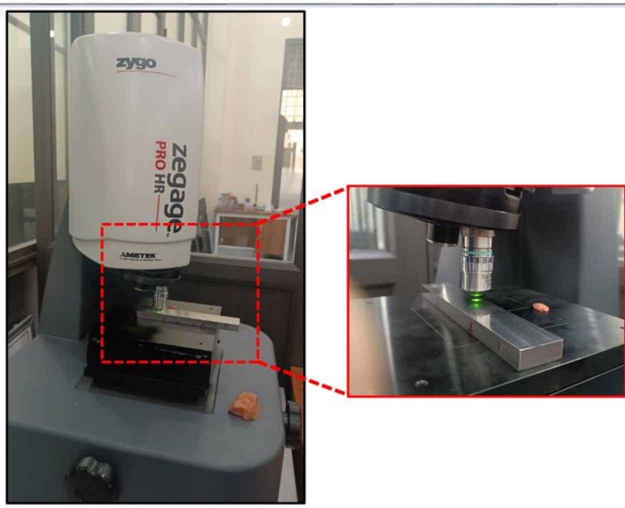
Experiments

MQL and LCO_2

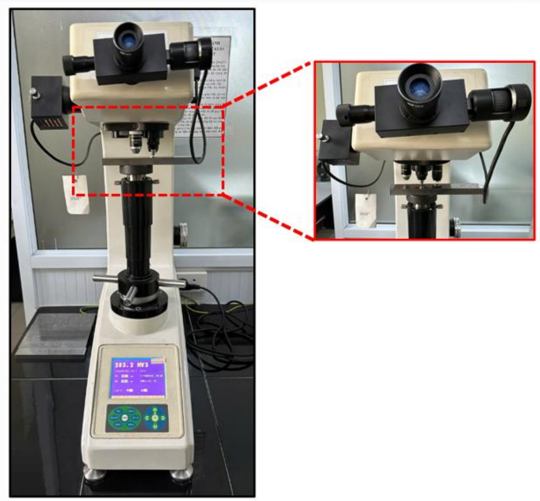
Milling operation

Burnishing operation

Measuring devices



3D roughness tester



Vickers hardness tester

Particle counter

Comparisons at different machining conditions

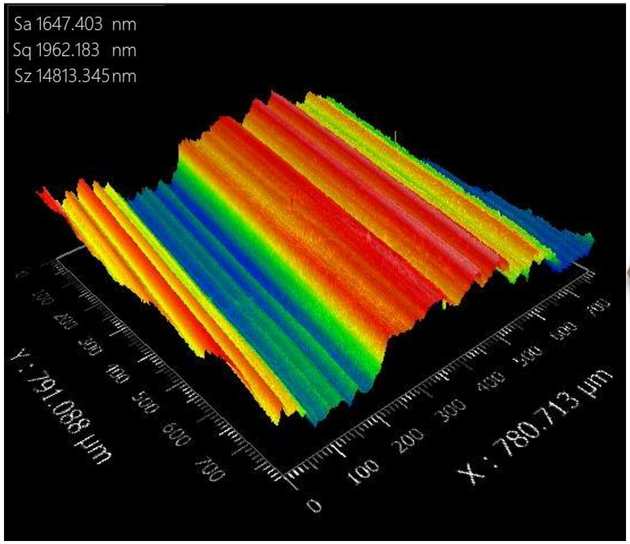
No	S (rpm)	f (mm/min)	D (mm)	P (MPa)	QM (ml/h)	QC (L/min)	Sz (nm)	VH (HV)
1	1600	140	0.10	CAMQL: P = 4 Bar; QM = 150 ml/h; QC = 20 L/min			1268.906	254.2
2	1200	120	0.12				1092.593	258.9
3	1400	100	0.16				956.346	269.2
4	1000	80	0.20				1046.097	279.4
5	1600	140	0.10	MQL: P = 4 Bar; QM = 150 ml/h			2356.253	247.7
6	1200	120	0.12				2625.436	249.1
7	1400	80	0.16				1633.856	266.6
8	1000	140	0.20				1741.973	260.6
9	1600	140	0.10	Dry			2693.674	232.5
10	1200	120	0.12				3659.399	245.1
11	1400	100	0.16				2491.264	252.6
12	1000	80	0.20				3601.3710	258.3

