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Review of Intelligence for Additive and Subtractive Manufacturing: Current Status and Future Prospects

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Abstract

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Abstract

Additive manufacturing (AM), an enabler of Industry 4.0, recently opened limitless possibilities in various sectors covering personal, industrial, medical, aviation and even extra-terrestrial applications. Although significant research thrust is prevalent on this topic, a detailed review covering the impact, status, and prospects of artificial intelligence (AI) in the manufacturing sector has been ignored in the literature. Therefore, this review provides comprehensive information on smart mechanisms and systems emphasizing additive, subtractive and/or hybrid manufacturing processes in a collaborative, predictive, decisive, and intelligent environment. Relevant electronic databases were searched, and 248 articles were selected for qualitative synthesis. Our review suggests that significant improvements are required in connectivity, data sensing, and collection to enhance both subtractive and additive technologies, though the pervasive use of AI by machines and software helps to automate processes. An intelligent system is highly recommended in both conventional and non-conventional subtractive manufacturing (SM) methods to monitor and inspect the workpiece conditions for defect detection and to control the machining strategies in response to instantaneous output. Similarly, AM product quality can be improved through the online monitoring of melt pool and defect formation using suitable sensing devices followed by process control using machine learning (ML) algorithms. Challenges in implementing intelligent additive and subtractive manufacturing systems are also discussed in the article. The challenges comprise difficulty in self-optimizing CNC systems considering real-time material property and tool condition, defect detections by in-situ AM process monitoring, issues of overfitting and underfitting data in ML models and expensive and complicated set-ups in hybrid manufacturing processes. © 2023 by the authors.

Author keywords

data analytics; digital twin; feedback control; intelligent manufacturing; smart system

Indexed keywords

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References (268)

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All

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1 Arinez, J.F., Chang, Q., Gao, R.X., Xu, C., Zhang, J.

Artificial Intelligence in Advanced Manufacturing: Current Status and Future Outlook

(2020) *Journal of Manufacturing Science and Engineering, Transactions of the ASME*, 142 (11), art. no. 110804. Cited 85 times.
https://asmedigitalcollection.asme.org/manufacturingscience
doi: 10.1115/1.4047855

View at Publisher

2 Monostori, L., Kádár, B., Bauernhansl, T., Kondoh, S., Kumara, S., Reinhart, G., Sauer, O., (...), Ueda, K.

Cyber-physical systems in manufacturing

(2016) *CIRP Annals*, 65 (2), pp. 621-641. Cited 1104 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/709764/description#description
doi: 10.1016/j.cirp.2016.06.005

View at Publisher

3 Lim, M.K., Xiong, W., Lei, Z.

Theory, supporting technology and application analysis of cloud manufacturing: a systematic and comprehensive literature review

(2020) *Industrial Management and Data Systems*, 120 (8), pp. 1585-1614. Cited 24 times.
http://www.emeraldinsight.com/info/journals/imds/imds.jsp
doi: 10.1108/IMDS-10-2019-0570

View at Publisher

4 Volpe, G., Mangini, A.M., Fanti, M.P.

An Architecture for Digital Processes in Manufacturing with Blockchain, Docker and Cloud Storage

(2021) *IEEE International Conference on Automation Science and Engineering*, 2021-August, pp. 39-44. Cited 4 times.
http://ieeexplore.ieee.org/xpl/conferences.jsp
ISBN: 978-166541873-7
doi: 10.1109/CASE49439.2021.9551633

View at Publisher

5 Liu, C., Vengayil, H., Lu, Y., Xu, X.

A Cyber-Physical Machine Tools Platform using OPC UA and MTConnect

(2019) *Journal of Manufacturing Systems*, 51, pp. 61-74. Cited 135 times.
http://www.elsevier.com
doi: 10.1016/j.jmsy.2019.04.006

View at Publisher

6 Cho, J., Kang, S., Kim, K.

Real-time precise object segmentation using a pixel-wise coarse-fine method with deep learning for automated manufacturing

