Technology Support for Protecting Contacting Surfaces of Half-Coupling—Shaft Press Joints Against Fretting Wear

Design, Simulation, Manufacturing: The Innovation Exchange

DSMIE 2019: Advances in Design, Simulation and Manufacturing II pp 216-225 | Cite as

- Vasyl Martsynkovskyy (1) View author's OrcID profile (View OrcID profile)
- Viacheslav Tarelnyk (1) View author's OrcID profile (View OrcID profile)
- Ievgen Konoplianchenko (1) Email author (konoplyanchenko@ukr.net)View author's OrcID profile (View OrcID profile)
- Oksana Gaponova (2) View author's OrcID profile (View OrcID profile)
- Mykhailo Dumanchuk (1) View author's OrcID profile (View OrcID profile)

1. Sumy National Agrarian University, , Sumy, Ukraine
2. Sumy State University, , Sumy, Ukraine

Conference paper
First Online: 07 June 2019

Part of the Lecture Notes in Mechanical Engineering book series (LNME)

Abstract

The paper describes the problem associated with the destruction occurred because of fretting wear (FW) of contacting surfaces of elastic coupling (EC) parts, among which the most attackable connection is a tension fit joint of half-coupling—shaft type, wherein the shaft outer cylindrical surface makes contact with the half-coupling inner cylindrical surface. The essence of the most known methods for improving the quality of press joints (increasing bearing capacity, raising joint tightness and shaft strength, as well as reducing FW) is in introducing certain intermediate layers between mating surfaces of parts. In contact, those intermediate layers get properties being significantly different from the original ones, i.e., the transferring occur of such a feature as sliding ability into the intermediate medium. As a novelty, to create such layers, it shows the application of the electric spark alloying (ESA) method, as the most promising, eco-friendly and energy-efficient. The paper presents the ESA processes of aluminizing, sulfidizing and carburizing, which simultaneously occur on the internal surfaces of the half-coupling (hub) in the areas of its ends, and make it possible to improve atmospheric corrosion (fretting corrosion) resistance, prevent adhesion between contacting surfaces, improve surface micro hardness and wear resistance, as well as provide for increasing the joint tightness.

Keywords

Aluminizing Carburizing Coating Elastic coupling Electrospark alloying Half-coupling—shaft Hub Fretting wear Sulfidizing Tension fit joint

References

1. Gaft, J., Martsinkovsky, V., Zagorulko, A., Gromyko, V.: Calculation and design of combined mechanical seal with self-adjusting clearance. In: Hoyes, J. (ed.) 17th International Symposium on Fluid Sealing, pp. 505–520. BHR Group, York (2003)
   Google Scholar (http://scholar.google.com/scholar_lookup?title=Calculation%20and%20design%20of%20combined%20mechanical%20seal%20with%20self-adjusting%20clearance&author=J.%20Gaft&author=V.%20Martsinkovsky&author=A.%20Zagorulko&author=V.%20Gromyko&pages=505-520&publication_year=2003)
2. Pavlenko, I., Liaposhchenko, A., Ochowiak, M., Demyanenko, M.: Solving the stationary hydroaeroelasticity problem for dynamic deflection elements of separation devices. Vibr. Phys. Syst. **29**, 2018026 (2018)
   Google Scholar (http://scholar.google.com/scholar_lookup?title=Solving%20the%20stationary%20hydroaeroelasticity%20problem%20for%20dynamic%20deflection%20elements%20of%20separation%20devices&author=I.%20Pavlenko&author=A.%20Liaposhchenko&author=M.%20Ochowiak&author=M.%20Demyanenko&journal=Vibr.%20Phys.%20Syst.&volume=29&pages=2018026&publication_year=2018)
3. Arsenyev, V., Vanyeyev, S., Protsenko, M., Gulyi, A.: Heat pump unit based on principle of stream thermocompression using water-ammonia solution. Procedia Eng. **39**, 254–260 (2012)
   CrossRef (https://doi.org/10.1016/j.proeng.2012.07.032)

Google Scholar (http://scholar.google.com/scholar_lookup?title=Heat%20pump%20unit%20based%20on%20principle%20of%20stream%20thermocompression%20using%20water-ammonia%20solution&author=V.%20Arsenyev&author=S.%20Vanyeyev&author=M.%20Protsenko&author=A.%20Gulyi&journal=Procedia%20Eng.&volume=39&pages=254-260&publication_year=2012)

4. Vaneev, S.M., Korolev, S.K., Rukhlov, Y.A., et al.: Compressed-air reaction motor and possibilities of its use. Chem. Petrol. Eng. **26**, 304–306 (1990)
CrossRef (https://doi.org/10.1007/BF01156878)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Compressed-air%20reaction%20motor%20and%20possibilities%20of%20its%20use&author=SM.%20Vaneev&author=SK.%20Korolev&author=YA.%20Rukhlov&journal=Chem.%20Petrol.%20Eng.&volume=26&pages=304-306&publication_year=1990)