Abbreviation:
S: Spindle speed
F: Feed rate
D: Depth of penetration
P: Air pressure
QM: Lubricant flow rate
QC: CO_2 flow rate
Sz: The maximum height roughness in defined area
VH: Vickers hardness

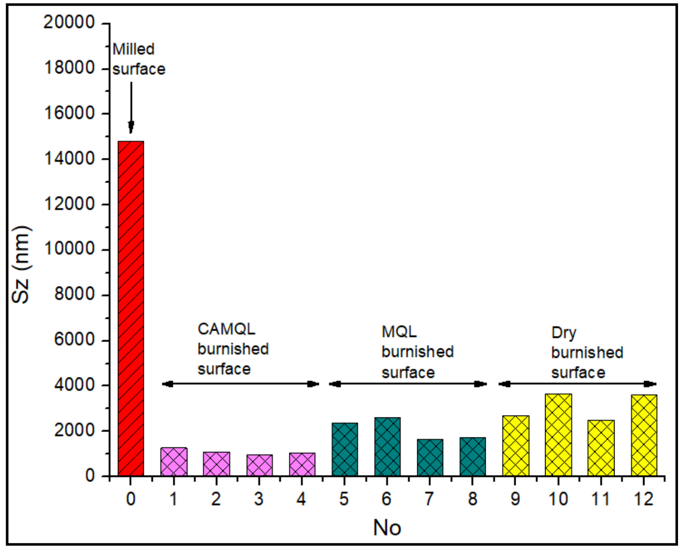
- **The Sz values at the CAMQL are reduced from 39.9% to 58.4% and from 52.9% to 97.1%, as compared to the MQL and dry conditions, respectively.**
- **The VH values at the CAMQL are reduced from 1.0% to 6.7% and from 5.3% to 8.5%, as compared to the MQL and dry conditions, respectively.**

