

# Optimised consolidation and characterisation of TiC-SiC-reinforced AISI-4340 composite coatings for conical pick remanufacture


ORIGINAL ARTICLE Published: 29 July 2025

Volume 139, pages 4575–4595, (2025) Cite this article

[Save article](#) [View saved research](#)

## The International Journal of Advanced Manufacturing Technology

[Aims and scope](#)[Submit manuscript](#)



[Idris Babatunde Akintunde](#), [Emmanuel Efemena Lindsay](#), [Eyitayo Olatunde Olakanmi](#) , [Raghupatruni Ventaka Satya Prasad](#), [Annelize Botes](#), [Sisa Lesley Pityana](#), [Samuel Skhosane](#) & [Tshephang Motimedi](#)

 223 Accesses  3 Citations [Explore all metrics](#) →

## Abstract

TiC-SiC-reinforced AISI-4340 composite clads have been identified as a suitable material to remanufacture worn conical picks. However, the inherent defects in the clad produced, the industrial requirement to improve clad microhardness, and abrasive wear resistance necessitate the need for optimising laser processing and material parameters. Therefore,

this research is conducted to investigate the effects of the powder feed rate, the scanning speed, the angle of inclination of the nozzle, and the yttria addition on the quality characteristics of the coating. The results show that as the feed rate increases from 6 to 8 g/min, the clad height increases, and the width decreases due to the reduced spreadability of the viscous melt pool. Clad height and width decrease as scanning speed increases from 0.4 to 0.5 m/min, attributed to reduced laser energy–powder interaction (LEPI) time. Furthermore, as the nozzle is inclined 2° and 4° away from the vertical, this results in an increased width and a reduced height due to the reduction of the beam deflection (increasing heat input) and loss of powder particles before reaching the focal point. Thus, the carbide melts (carbide dissolution) and reduces the reinforcing effect, leading to a decrease in wear resistance. Moreover, the addition of yttria lowers the dissolution temperature of the carbides, with a consequent increase in width and a lesser height of the clad. The geometric analysis of optimised clad established coatings with 2.3 mm height, minimal weld penetration (0.4 mm), and small HAZ of less than 1.4 mm produced. Furthermore, the microstructure revealed a homogenous dispersion of retained TiC particles in the morphology of the lath martensite, with minimal (2.6%) porosity. Additionally, the coating has the highest amount of TiC particles retained in the AISI-4340 matrix with an average microhardness of 1743 HV<sub>0.5</sub> and 26.24 mm<sup>3</sup> volume of material loss. The use of optimised clads for remanufacturing worn CM picks to be as new will adequately withstand the hardness of engrained quartz (1100–HV<sub>0.05</sub>) in the coal seam during underground cutting of the coal mass, thus mitigating the premature failure of the picks.

 This is a preview of subscription content, [log in via an institution](#)  to check access.

### Access this article

[Log in via an institution](#)

### Subscribe and save

 Springer+

from €37.37 /Month

Starting from 10 chapters or articles per month

Access and download chapters and articles from more than 300k books and 2,500 journals

Cancel anytime

[View plans](#) →

**Buy Now**

**Buy article PDF 39,95 €**

Price includes VAT (Nigeria)

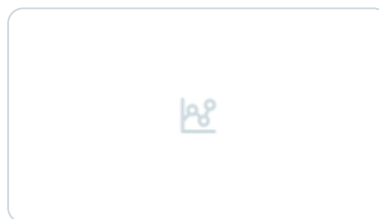
Instant access to the full article PDF.

[Institutional subscriptions](#) →

## Similar content being viewed by others

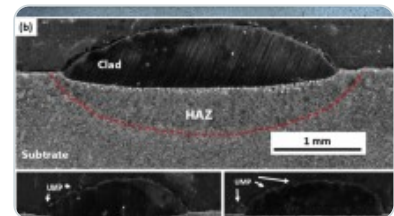
**Effects of process parameters and many-objective optimisation of SiC/TiC/16MnCr5...**

Article | 21 May 2025



**Hardness and residual stress modeling of powder injection laser cladding of P420...**

Article | 21 July 2017



**Effect of Laser Parameters on the Characteristics of a Laser Clad AISI 431...**

Article | 20 August 2021

## Explore related subjects

Discover the latest articles, books and news in related subjects, suggested using machine learning.