(2022) *Journal of Manufacturing Systems*, 62, pp. 114-123. Cited 4 times.
http://www.elsevier.com
doi: 10.1016/j.jmsy.2021.11.004

View at Publisher

7 Boccella, A.R., Centobelli, P., Cerchione, R., Murino, T., Riedel, R.

Evaluating centralized and heterarchical control of smart manufacturing systems in the era of industry 4.0

(2020) *Applied Sciences (Switzerland)*, 10 (3), art. no. 755. Cited 36 times.
https://res.mdpi.com/d_attachment/applsci/applsci-10-00755/article_deploy/applsci-10-00755-v2.pdf
doi: 10.3390/app10030755

View at Publisher

8 Wang, S., Wan, J., Li, D., Zhang, C.

Implementing Smart Factory of Industrie 4.0: An Outlook

(2016) *International Journal of Distributed Sensor Networks*, 2016, art. no. 3159805. Cited 919 times.
http://www.hindawi.com/journals/ijdsn/contents/
doi: 10.1155/2016/3159805

View at Publisher

9 Zhang, Y., Qian, C., Lv, J., Liu, Y.

Agent and cyber-physical system based self-organizing and self-adaptive intelligent shopfloor

(2017) *IEEE Transactions on Industrial Informatics*, 13 (2), art. no. 7593295, pp. 737-747. Cited 208 times.
http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=9424
doi: 10.1109/TII.2016.2618892

View at Publisher

10 Sarı, T., Güleş, H.K., Yiğitol, B.

Awareness and readiness of Industry 4.0: The case of Turkish manufacturing industry

(2020) *Advances in Production Engineering And Management*, 15 (1), pp. 57-68. Cited 34 times.
http://apem-journal.org/Archives/2020/APEM15-1_057-068.pdf
doi: 10.14743/APEM2020.1.349

View at Publisher

11 Thames, L., Schaefer, D.

Industry 4.0: An Overview of Key Benefits, Technologies, and Challenges

(2017) *Springer Series in Advanced Manufacturing*, pp. 1-33. Cited 54 times.
https://www.springer.com/series/7113
doi: 10.1007/978-3-319-50660-9_1

View at Publisher

12 Yuan, C., Li, G., Kamarthi, S., Jin, X., Moghaddam, M.

Trends in intelligent manufacturing research: a keyword co-occurrence network based review

(2022) *Journal of Intelligent Manufacturing*, 33 (2), pp. 425-439. Cited 9 times.
www.kluweronline.com/issn/0956-5515/
doi: 10.1007/s10845-021-01885-x

View at Publisher

13 Sarker, I.H.
AI-Based Modeling: Techniques, Applications and Research Issues Towards Automation, Intelligent and Smart Systems
(2022) *SN Comput. Sci*, 3, p. 158. Cited 58 times.

14 Gajsek, B., Marolt, J., Rupnik, B., Lerher, T., Sternad, M.
Using maturity model and discrete-event simulation for industry 4.0 implementation

(2019) *International Journal of Simulation Modelling*, 18 (3), pp. 488-499. Cited 34 times.
http://www.ijsimm.com/
doi: 10.2507/IJSIMM18(3)489

View at Publisher

15 Caggiano, A.
Cloud-based manufacturing process monitoring for smart diagnosis services

(2018) *International Journal of Computer Integrated Manufacturing*, 31 (7), pp. 612-623. Cited 64 times.
http://www.tandfonline.com/loi/tcim20
doi: 10.1080/0951192X.2018.1425552

View at Publisher

16 Cheng, K., Niu, Z.-C., Wang, R.C., Rakowski, R., Bateman, R.
Smart Cutting Tools and Smart Machining: Development Approaches, and Their Implementation and Application Perspectives

(2017) *Chinese Journal of Mechanical Engineering (English Edition)*, 30 (5), pp. 1162-1176. Cited 35 times.
https://link.springer.com/journal/10033
doi: 10.1007/s10033-017-0183-4

View at Publisher

17 Ong, P., Lee, W.K., Lau, R.J.H.
Tool condition monitoring in CNC end milling using wavelet neural network based on machine vision