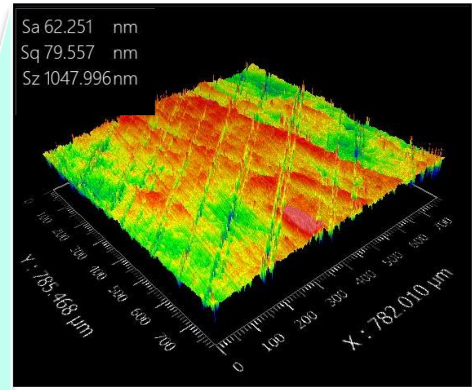
Evaluation of surface roughness

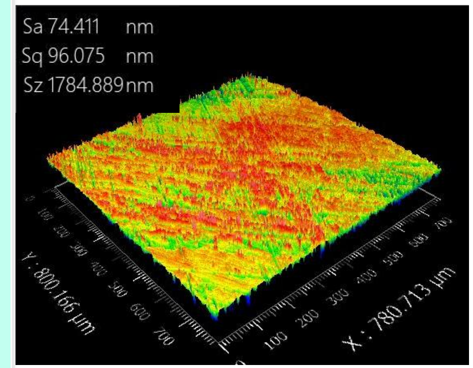
Milled surface

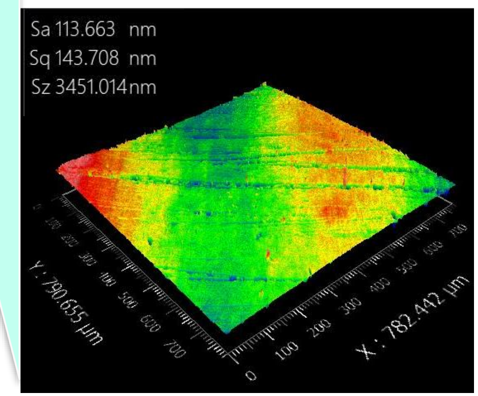


Comparisons at different conditions





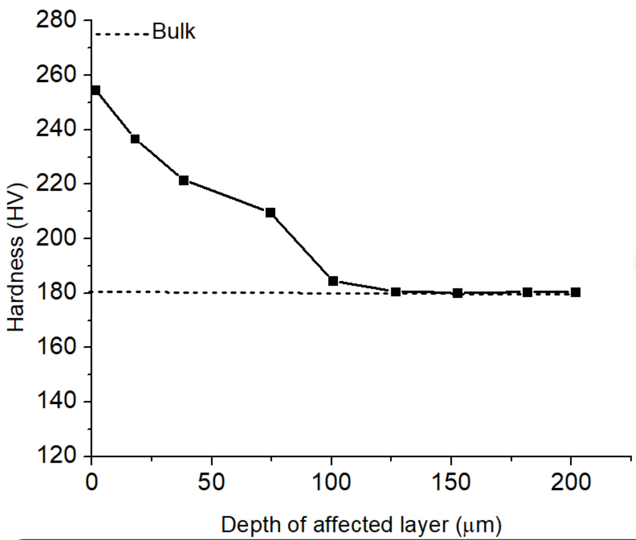




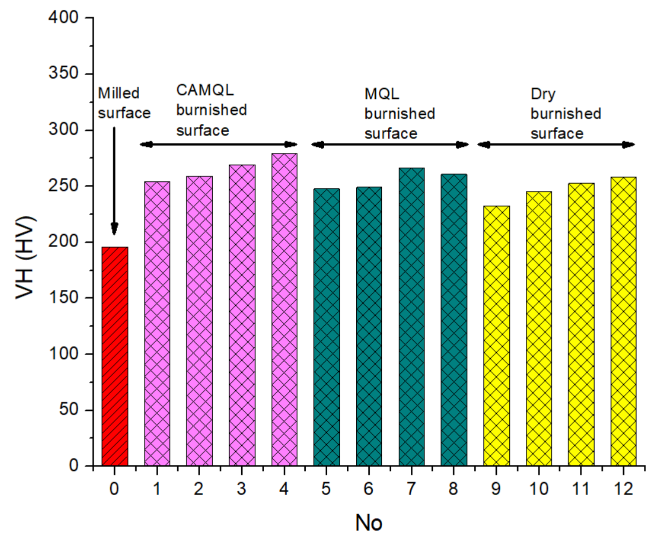
- **The Sz at the CAMQL, MQL, and dry are reduced by 90.5%, 87.9%, and 76.7%, respectively, as compared to the milled surface.**