[Ceramics](#)[Coatings](#)[Composites](#)[Materials Characterization Technique](#)[Laser Material Processing](#)[Materials Engineering](#)[Laser Cladding and Coating Technologies for Wear Resistance](#)

## References

1. Dewangan S, Chattopadhyaya S (2016) Performance analysis of two different conical picks used in linear cutting operation of coal. Arab J Sci Eng 41(1):249–265.

<https://doi.org/10.1007/s13369-015-1786-7>

[Article](#) [Google Scholar](#)

2. Dewangan S, Chattopadhyaya S, Hloch S (2015) Critical damage analysis of WC-Co Tip of conical pick due to coal excavation in mines. Adv Mater Sci Eng 2015.

<https://doi.org/10.1155/2015/292046>

[Article](#) [Google Scholar](#)

3. Akintunde IB, Lindsay EE, Olakanmi EO, Prasad RVS, Matshediso B, Motimedi T, Botes A, Pityana SL (2023) Performance evaluation and failure analysis of conical picks used in a Botswana (Ngwato) mine. Eng Fail Anal 143(Part B).

<https://doi.org/10.1016/j.engfailanal.2022.106872>

4. Jia D, Shi W, Zhang H, Wu T, Diao Y, Li K, Lu C (2023) Effects of Y<sub>2</sub>O<sub>3</sub> content on wear resistance and corrosion resistance of 316L/TiC coating fabricated by laser cladding.

Coatings 13. <https://doi.org/10.3390/coatings13081348>

5. Zheng Y, Liu J, Ahmad R (2020) A cost-driven process planning method for hybrid additive–subtractive remanufacturing. J Manuf Syst 55:248–63.

<https://doi.org/10.1016/j.jmsy.2020.03.006>

[Article](#) [Google Scholar](#)

6. Dalae M, Cerrutti E, Dey I, Leinenbach C, Wegener K (2022) Parameters development for optimum deposition rate in laser DMD of stainless steel EN X3CrNiMo13 4. *Laser Manuf Mater Process* 9:1–17. <https://doi.org/10.1007/s40516-021-00161-3>

[Article](#) [Google Scholar](#)

7. Zhu H, Dong K, Wang H, Huang J, Li J, Xie Z (2013) Reaction mechanisms of the TiC/Fe composite fabricated by exothermic dispersion from Fe–Ti–C element system. *Powder Technol* 246:456–461

[Article](#) [Google Scholar](#)

8. Jin C, Plucknett KP (2016) Microstructure instability in TiC–316L stainless steel cermets. *Int J Refract Met Hard Mater* 58:74–83

[Article](#) [Google Scholar](#)

9. Pérez ED, Wallaert E, Duprez L, Atrens A, Verbeken K (2013) Thermal desorption spectroscopy study of the interaction of hydrogen with TiC precipitates. *Met Mater Int* 19:741–748

[Article](#) [Google Scholar](#)

10. Guo C, Chen J, Zhou J, Zhao J, Wang L, Yu Y, Zhou H (2012) Effects of WC–Ni content on microstructure and wear resistance of laser cladding Ni–based alloys coating. *Surf Coat Technol* 206:2064–2071. <https://doi.org/10.1016/j.surfcoat.2011.06.005>

[Article](#) [Google Scholar](#)

11. Qu J, Xiong W, Ye D, Yao Z, Liu W, Lin S (2010) Effect of WC content on the microstructure and mechanical properties of Ti(C<sub>0.5</sub>N<sub>0.5</sub>)-WC–Mo–Ni cermets. *Int J Refract Met Hard Mater* 28:243–249. <https://doi.org/10.1016/j.ijrmhm.2009.10.005>

[Article](#) [Google Scholar](#)