(2019) *International Journal of Advanced Manufacturing Technology*, 104 (1-4), pp. 1369-1379. Cited 63 times.
http://www.springerlink.com/content/0268-3768
doi: 10.1007/s00170-019-04020-6

View at Publisher

18 Liu, L., Zhang, X., Wan, X., Zhou, S., Gao, Z.
Digital twin-driven surface roughness prediction and process parameter adaptive optimization

(2022) *Advanced Engineering Informatics*, 51, art. no. 101470. Cited 22 times.
https://www.journals.elsevier.com/advanced-engineering-informatics
doi: 10.1016/j.aei.2021.101470

View at Publisher

19 Chuo, Y.S., Lee, J.W., Mun, C.H., Noh, I.W., Rezvani, S., Kim, D.C., Lee, J., (...), Park, S.S.

Artificial intelligence enabled smart machining and machine tools

(2022) *Journal of Mechanical Science and Technology*, 36 (1). Cited 13 times.
http://www.springerlink.com/content/1738-494X
doi: 10.1007/s12206-021-1201-0

View at Publisher

20 Araújo, N., Pacheco, V., Costa, L.

Smart Additive Manufacturing: The Path to the Digital Value Chain

(2021) *Technologies*, 9 (4), art. no. 88. Cited 4 times.
www.mdpi.com/journal/technologies
doi: 10.3390/technologies9040088

View at Publisher

21 Brown, K.A., Gu, G.X.
Dimensions of Smart Additive Manufacturing
(2021) *Adv. Intell. Syst*, 3, p. 2100240. Cited 3 times.

22 Kim, D.B., Witherell, P., Lipman, R., Feng, S.C.

Streamlining the additive manufacturing digital spectrum: A systems approach

(2015) *Additive Manufacturing*, 5, pp. 20-30. Cited 87 times.
doi: 10.1016/j.addma.2014.10.004

View at Publisher

23 Kunovjanek, M., Knofius, N., Reiner, G.

Additive manufacturing and supply chains–a systematic review

(2022) *Production Planning and Control*, 33 (13), pp. 1231-1251. Cited 39 times.
www.tandf.co.uk/journals/titles/09537287.asp
doi: 10.1080/09537287.2020.1857874

View at Publisher

24 Wang, C., Tan, X.P., Tor, S.B., Lim, C.S.

Machine learning in additive manufacturing: State-of-the-art and perspectives

(2020) *Additive Manufacturing*, 36, art. no. 101538. Cited 242 times.
https://www.journals.elsevier.com/additive-manufacturing
doi: 10.1016/j.addma.2020.101538

View at Publisher

25 Oleff, A., Küster, B., Stonis, M., Overmeyer, L.
Process monitoring for material extrusion additive manufacturing: a state-of-the-art review

(2021) *Progress in Additive Manufacturing*, 6 (4), pp. 705-730. Cited 23 times.
https://link.springer.com/journal/40964
doi: 10.1007/s40964-021-00192-4

View at Publisher

26 Du, W., Bai, Q., Zhang, B.
A Novel Method for Additive/Subtractive Hybrid Manufacturing of Metallic Parts

(2016) *Procedia Manufacturing*, 5, pp. 1018-1030. Cited 95 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2016.08.067

View at Publisher

27 Bhaduri, D., Penchev, P., Batal, A., Dimov, S., Soo, S.L., Sten, S., Harrysson, U., (...), Dong, H.
Laser polishing of 3D printed mesoscale components

(2017) *Applied Surface Science*, 405, pp. 29-46. Cited 152 times.
http://www.journals.elsevier.com/applied-surface-science/
doi: 10.1016/j.apsusc.2017.01.211

View at Publisher

28 Boban, J., Ahmed, A., Jithinraj, E.K., Rahman, M.A., Rahman, M.
Polishing of additive manufactured metallic components: retrospect on existing methods and future prospects
(Open Access)