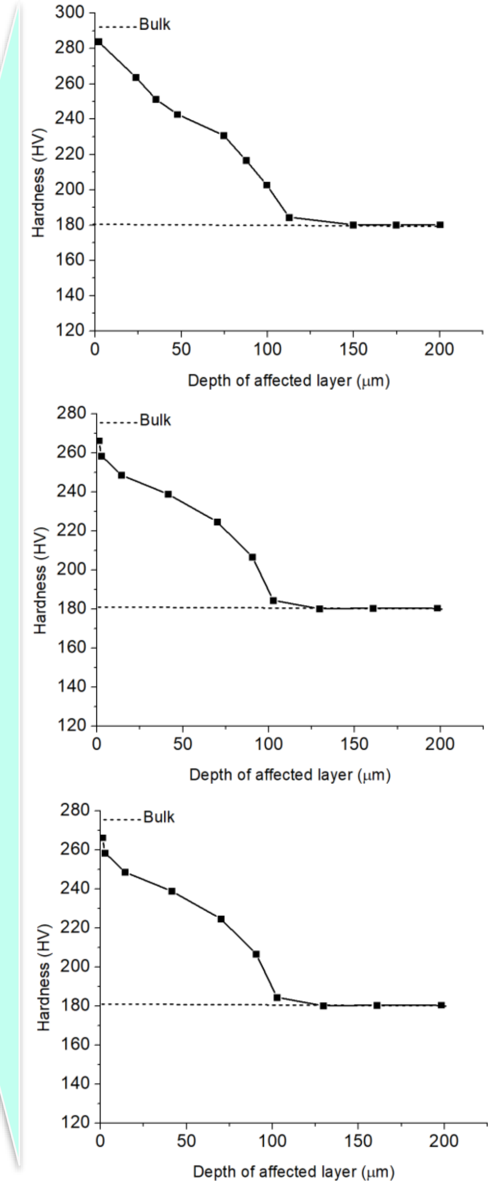
Evaluation of Vickers hardness

Milled surface



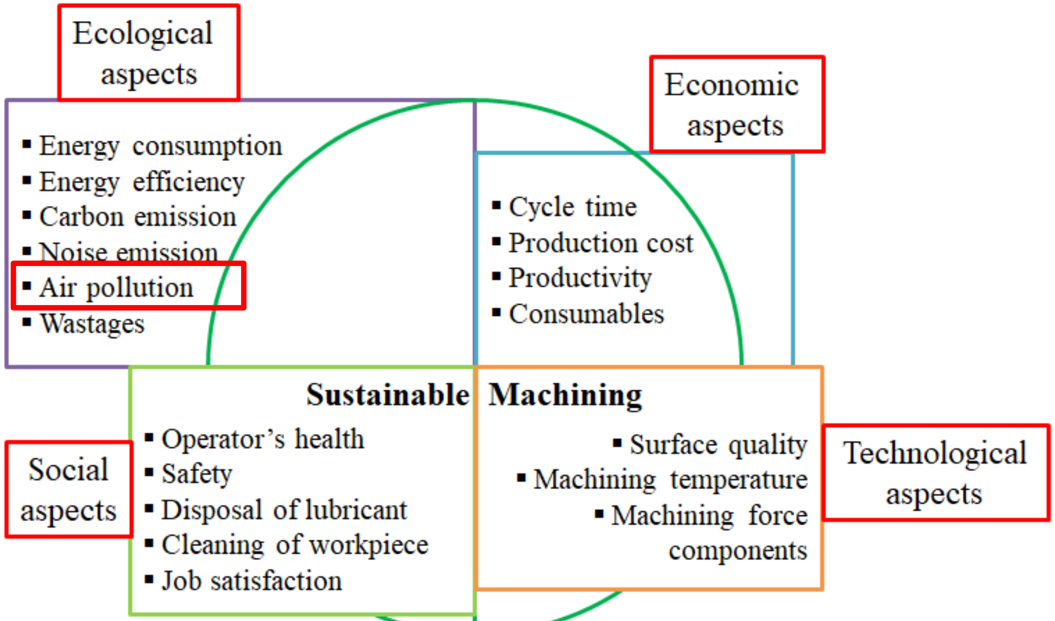
Comparisons at different conditions



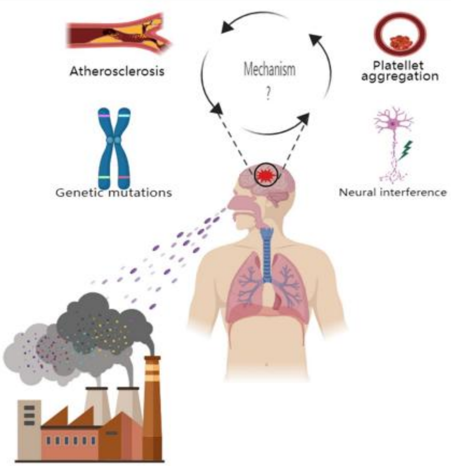


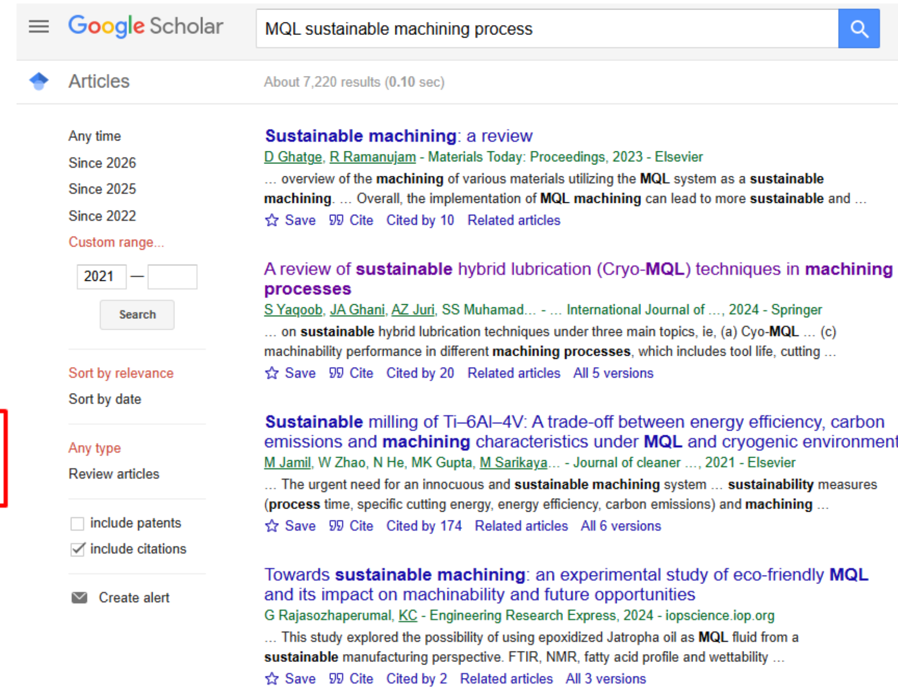
- **The VH at the CAMQL, MQL, and dry are