12. Zhang Z, Wang X, Zhang Q, Liang Y, Ren L, Li X (2019) Fabrication of Fe-based composite coatings reinforced by TiC particles and its microstructure and wear resistance of 40Cr gear steel by low energy pulsed laser cladding. *Opt Laser Technol* 119. <https://doi.org/10.1016/j.optlastec.2019.105622>
13. Yuan Q, Chai L, Yang T, Wang H, Shen J, Guo N, Yin X, Xiao J (2023) Laser-clad FeCrAl/TiC composite coating on ferrite/martensitic steel: significant grain refinement and wear resistance enhancement induced by adding TiC. *Surf Coat Technol* 456. <https://doi.org/10.1016/j.surfcoat.2023.129272>
14. Zhu HM, Ouyang MN, Hu JP, Zhang JW, Qiu CJ (2021) Design and development of TiC-reinforced 410 martensitic stainless-steel coatings fabricated by laser cladding. *Ceram Int* 47:12505–12513. <https://doi.org/10.1016/j.ceramint.2021.01.108>

[Article](#) [Google Scholar](#)

15. Li L, Wang J, Lin P, Liu H (2017) Microstructure and mechanical properties of functionally graded TiCp/Ti6Al4V composite fabricated by laser melting deposition. *Ceram Int* 43(18):16638–16651. <https://doi.org/10.1016/j.ceramint.2017.09.054>

[Article](#) [Google Scholar](#)

16. Chen L, Yu T, Guan C, Zhao YU (2022) Microstructure and properties of metal parts remanufactured by laser cladding TiC and TiB<sub>2</sub> reinforced Fe-based coatings. *Ceram Int* 48(10):14127–14140. <https://doi.org/10.1016/j.ceramint.2022.01.299>

[Article](#) [Google Scholar](#)

17. Yang S, Chen N, Liu W, Zhong ML, Wang ZJ, Kokawa H (2004) Fabrication of nickel composite coatings reinforced with TiC particles by laser cladding. *Surf Coating Technol* 183:254–260

[Article](#) [Google Scholar](#)

18. Yue H, Lv N, Guo C, Zhao L, Li Q, Zhang J, Zhang Y (2022) Microstructure and mechanical properties of TiC/FeCrSiB coating by laser additive remanufacturing on shearer spiral blade. Surf Coat Technol 431.

<https://doi.org/10.1016/j.surfcoat.2021.128043>

19. Huang Y, Lu Y, Cheng Y, Liu Y, Liu D, Gao X (2025) Reinforcement phase addition on microstructure and impact toughness of iron-matrix composites. Eng Fail Anal 170.

<https://doi.org/10.1016/j.engfailanal.2024.109247>

20. Hu Z, Ning K, Lu K (2017) Spark plasma sintered silicon carbide ceramics with nanostructured ferritic alloy as sintering aid. Mater Sci Eng A 682:586–592

[Article](#) [Google Scholar](#)

21. Wu CL, Zhang S, Zhang CH, Zhang JB, Liu Y, Chen J (2019) Effects of SiC content on phase evolution and corrosion behaviour of SiC reinforced 316L stainless steel matrix composites by laser melting deposition. Opt Laser Technol 115:134–139.

<https://doi.org/10.1016/j.optlastec.2019.02.029>

[Article](#) [Google Scholar](#)

22. Hu Z, Ning K, Lu K (2016) Study of spark plasma sintered nanostructured ferritic steel alloy with silicon carbide addition. Mater Sci Eng A 670:75–80

[Article](#) [Google Scholar](#)

23. Lacaze J, Sundman B (1991) An assessment of the Fe-C-Si system. Met Trans A 22:2211–2223

[Article](#) [Google Scholar](#)

24. Pickering FB (1978) Physical metallurgy and the design of steels. Applied Science Publishers

[Google Scholar](#)

25. Cheng J, Xing Y, Dong E, Zhao L, Liu H, Chang T, Chen M, Wang J, Lu J, Wan J (2022) An overview of laser metal deposition for cladding: defect formation mechanisms, defect suppression methods, and performance improvements of laser-cladded layers. Materials 15. <https://doi.org/10.3390/ma15165522>