(2022) *International Journal of Advanced Manufacturing Technology*, 121 (1-2), pp. 83-125. Cited 5 times.
https://www.springer.com/journal/170
doi: 10.1007/s00170-022-09382-y

View at Publisher

29 Manogharan, G., Wysk, R., Harrysson, O., Aman, R.
AIMS - A Metal Additive-hybrid Manufacturing System: System Architecture and Attributes

(2015) *Procedia Manufacturing*, 1, pp. 273-286. Cited 56 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2015.09.021

View at Publisher

30 Kerbrat, O., Mognol, P., Hascoët, J.-Y.
A new DFM approach to combine machining and additive manufacturing

(2011) *Computers in Industry*, 62 (7), pp. 684-692. Cited 125 times.
doi: 10.1016/j.compind.2011.04.003

View at Publisher

31 Dilberoglu, U.M., Gharehpapagh, B., Yaman, U., Dolen, M.
The Role of Additive Manufacturing in the Era of Industry 4.0

(2017) *Procedia Manufacturing*, 11, pp. 545-554. Cited 455 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2017.07.148

View at Publisher

32 Pragana, J.P.M., Sampaio, R.F.V., Bragança, I.M.F., Silva, C.M.A., Martins, P.A.F.
Hybrid metal additive manufacturing: A state–of–the-art review

(2021) *Advances in Industrial and Manufacturing Engineering*, 2, art. no. 100032. Cited 75 times.
https://www.sciencedirect.com/journal/advances-in-industrial-and-manufacturing-engineering/about/aims-and-scope
doi: 10.1016/j.aime.2021.100032

View at Publisher

33 Grzesik, W.
Hybrid additive and subtractive manufacturing processes and systems: A review

(2018) *Journal of Machine Engineering*, 18 (4), pp. 5-24. Cited 30 times.
http://www.not.pl/wydawnictwo/2018JOM/V4/1_GRZESIK.pdf
doi: 10.5604/01.3001.0012.7629

View at Publisher

34 Behandish, M., Nelaturi, S., de Kleer, J.
Automated process planning for hybrid manufacturing

(2018) *CAD Computer Aided Design*, 102, pp. 115-127. Cited 42 times.
doi: 10.1016/j.cad.2018.04.022

View at Publisher

35 Abdulhameed, O., Al-Ahmari, A.M., Ameen, W., Mian, S.H.
Novel dynamic CAPP system for hybrid additive–subtractive–inspection process

(2018) *Rapid Prototyping Journal*, 24 (6), pp. 988-1002. Cited 8 times.
http://www.emeraldinsight.com/info/journals/rpj/rpj.jsp
doi: 10.1108/RPJ-11-2017-0239

View at Publisher

36 Dávila, J.L., Neto, P.I., Noritomi, P.Y., Coelho, R.T., da Silva, J.V.L.
Hybrid manufacturing: a review of the synergy between directed energy deposition and subtractive processes

(2020) *International Journal of Advanced Manufacturing Technology*, 110 (11-12), pp. 3377-3390. Cited 32 times.
http://www.springerlink.com/content/0268-3768
doi: 10.1007/s00170-020-06062-7

View at Publisher

37 Jena, M.C., Mishra, S.K., Moharana, H.S.

Application of Industry 4.0 to enhance sustainable manufacturing

(2020) *Environmental Progress and Sustainable Energy*, 39 (1), art. no. 13360. Cited 47 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1944-7450
doi: 10.1002/ep.13360

View at Publisher

38 Smith, C.S., Wright, P.K.

CyberCut: A world wide web based design-to-fabrication tool

(1996) *Journal of Manufacturing Systems*, 15 (6), pp. 432-442. Cited 131 times.
http://www.elsevier.com
doi: 10.1016/S0278-6125(97)83056-7

View at Publisher

39 Chand, R., Sharma, V.S., Trehan, R., Gupta, M.K., Sarikaya, M.

Investigating the Dimensional Accuracy and Surface Roughness for 3D Printed Parts Using a Multi-jet Printer (Open Access)