improved by 53.2%, 42.8%, and 41.7%, respectively, as compared to the milled surface.**

Evaluation of sustainable indicator



PM2.5& PM10 negative impacts





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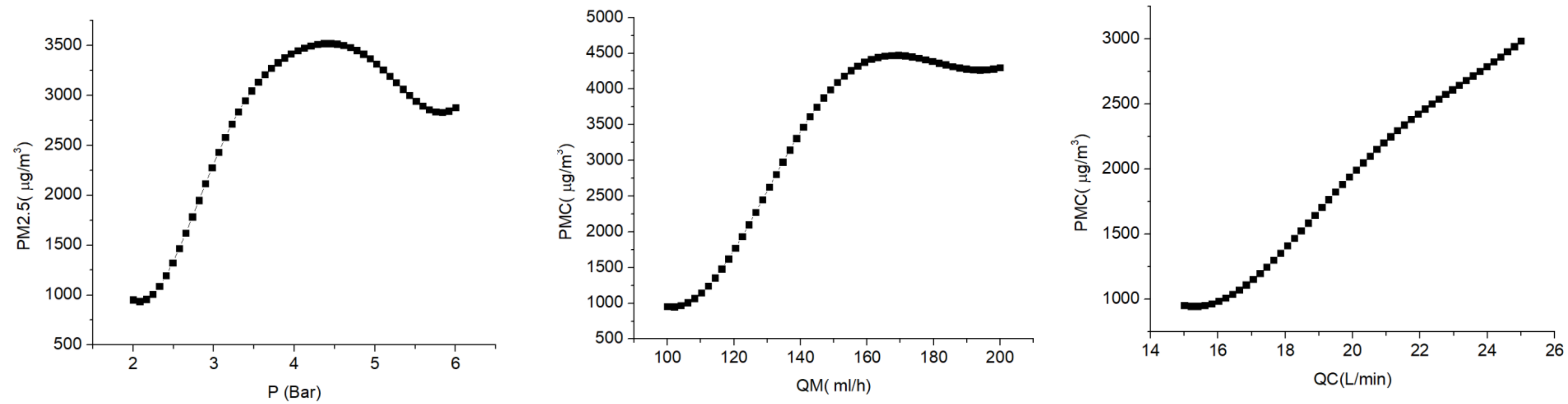
Are MQL, LN_2 and LCO_2 sustainable approaches?