26. Chen L, Chen W, Li D, Jing P, Yin H, Wu H, Xie Y, Wang X (2022) Effect of nano-La<sub>2</sub>O<sub>3</sub> doping on the tribological behaviour of laser cladded WC-12Co coating on 65Mn steel under water lubrication condition. Tribol Int 169. <https://doi.org/10.1016/j.triboint.2022.107428>

27. Yang Z, Hao H, Gao Q, Cao Y, Han R, Qi H (2021) Strengthening mechanism and high-temperature properties of H13 + WC/Y<sub>2</sub>O<sub>3</sub> laser-cladding coatings. Surf Coat Technol 405. <https://doi.org/10.1016/j.surfcoat.2020.126544>

28. Liu QB, Zou JL, Zheng M, Dong C (2005) Effect of Y<sub>2</sub>O<sub>3</sub> content on microstructure of gradient bioceramic composite coating produced by wide-band laser cladding. Key Eng Mater 288–289:351–354. <https://doi.org/10.4028/www.scientific.net/KEM.288-289.351>

[Article](#) [Google Scholar](#)

29. Wang C, Gao Y, Wang R, Wei D, Cai M, Fu Y (2018) Microstructure of laser-clad Ni60 cladding layers added with different amounts of rare-earth oxides on 6063 Al alloys. J Alloys Compd 740:109–1107. <https://doi.org/10.1016/j.jallcom.2018.01.061>

[Article](#) [Google Scholar](#)

30. Wang DS, Liang EJ, Chao MJ, Yuan B (2008) Investigation on the microstructure and cracking susceptibility of laser-clad V2O5/NiCrBSiC alloy coatings. Surf Coat Technol 202:1371–1378. <https://doi.org/10.1016/j.surfcoat.2007.06.036>

[Article](#) [Google Scholar](#)

31. Zhu R, Li Z, Li X, Sun Q (2015) Microstructure and properties of the low-power-laser clad coatings on magnesium alloy with different amount of rare earth addition. Appl Surf Sci 353:405–413. <https://doi.org/10.1016/j.apsusc.2015.06.071>

[Article](#) [Google Scholar](#)

32. Zhang M, Wang XH, Qu KL, Liu SS (2019) Effect of rare earth oxide on microstructure and high-temperature oxidation properties of laser cladding coatings on 5CrNiMo die steel substrate. Opt Laser Tech 119. <https://doi.org/10.1016/j.optlastec.2019.105597>

33. Zhang Z, Yang Q, Yu Z, Wang H, Zhang T (2022) Influence of Y<sub>2</sub>O<sub>3</sub> addition on the microstructure of TiC reinforced Ti-based composite coating prepared by laser cladding. Mater Charact 189:111962

[Article](#) [Google Scholar](#)

34. Ding Z, Fang Z, Wang G, Wu C, Yang S (2023) Microstructure and properties of Mo-Si-B-Y<sub>2</sub>O<sub>3</sub> composite coating on nickel-based alloy by laser cladding. Opt Laser Technol 164:109473

[Article](#) [Google Scholar](#)

35. Chen T, Liu D, Wu F, Wang H (2018) Effect of CeO<sub>2</sub> on microstructure and wear resistance of TiC bioinert coatings on Ti6Al4V alloy by laser cladding. Materials 11:58. <https://doi.org/10.3390/ma11010058>

[Article](#) [Google Scholar](#)

36. Emamian A, Corbin SF, Khajepour A (2010) Effect of laser cladding process parameters on clad quality and in-situ formed microstructure of ferritic composite coatings. *Surf Coat Technol* 205(7):2007–2015.  
<https://doi.org/10.1016/j.surfcoat.2010.08.087>

[Article](#) [Google Scholar](#)

37. Zhang J, Song B, Wei Q, Bourell D, Shi Y (2019) A review of selective laser melting of aluminium alloys: processing, microstructure, property and developing trends. *J Mater Sci Technol* 35:270–284

[Article](#) [Google Scholar](#)

38. Wang Z, Jiang B, Wu S, Liu W (2023) Anisotropic tension-compression asymmetry in SLM 316 L stainless steel. *Int J Mech Sci* 246:108139