(2023) *Journal of Materials Engineering and Performance*, 32 (3), pp. 1145-1159. Cited 4 times.
https://www.springer.com/journal/11665
doi: 10.1007/s11665-022-07153-0

View at Publisher

40 Ngo, T.D., Kashani, A., Imbalzano, G., Nguyen, K.T.Q., Hui, D.

Additive manufacturing (3D printing): A review of materials, methods, applications and challenges

(2018) *Composites Part B: Engineering*, 143, pp. 172-196. Cited 3855 times.
https://www.journals.elsevier.com/composites-part-b-engineering
doi: 10.1016/j.compositesb.2018.02.012

View at Publisher

41 DIng, D., Zhao, Z., Huang, R., Dai, C., Zhang, X., Xu, T., Fu, Y.

Error Modeling and Path Planning for Freeform Surfaces by Laser Triangulation On-Machine Measurement

(2021) *IEEE Transactions on Instrumentation and Measurement*, 70, art. no. 9369327. Cited 12 times.
https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=19
doi: 10.1109/TIM.2021.3063751

View at Publisher

42 Sathish, K., Kumar, S.S., Magal, R.T., Selvaraj, V., Narasimharaj, V., Karthikeyan, R., Sabarinathan, G., (...), Kassa, A.E.

A Comparative Study on Subtractive Manufacturing and Additive Manufacturing (Open Access)

(2022) *Advances in Materials Science and Engineering*, 2022, art. no. 6892641. Cited 6 times.
http://www.hindawi.com/journals/amse/
doi: 10.1155/2022/6892641

View at Publisher

43 Yusuf, S.M., Cutler, S., Gao, N.

Review: The impact of metal additive manufacturing on the aerospace industry (Open Access)

(2019) *Metals*, 9 (12), art. no. 1286. Cited 122 times.
https://www.mdpi.com/2075-4701/9/12/1286/pdf
doi: 10.3390/met9121286

View at Publisher

44 Korpela, M., Riikonen, N., Piili, H., Salminen, A., Nyrhilä, O.

Additive Manufacturing-Past, Present, and the Future

(2020) *Technical, Economic and Societal Effects of Manufacturing 4.0: Automation, Adaption and Manufacturing in Finland and Beyond*, pp. 17-41. Cited 12 times.
https://link.springer.com/book/10.1007/978-3-030-46103-4
ISBN: 978-303046103-4; 978-303046102-7
doi: 10.1007/978-3-030-46103-4_2

View at Publisher

45 Pereira, T., Kennedy, J.V., Potgieter, J.

A comparison of traditional manufacturing vs additive manufacturing, the best method for the job (Open Access)

(2019) *Procedia Manufacturing*, 30, pp. 11-18. Cited 160 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2019.02.003

View at Publisher

46 Paris, H., Mokhtarian, H., Coatanéa, E., Museau, M., Ituarte, I.F.

Comparative environmental impacts of additive and subtractive manufacturing technologies (Open Access)

(2016) *CIRP Annals - Manufacturing Technology*, 65 (1), pp. 29-32. Cited 153 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/709764/description#description
doi: 10.1016/j.cirp.2016.04.036

View at Publisher

47 Boban, J., Ahmed, A.

Electric discharge assisted post-processing performance of high strength-to-weight ratio alloys fabricated using metal additive manufacturing

(2022) *CIRP Journal of Manufacturing Science and Technology*, 39, pp. 159-174. Cited 5 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/714185/description#description
doi: 10.1016/j.cirpj.2022.08.002

View at Publisher

48 Ingarao, G., Priarone, P.C.

A comparative assessment of energy demand and life cycle costs for additive- and subtractive-based manufacturing approaches (Open Access)

(2020) *Journal of Manufacturing Processes*, Part A 56, pp. 1219-1229. Cited 32 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/620379/description#description
doi: 10.1016/j.jmapro.2020.06.009

View at Publisher

49 Sdvizhenskii, P.A., Lednev, V.N., Asyutin, R.D., Grishin, M.Y., Tretyakov, R.S., Pershin, S.M.

Online laser-induced breakdown spectroscopy for metal-particle powder flow analysis during additive manufacturing