Impacts of process parameters on PM2.5

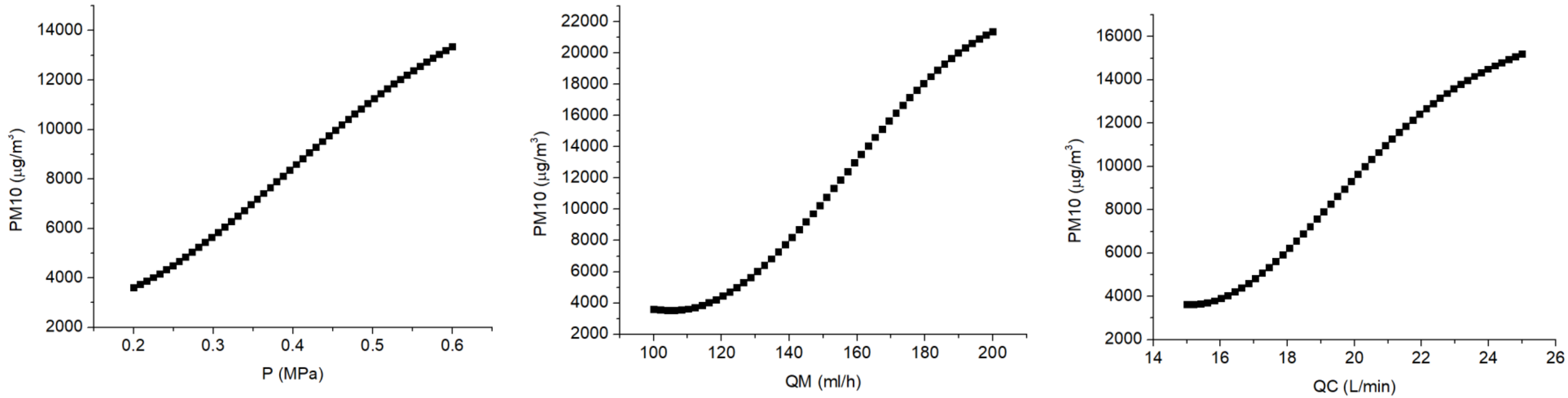
Experimental data



- **Higher *PM2.5* values are found with increased process parameters. The relative increases in terms of the *P*, *QM*, and *QC* are 90.23%, 108.27%, and 84.05%, respectively.**
- **A higher *P* produces low oil-mist's diameter and increases its velocity, leading to higher amount of particulate matter; hence, the *PM2.5* increases.**
- **A higher *QM* increases amount of the oil in the air; hence, the *PM2.5* increases.**
- **A higher *QC* increases the amount of liquid CO_2 penetrating the burnishing region, leading to an increased *PM2.5* under the impact of the machining temperature.**

Impacts of process parameters on PM10

Experimental data



- Higher *PM10* values are found with increased process parameters. The relative increases in terms of the *P*, *QM*, and *QC* are 88.2%, 195.45%, and 108.11%, respectively.
- A higher *P* produces low oil-mist's diameter and increases its velocity, leading to higher amount of particulate matter; hence, the *PM10* increases.
- A higher *QM* increases amount of the oil in the air; hence, the *PM10* increases.
- A higher *QC* increases the amount of liquid CO_2 penetrating the burnishing region, leading to an increased *PM10* under the impact of the machining temperature.

Conclusions

- The roughness was significantly reduced using the LMQLB operation and the nanoscale could be obtained at the optimal data.
- The cryogenic-assisted MQL provided better data for the *Sz* and *VH,* as compared to the MQL and dry conditions.
- The liquid CO_2-assited MQL method significantly produces the PM2.5 and PM10. The PM2.5 and PM10 are not directly produced by the liquid CO_2, however, the machining temperature can transfer the liquid CO_2 to the PM2.5 and PM10.
- The CAMQL approach can be used to cool and lubricate different burnishing processes.
- The obtained results can be efficiently used in the mold industrial sector.

I would like to express my gratitude and appreciation.
Thank you for your listening