[Article](#) [Google Scholar](#)

39. Khorram A, Davoodi Jamaloei A, Sepehrnia R (2022) Analysis of solidification crack behaviour for Amdry 997 coating on Inconel 713 LC super alloy by laser cladding process. *Optik* 264:169407

[Article](#) [Google Scholar](#)

40. Meng X, Jiang Y, Wang H, Su C, Shan C, Lu J, Xue W, Wu S, Wang Z (2024) Effect of variable laser incident angles on microstructure and mechanical properties of laser-cladded Inconel 718. *Surf Coat Technol* 477.  
<https://doi.org/10.1016/j.surfcoat.2023.130310>

41. Li X, Li T, Shi B, Wang D, Adnan M, Lu H (2020) The influence of substrate tilt angle on the morphology of laser cladding layer. *Surf Coat Technol* 391.  
<https://doi.org/10.1016/j.surfcoat.2020.125706>

42. Hao J, Liu Y, Yang S, Liu H, Yang H, Liu H, Liu X (2024) Numerical simulation and morphological analysis of laser cladded 316L stainless steel on inclined substrates. *Opt Laser Technol* 177. <https://doi.org/10.1016/j.optlastec.2024.111137>
43. Hao J, Meng Q, Li C, Li Z, Wu D (2019) Effects of tilt angle between laser nozzle and substrate on bead morphology in multi-axis laser cladding. *J Manuf Process* 43:311–322. <https://doi.org/10.1016/j.jmapro.2019.04.025>
- [Article](#) [Google Scholar](#)
44. Lian G, Chu M, Feng M, Chen C, Xiao H, Lu H (2025) The inclined morphology and molten pool of laser cladding under different cladding methods. *Opt Laser Technol* 180. <https://doi.org/10.1016/j.optlastec.2024.111445>
45. Lewis SR, Lewis R, Fletcher DI (2015) Assessment of laser cladding as an option for repairing/enhancing rails. *Wear* 330–331:581–591. <https://doi.org/10.1016/j.wear.2015.02.027>
- [Article](#) [Google Scholar](#)
46. Dass A, Moridi A (2019) State of the art in directed energy deposition: from additive manufacturing to materials design. *Coatings* 9:418. <https://doi.org/10.3390/coatings9070418>
- [Article](#) [Google Scholar](#)
47. American Society of Testing and Materials (2004) Standard method for measuring abrasion using the dry sand/rubber wheel apparatus, G65, vol 3.02. pp 1–12
48. Goodarzi DM, Pekkarinen J, Salminen A (2017) Analysis of laser cladding process parameter influence on the clad bead geometry. *Weld World* 61:883–891

[Article](#) [Google Scholar](#)

49. Guo C, Lv N, Yue H, Li Q, Zhang J (2022) Laser additive remanufacturing parameters optimisation and experimental study of heavy-duty sprocket. *Int J Adv Manuf Technol* 118:3789–3800. <https://doi.org/10.1007/s00170-021-08201-0>

[Article](#) [Google Scholar](#)

50. Zeng X, Wang Q, Chen C, Lian G, Huang X (2021) Effects of WC addition on the morphology, microstructure, and mechanical properties of Fe50/TiC/WC laser claddings on AISI 1045 steel. *Surf Coat Technol* 427.

<https://doi.org/10.1016/j.surfcoat.2021.127781>

51. Choo H, Sham KL, Bohling J, Ngo A, Xiao X, Ren Y, Depond PJ, Matthews MJ, Garlea E (2019) Effect of laser power on defect, texture, and microstructure of a laser powder bed fusion processed 316L stainless steel. *Mater Des* 164:107534

[Article](#) [Google Scholar](#)

52. Deng D, Li T, Huang Z, Jiang H, Yang S, Zhang Y (2022) Multi-response optimization of laser cladding for TiC particle reinforced Fe matrix composite based on Taguchi method and grey relational analysis. *Opt Laser Technol* 153.