(2020) *Journal of Analytical Atomic Spectrometry*, 35 (2), pp. 246-253. Cited 15 times.
http://pubs.rsc.org/en/journals/journal/ja
doi: 10.1039/c9ja00343f

View at Publisher

50 Xia, C., Pan, Z., Polden, J., Li, H., Xu, Y., Chen, S., Zhang, Y.

A review on wire arc additive manufacturing: Monitoring, control and a framework of automated system

(2020) *Journal of Manufacturing Systems*, 57, pp. 31-45. Cited 141 times.
http://www.elsevier.com
doi: 10.1016/j.jmsy.2020.08.008

View at Publisher

51 Chabot, A., Laroche, N., Carcreff, E., Rauch, M., Hascoët, J.-Y.

Towards defect monitoring for metallic additive manufacturing components using phased array ultrasonic testing

(2020) *Journal of Intelligent Manufacturing*, 31 (5), pp. 1191-1201. Cited 38 times.
www.kluweronline.com/issn/0956-5515/
doi: 10.1007/s10845-019-01505-9

View at Publisher

52 Cao, L., Li, J., Hu, J., Liu, H., Wu, Y., Zhou, Q.

Optimization of surface roughness and dimensional accuracy in LPBF additive manufacturing (Open Access)

(2021) *Optics and Laser Technology*, 142, art. no. 107246. Cited 38 times.
https://www.journals.elsevier.com/optics-and-laser-technology
doi: 10.1016/j.optlastec.2021.107246

View at Publisher

53 Boban, J., Ahmed, A., Rahman, M.A., Rahman, M.

Wire electrical discharge polishing of additive manufactured metallic components

(2020) *Procedia CIRP*, 87, pp. 321-326. Cited 11 times.
http://www.sciencedirect.com/science/journal/22128271
doi: 10.1016/j.procir.2020.02.023

View at Publisher

54 Abdulhameed, O., Al-Ahmari, A., Ameen, W., Mian, S.H.

Additive manufacturing: Challenges, trends, and applications

(2019) *Advances in Mechanical Engineering*, 11 (2). Cited 232 times.
http://ade.sagepub.com/
doi: 10.1177/1687814018822880

View at Publisher

55 Bourell, D., Kruth, J.P., Leu, M., Levy, G., Rosen, D., Beese, A.M., Clare, A.

Materials for additive manufacturing

(2017) *CIRP Annals - Manufacturing Technology*, 66 (2), pp. 659-681. Cited 567 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/709764/description#description
doi: 10.1016/j.cirp.2017.05.009

View at Publisher

56 Kok, Y., Tan, X.P., Wang, P., Nai, M.L.S., Loh, N.H., Liu, E., Tor, S.B.

Anisotropy and heterogeneity of microstructure and mechanical properties in metal additive manufacturing: A critical review (Open Access)

(2018) *Materials and Design*, 139, pp. 565-586. Cited 725 times.
doi: 10.1016/j.matdes.2017.11.021

View at Publisher

57 Arias-González, F., Barro, O., Del Val, J., Lusquiños, F., Fernández-Arias, M., Comesaña, R., Riveiro, A., (...), Pou, J.

Laser-directed energy deposition: Principles and applications (Open Access)

(2021) *Additive Manufacturing*, pp. 121-157. Cited 7 times.
https://www.sciencedirect.com/book/9780128184110
ISBN: 978-012818411-0
doi: 10.1016/B978-0-12-818411-0.00003-3

View at Publisher

58 Atzeni, E., Salmi, A.

Economics of additive manufacturing for end-usable metal parts (Open Access)

(2012) *International Journal of Advanced Manufacturing Technology*, 62 (9-12), pp. 1147-1155. Cited 471 times.
doi: 10.1007/s00170-011-3878-1

View at Publisher

59 Yakout, M., Phillips, I., Elbestawi, M.A., Fang, Q.

In-situ monitoring and detection of spatter agglomeration and delamination during laser-based powder bed fusion of Invar 36

