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High-speed machining parametric optimization of 15CDV6 HSLA steel under minimum quantity and flood lubrication

Khawaja, A.H.[a,*], **Jahanzaib, M.**[b], **Cheema, T.A.**[c]

[a]Department of Mechanical Engineering, University of Engineering and Technology, Taxila, Pakistan
[b]Department of Industrial Engineering, University of Engineering and Technology, Taxila, Pakistan
[c]Department of Mechanical Engineering, GIK Institute of Engineering Sciences, Topi, Pakistan

ABSTRACT

High-speed machining (HSM) maintains a high interest in the preparation of metal parts for optimum results, but with the application of HSM, the sustainability issue becomes important. To overcome the problem, minimum quantity lubrication (MQL) during HSM is one of the innovative and challenging tasks during conventional cutting (milling) to improve quality, productivity, and strength under the umbrella of sustainability. The objective of this research is to achieve sustainable machining by simultaneously optimizing sustainable machining drivers during the HSM of 15CDV6 HSLA steel under MQL and flood lubrication. The response surface methodology has been applied for the development of mathematical models and selecting the best combination of process parameters to optimized responses, i.e. surface roughness, material removal rate, and strength. Optimization associated with sustainability produced compromising optimal results (Min. *Ra* 0.131 μm, Max. *MRR* 0.64 cm^3/min, and Max. *ST* 1132 MPa) at the highest cutting speed 270 m/min and the lowest feed rate 0.09 mm/rev and depth of cut 0.15 mm under MQL. The comparative investigation exposed that significant improvement in *Ra* (1.1-16.6 %) and *ST* (1.3-2.3 %) of the material using MQL has been witnessed and gives a strong indication that MQL is the best substitute than the flood lubrication. The scientific contribution of the approach is to develop mathematical models under MQL and flood lubrication that will aid practitioners to choose input parameters for desired responses without experimentations. The work would be beneficial in the field of aviation, defense, and aeronautical applications due to the excellent mechanical properties of 15CDV6 HSLA steel.

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**Corresponding author:*
amar.khawaja@students.uettaxila.edu.pk
(Khawaja, A.H.)

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Izvirni znanstveni članek

Optimizacija parametrov visokohitrostne obdelave jekla 15CDV6 HSLA z minimalno količino maziva in s konvencionalnim mazanjem

Khawaja, A.H.[a,*], **Jahanzaib, M.**[b], **Cheema, T.A.**[c]

[a]Department of Mechanical Engineering, University of Engineering and Technology, Taxila, Pakistan
[b]Department of Industrial Engineering, University of Engineering and Technology, Taxila, Pakistan
[c]Department of Mechanical Engineering, GIK Institute of Engineering Sciences, Topi, Pakistan

POVZETEK

Visokohitrostna obdelava (HSM) je zanimiva tehnologija za pripravo kovinskih izdelkov, saj zagotavlja dobre rezultate, vendar pa z uporabo HSM postane pomembno vprašanje trajnosti. Ena od inovativnih in hkrati zahtevnih rešitev za izboljšanje kakovosti površine, produktivnosti obdelave in trdnosti materiala ob upoštevanju vidika trajnosti med rezkanjem HSM je mazanje z minimalno količino maziva (MQL). Cilj raziskave je doseči trajnostno obdelavo HSM jekla 15CDV6 HSLA. V ta namen je bila izvedena primerjalna analiza med rezultati optimizacije parametrov obdelave ob uporabi minimalne količine maziva in med rezultati optimizacije parametrov obdelave ob uporabi konvencionalnega mazanja. Za razvoj matematičnih modelov, ki omogočajo izbiro najboljše kombinacije procesnih parametrov za kakovostne kazalnike hrapavost površine, hitrost odstranjevanja materiala in trdnost, je bila uporabljena metodologija odzivne površine. Optimalni rezultati (Min. *Ra* 0,131 μm, Max. *MRR* 0,64 cm3/min in Max. *ST* 1132 MPa) so bili ugotovljeni pri rezalni hitrosti 270 m/min, podajalni hitrosti 0,09 mm/vrt in globini rezanja 0,15 mm, in sicer pri uporabi pristopa MQL, kar je z vidika trajnosti ugodno. Primerjalna analiza je razkrila izboljšanje *Ra* (1,1-16,6 %) in *ST* (1,3-2,3 %) z uporabo MQL, kar nakazuje, da je MQL dober nadomestek za konvencionalno mazanje. Glavni znanstveni prispevek raziskave so razviti matematični modeli za MQL in konvencionalno mazanje, ki bodo strokovnjakom, brez eksperimentiranja, pomagali izbrati vhodne parametre za želene odzive pri obdelavi HSM jekla 15CDV6 HSLA. Zaradi odličnih mehanskih lastnosti jekla 15CDV6 HSLA bodo rezultati raziskave koristni na področju letalskih in vojaških tehnologij.

PODATKI O ČLANKU

Ključne besede:
Visokohitrostna obdelava;
Rezkaje;
Jeklo HSLA;
Krom-molibden-vanadijevo jeklo (15CDV6);
Minimalna količina mazanja;
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Trajnost

**Kontaktna oseba:*
amar.khawaja@students.uettaxila.edu.pk
(Khawaja, A.H.)

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