<https://doi.org/10.1016/j.optlastec.2022.108259>

53. Lee Y, Nordin M, Babu SS, Farson DF (2014) Effect of fluid convection on dendrite arm spacing in laser deposition. *Metallurg Mater Trans B* 45B:1521.

<https://doi.org/10.1007/s11663-014-0054-7>

54. Chen L, Zhao Y, Guan C, Yu T (2021) Effects of CeO<sub>2</sub> addition on microstructure and properties of ceramics reinforced Fe-based coatings by laser cladding. *J Int J Adv Manuf Technol*. <https://doi.org/10.1007/s00170-021-07297-8>

[Article](#) [Google Scholar](#)

55. Chen H, Lu Y, Sun Y, Wei Y, Wang X, Liu D (2020) Coarse TiC particles reinforced H13 steel matrix composites produced by laser cladding. Surf Coat Technol 395. <https://doi.org/10.1016/j.surfcoat.2020.125867>
56. Roy KA, Kheirandish S, Saghafian H (2010) The effect of lower bainite volume fraction on tensile and impact properties of D6AC medium carbon low alloy ultrahigh strength steel. Iran J Mater Sci Eng 7(3):31–38
- [Google Scholar](#)
57. Berreth K, Michler T (2022) Martensite fractions measured by XRD on fracture surfaces of austenitic stainless steels tensile tested in gaseous helium and hydrogen. Metallogr Microstruct Anal 11:873–876. <https://doi.org/10.1007/s13632-022-00910-6>
- [Article](#) [Google Scholar](#)
58. Wang XH, Zhang M, Liu XM, Qu SY, Zou ZD (2008) Microstructure and wear properties of TiC/FeCrBSi surface composite coating prepared by laser cladding. Surf Coat Technol 202(15):3600–3606
- [Article](#) [Google Scholar](#)
59. Onuoha CC, Jin C, Farhat ZN, Kipouros GJ, Plucknett KP (2016) The effects of TiC grain size and steel binder content on the reciprocating wear behaviour of TiC-316L stainless steel cermets. Wear 350:116–129
- [Article](#) [Google Scholar](#)
60. Prabhu TR, Varma VK, Vedantam S (2014) Effect of SiC volume fraction and size on dry sliding wear of Fe/SiC/graphite hybrid composites for high sliding speed applications. Wear 309:1–10
- [Article](#) [Google Scholar](#)

61. Swain BK, Bhuyan S, Behera R, Mohapatra SS, Behera A (2020) Tribology in materials and manufacturing - wear, friction and lubrication, wear: a serious problem in industry. In: book chapter: Tribology Publisher: Intechopen. pp 1–20. <https://doi.org/10.5772/intechopen.94211>
62. Alojali HM, Benyounis KY (2016) Advances in Tool wear in Turning Process. Ref Mod Mater Sci Mater Eng. <https://doi.org/10.1016/B978-0-12-803581-8.04031-5>. Elsevier
63. Cozza RC (2014) Third abrasive wear mode: is it possible? J Market Res 3(2):191–193. <https://doi.org/10.1016/j.jmrt.2014.03.010>

[Article](#) [Google Scholar](#)

64. Spalding IJ (2007) Applied laser tooling. J Mod Opt 35:754–755

[Article](#) [Google Scholar](#)

65. Liu J, Jia L, Xu C, Huaming W (2017) Effect of dilution and macro segregation on corrosion resistance of laser clad AerMet100 steel coating on 300M steel substrate. Surf Coat Technol 325:352–359. <https://doi.org/10.1016/j.surfcoat.2017.04.035>

[Article](#) [Google Scholar](#)

66. Han T, Zhou K, Chen Z, Gao Y (2022) Research progress on laser cladding alloying and composite processing of steel materials. Metals 12:2055. <https://doi.org/10.3390/met12122055>

[Article](#) [Google Scholar](#)

67. Lepski D, Brückner F (2009) Laser cladding. In: Dowden J (eds) The theory of laser materials processing. Springer series in materials science, vol 119. Springer, Dordrecht. [https://doi.org/10.1007/978-1-4020-9340-1\\_8](https://doi.org/10.1007/978-1-4020-9340-1_8)