(2021) *Optics and Laser Technology*, 136, art. no. 106741. Cited 22 times.
https://www.journals.elsevier.com/optics-and-laser-technology
doi: 10.1016/j.optlastec.2020.106741

View at Publisher

60 Lalegani Dezaki, M., Serjouei, A., Zolfagharian, A., Fotouhi, M., Moradi, M., Ariffin, M.K.A., Bodaghi, M.

A review on additive/subtractive hybrid manufacturing of directed energy deposition (DED) process

(2022) *Advanced Powder Materials*, 1 (4), art. no. 100054. Cited 15 times.
https://www.sciencedirect.com/journal/advanced-powder-materials/issues
doi: 10.1016/j.apmate.2022.100054

View at Publisher

61 Newman, S.T., Zhu, Z., Dhokia, V., Shokrani, A.

Process planning for additive and subtractive manufacturing technologies

(2015) *CIRP Annals - Manufacturing Technology*, 64 (1), pp. 467-470. Cited 155 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/709764/description#description
doi: 10.1016/j.cirp.2015.04.109

View at Publisher

62 Liu, C., Yan, D., Tan, J., Mai, Z., Cai, Z., Dai, Y., Jiang, M., (...), Chen, Z.

Development and experimental validation of a hybrid selective laser melting and CNC milling system (Open Access)

(2020) *Additive Manufacturing*, 36, art. no. 101550. Cited 14 times.
https://www.journals.elsevier.com/additive-manufacturing
doi: 10.1016/j.addma.2020.101550

View at Publisher

63 Chen, N., Frank, M.

Process planning for hybrid additive and subtractive manufacturing to integrate machining and directed energy deposition

(2019) , 34, pp. 205-213. Cited 23 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2019.06.140

View at Publisher

64 Xu, K., Li, Y., Liu, C., Liu, X., Hao, X., Gao, J., Maropoulos, P.G.

Advanced Data Collection and Analysis in Data-Driven Manufacturing Process

(2020) *Chinese Journal of Mechanical Engineering (English Edition)*, 33 (1), art. no. 43. Cited 44 times.
https://link.springer.com/journal/10033
doi: 10.1186/s10033-020-00459-x

View at Publisher

65 Amanullah, A.N.M., Murshiduzzaman, Saleh, T., Khan, R.

Design and Development of a Hybrid Machine Combining Rapid Prototyping and CNC Milling Operation

(2017) *Procedia Engineering*, 184, pp. 163-170. Cited 22 times.
http://www.sciencedirect.com/science/journal/18777058
doi: 10.1016/j.proeng.2017.04.081

View at Publisher

66 Boban, J., Ahmed, A.

Improving the surface integrity and mechanical properties of additive manufactured stainless steel components by wire electrical discharge polishing (Open Access)

(2021) *Journal of Materials Processing Technology*, 291, art. no. 117013. Cited 22 times.
https://www.journals.elsevier.com/journal-of-materials-processing-technology
doi: 10.1016/j.jmatprotec.2020.117013

View at Publisher

67 Sebbe, N.P.V., Fernandes, F., Sousa, V.F.C., Silva, F.J.G.

Hybrid Manufacturing Processes Used in the Production of Complex Parts: A Comprehensive Review (Open Access)

(2022) *Metals*, 12 (11), art. no. 1874. Cited 2 times.
http://www.mdpi.com/journal/metals
doi: 10.3390/met12111874

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68 Li, L., Haghighi, A., Yang, Y.