68. Varela JA, Amado JM, Tobar MJ, Mateo MP, Yanez A, Nicolas G (2015) Characterisation of hard coatings produced by laser cladding using laser-induced breakdown spectroscopy technique. *Appl Surf Sci* 336:396–400.  
<https://doi.org/10.1016/j.apsusc.2015.01.037>
- [Article](#) [Google Scholar](#)
69. Morgado TLM, Navas H, Brites R (2016) Wear study of innovative Ti-Ta alloys. *Proc Struct Integr* 2:1266–1276
- [Google Scholar](#)
70. Shevchenko VY, Kovalchuk MV, Oryshchenko AS (2019) Synthesis of a new class of materials with a regular (periodic) interconnected microstructure. *Glass Phys Chem* 45(6):412–418
- [Article](#) [Google Scholar](#)
71. Shevchenko VY, Perevislov SN, Ugolkov VL (2021) Physicochemical interaction processes in the carbon (diamond)–silicon system. *Glass Phys Chem* 47(3):197–208.  
<https://doi.org/10.1134/S108765962103010X>
- [Article](#) [Google Scholar](#)
72. Bazhin P, Antipov M, Konstantinov A, Khomenko N (2022) In-situ study of the process of self-propagating high-temperature synthesis of titanium carbide with a nichrome binder. *Mater Lett* 308. <https://doi.org/10.1016/j.matlet.2021.131086>
73. Abrahão Júnior R, Isabela de Fátima Silva Vidal, Leonardo Benevides Etrusco, Telmo Diana Sumak, Klebson Luiz Silva, Raphael Mariano de Souza, José Roberto de Oliveira (2024) Metallurgical silicon carbide for steelmaking: a thermodynamic simulation. *Tecnol Metal Mater Min*. <https://doi.org/10.4322/2176-1523.20242956>

74. Wallace KE, Hill RG, Pembroke JT, Brown CJ, Hatton PV (1999) Influence of sodium oxide content on bioactive glass properties. *J Mater Sci Mater Med* 10(12):697–701. <https://doi.org/10.1023/a:1008910718446>. (PMID: 15347935)

[Article](#) [Google Scholar](#)

75. Yang C, Bai J, Wang G, Wang H, Ma S (2023) Effect of Na<sub>2</sub>O content on wettability, crystallisation and performances of sealing glass. *J Market Res* 23:4117–4134. <https://doi.org/10.1016/j.jmrt.2023.02.073>

[Article](#) [Google Scholar](#)

76. Akintunde IB, Lindsay EE, Olakanmi EO, Prasad RVS, Matshediso BI, Motimedi T, Botes A, Pityana SL (2025) Selection of wear-resistant materials and implementation framework for remanufacturing ground exploring tools (GETs) for coal mining applications: case-study of continuous miner cutter (CMCs) components. *J Remanuf.* <https://doi.org/10.1007/s13243-025-00148-9>

77. Che L, Sun W, Huang Y, Chao Y (2014) Laser cladding technology in the repair of shearer picks. *Comput Model New Technol* 18(12A):563–565

[Google Scholar](#)

## Acknowledgements

---

The technical support of the Council for Scientific and Industrial Research (CSIR), South Africa, is acknowledged. Also, the authors recognise the contribution of Morupule Coal Mines, Palapye, Botswana.

## Funding

---

The article is an outcome of the Education for Laser-based Manufacturing (ELbM) Scholarship research project with Agreement No. 2019–1973/5 and Project No. 614655, funded by the European Commission's 'Education, Audiovisual and Culture Executive Agency' (EACEA). Furthermore, research grant no. HLHA23X task ALC-R016 offered by the African Laser Centre (ALC), South Africa, and Postgraduate research grant award (DVC/RDI/2/1/7 V (149); Code: S00390 presented by Botswana International University of Science and Technology (BIUST).

## Author information

---

### Authors and Affiliations

**Department of Mechanical, Energy & Industrial Engineering, Botswana International University of Science & Technology, Palapye, Botswana**

Idris Babatunde Akintunde, Emmanuel Efemena Lindsay & Eyitayo Olatunde Olakanmi

**UNESCO Chair On Sustainable Manufacturing & Innovation Technologies (UCoSMIT) Team, Botswana International University of Science & Technology, Private Mail Bag 16, Palapye, Botswana**

Idris Babatunde Akintunde, Emmanuel Efemena Lindsay, Eyitayo Olatunde Olakanmi & Raghupatruni Ventaka Satya Prasad

**Advanced Manufacturing & Engineering Education (AMEE) Research Group, Botswana International University of Science & Technology, Palapye, Botswana**

Idris Babatunde Akintunde, Emmanuel Efemena Lindsay, Eyitayo Olatunde Olakanmi & Raghupatruni Ventaka Satya Prasad

**Department of Chemical, Materials & Metallurgical Engineering, Botswana International University of Science & Technology, Palapye, Botswana**  
Raghupatruni Ventaka Satya Prasad

**Department of Materials & Metallurgical Engineering, Federal University of Technology, Minna, Nigeria**  
Idris Babatunde Akintunde

**Department of Mechanical Engineering, Nelson Mandela University, Port Elizabeth, South Africa**  
Annelize Botes

## Laser-Enabled Manufacturing Research Group, Council for Scientific & Industrial Research, Pretoria, South Africa

Sisa Lesley Pityana & Samuel Skhosane

Morupule Coal Mines, Palapye, Botswana

Tshephang Motimedi

## Contributions

Idris Babatunde Akintunde: conceptualization, writing—original draft, methodology, investigation, data curation, validation, writing—review and editing. Emmanuel Efemena Lindsay: writing—review and editing, validation, data curation. Eyitayo Olatunde Olakanmi: funding acquisition, supervision, conceptualization, methodology, writing—review and editing, project administration. Raghupatruni, Ventaka Satya Prasad: writing—review and editing, data curation. Annelize Botes: supervision, project administration, investigation, conceptualization, validation, writing—review and editing. Sisa Lesley Pityana: project administration, methodology, supervision, conceptualization. Sammuell Skhosane: methodology, validation, data curation. Tshephang Motimedi: supervision, conceptualization.

## Corresponding author

Correspondence to [Eyitayo Olatunde Olakanmi](#).

## Ethics declarations

---

## Conflict of interest

The authors declare no competing interests.

## Additional information

---

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## Highlights

- Increasing the feed rate from 6 to 8 g/min results in increased clad height and contact angle, while width, weld penetration, and heat-affected zone (HAZ) are reduced.
- The clad width, height, contact angle, weld penetration, and HAZ decrease with increasing scanning speed from 0.4 to 0.5 m/min.
- Increased inclined beam increased carbide dissolution, width, weld penetration, and HAZ.
- Yttrium (III) oxide ( $Y_2O_3$ ) addition enhances the quantity and spreadability of the melt pool, which increases carbide dissolution and lowers clad height.
- The microhardness and wear performance of coatings increase with increasing TiC particles retained in the clad.
- Optimised clad has minimal (2.6%) porosity, the highest Titanium Carbide (TiC) particles retained, and minimal material loss ( $26.24 \text{ mm}^3$ ).

## Rights and permissions

---

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.

[Reprints and permissions](#)

## About this article

---

### Cite this article

Akintunde, I.B., Lindsay, E.E., Olakanmi, E.O. *et al.* Optimised consolidation and characterisation of TiC-SiC-reinforced AISI-4340 composite coatings for conical pick

remanufacture. *Int J Adv Manuf Technol* **139**, 4575–4595 (2025).

<https://doi.org/10.1007/s00170-025-16179-2>

Received

21 April 2025

Accepted

17 July 2025

Published

29 July 2025

Version of record

29 July 2025

Issue date

August 2025

DOI

<https://doi.org/10.1007/s00170-025-16179-2>

## Keywords

[Laser consolidation](#)

[Carbide dissolution](#)

[Beam deflection](#)

[Clad geometry](#)

[Weld penetration](#)

[Volume of material loss](#)