A novel 6-axis hybrid additive-subtractive manufacturing process: Design and case studies (Open Access)

(2018) *Journal of Manufacturing Processes*, 33, pp. 150-160. Cited 84 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/620379/description#description
doi: 10.1016/j.jmapro.2018.05.008

View at Publisher

69 Cortina, M., Arrizubieta, J.I., Ruiz, J.E., Ukar, E., Lamikiz, A.

Latest developments in industrial hybrid machine tools that combine additive and subtractive operations

(2018) *Materials*, 11 (12), art. no. 2583. Cited 61 times.
https://www.mdpi.com/1996-1944/11/12/2583/pdf
doi: 10.3390/ma11122583

View at Publisher

70 Wang, L.

From Intelligence Science to Intelligent Manufacturing (Open Access)

(2019) *Engineering*, 5 (4), pp. 615-618. Cited 66 times.
http://www.journals.elsevier.com/engineering/
doi: 10.1016/j.eng.2019.04.011

View at Publisher

71 Iqbal, A., Zhao, G., Suhaimi, H., He, N., Hussain, G., Zhao, W.

Readiness of subtractive and additive manufacturing and their sustainable amalgamation from the perspective of Industry 4.0: a comprehensive review (Open Access)

(2020) *International Journal of Advanced Manufacturing Technology*, 111 (9-10), pp. 2475-2498. Cited 20 times.
http://www.springerlink.com/content/0268-3768
doi: 10.1007/s00170-020-06287-6

View at Publisher

72 Aggour, K.S., Gupta, V.K., Ruscitto, D., Ajdelsztajn, L., Bian, X., Brosnan, K.H., Chennimalai Kumar, N., (...), Vinciquerra, J.

Artificial intelligence/machine learning in manufacturing and inspection: A GE perspective

(2019) *MRS Bulletin*, 44 (7), pp. 545-558. Cited 39 times.
http://journals.cambridge.org/MRS
doi: 10.1557/mrs.2019.157

View at Publisher

73 Caggiano, A., Zhang, J., Alfieri, V., Caiazzo, F., Gao, R., Teti, R.

Machine learning-based image processing for on-line defect recognition in additive manufacturing

(2019) *CIRP Annals*, 68 (1), pp. 451-454. Cited 201 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/709764/description#description
doi: 10.1016/j.cirp.2019.03.021

View at Publisher

74 Poole, D.L., Mackworth, A.K., Goebel, R.
(1998) *Computational Intelligence: A Logical Approach*. Cited 422 times.
Oxford University Press, New York, NY, USA

75 Kim, D.-H., Song, J.-Y.

Knowledge-evolutionary intelligent machine-tools - Part 1: Design of dialogue agent based on standard platform

(2006) *Journal of Mechanical Science and Technology*, 20 (11), pp. 1863-1872. Cited 10 times.
doi: 10.1007/BF03027579

View at Publisher

76 Kim, D.-H., Song, J.-Y., Lee, J.-H., Cha, S.-K.

DevelopMent and evaluation of intelligent Machine tools based on knowledge evolution in M2M environMent

(2009) *Journal of Mechanical Science and Technology*, 23 (10), pp. 2807-2813. Cited 10 times.
doi: 10.1007/s12206-009-0725-5

View at Publisher

77 Lee, S.W., Lee, H.K.

Rule-based cutting condition recommendation system for intelligent machine tools

(2009) *Journal of Mechanical Science and Technology*, 23 (4), pp. 1202-1210. Cited 9 times.
doi: 10.1007/s12206-009-0306-7

View at Publisher

78 Reisch, R., Hauser, T., Kamps, T., Knoll, A.

Robot based wire arc additive manufacturing system with context-sensitive multivariate monitoring framework

(2020) *Procedia Manufacturing*, 51, pp. 732-739. Cited 22 times.
http://www.journals.elsevier.com/procedia-manufacturing
doi: 10.1016/j.promfg.2020.10.103

View at Publisher

79 Verl, A., Lechler, A., Schlechtendahl, J.

Glocalized cyber physical production systems

(2012) *Production Engineering*, 6 (6), pp. 643-649. Cited 34 times.
doi: 10.1007/s11740-012-0418-2

View at Publisher

80 Stentoft, J., Olhager, J., Heikkilä, J., Thoms, L.

Manufacturing backshoring: a systematic literature review
(Open Access)

(2016) *Operations Management Research*, 9 (3-4), pp. 53-61. Cited 110 times.
http://www.springer.com/business/production/journal/12063
doi: 10.1007/s12063-016-0111-2

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