5. Pavlenko, I., Trojanowska, J., Gusak, O., Ivanov, V., Pitel, J., Pavlenko, V.: Estimation of the reliability of automatic axial-balancing devices for multistage centrifugal pumps. Periodica Polytech. Mech. Eng. **63**(1), 52–56 (2019)
CrossRef (https://doi.org/10.3311/PPme.12801)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Estimation%20of%20the%20reliability%20of%20automatic%20axial-balancing%20devices%20for%20multistage%20centrifugal%20pumps&author=I.%20Pavlenko&author=J.%20Trojanowska&author=O.%20Gusak&author=V.%20Ivanov&author=J.%20Pitel&author=V.%20Pavlenko&journal=Periodica%20Polytech.%20Mech.%20Eng.&volume=63&issue=1&pages=52-56&publication_year=2019)

6. Korczak, A., Martsynkovskyy, V., Peczkis, G., Zahorulko, A.: Diagnosis of the phenomenon of flow as an inspiration to inventions in the domain of constructing hydraulic machines. Procedia Eng. **39**, 286–302 (2012)
CrossRef (https://doi.org/10.1016/j.proeng.2012.07.035)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Diagnosis%20of%20the%20phenomenon%20of%20flow%20as%20an%20inspiration%20to%20inventions%20in%20the%20domain%20of%20constructing%20hydraulic%20machines&author=A.%20Korczak&author=V.%20Martsynkovskyy&author=G.%20Peczkis&author=A.%20Zahorulko&journal=Procedia%20Eng.&volume=39&pages=286-302&publication_year=2012)

7. Batracov, A.B., Bazaleev, M.I., Donets, S.E., Klepikov, V.F., Lonin, Y., Lytvynenko, V.V., Ponomarev, A.G., Uvarov, V.V., Robuk, V.T., Uvarov, V.N.: The particularities of the high current relativistic electron beams influence on construction materials targets. Probl. At. Sci. Technol. **6**(88), 225–229 (2013)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20particularities%20of%20the%20high%20current%20relativistic%20electron%20beams%20influence%20on%20construction%20materials%20targets&author=AB.%20Batracov&author=MI.%20Bazaleev&author=SE.%20Donets&author=VF.%20Klepikov&author=Y.%20Lonin&author=VV.%20Lytvynenko&author=AG.%20Ponomarev&author=VV.%20Uvarov&author=VT.%20Robuk&author=VN.%20Uvarov&journal=Probl.%20At.%20Sci.%20Technol.&volume=6&issue=88&pages=225-229&publication_year=2013)

8. Tarelnyk, V., et al.: New sulphiding method for steel and cast iron parts. In: IOP Conference Series: Materials Science and Engineering, vol. 233, p. 012049 (2017)
CrossRef (https://doi.org/10.1088/1757-899X/233/1/012049)
Google Scholar (http://scholar.google.com/scholar_lookup?title=New%20sulphiding%20method%20for%20steel%20and%20cast%20iron%20parts&author=V.%20Tarelnyk&author=V.%20Martsynkovskyy&author=O.%20Gaponova&author=Ie.%20Konoplianchenko&author=M.%20Dovzyk&author=N.%20Tarelnyk&author=S.%20Gorovoy&journal=IOP%20Conference%20Series%3A%20Materials%20Science%20and%20Engineering&volume=233&pages=012049&publication_year=2017)

9. Tarelnyk, V.B., Gaponova, O.P., Konoplianchenko, I.V., Dovzhyk, M.Ya.: Investigation of regularities of the processes of formation of surface layers with electroerosive alloying. Part II. Metallofiz. New Technol. **3**(39), 363–385 (2017)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Investigation%20of%20regularities%20of%20the%20processes%20of%20formation%20of%20surface%20layers%20with%20electroerosive%20alloying.%20Part%20II.%20Metallofiz&author=VB.%20Tarelnyk&author=OP.%20Gaponova&author=IV.%20Konoplianchenko&author=M%20Ya.%20Dovzhyk&journal=New%20Technol.&volume=3&issue=39&pages=363-385&publication_year=2017)

10. Tarelnyk, V.B., Gaponova, O.P., Konoplianchenko, I.V., Herasymenko, V.A., Evtushenko, N.S.: The analysis of a structural state of surface layer after electroerosive alloying. I. Features of formation of electroerosive coatings on steel 45. Metallofiz. New Technol. **2**(40), 235–254 (2018)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20analysis%20of%20a%20structural%20state%20of%20surface%20layer%20after%20electroerosive%20alloying.%20I.%20Features%20of%20formation%20of%20electroerosive%20coatings%20on%20steel%2045.%20Metallofiz&author=VB.%20Tarelnyk&author=OP.%20Gaponova&author=IV.%20Konoplianchenko&author=VA.%20Herasymenko&author=NS.%20Evtushenko&journal=New%20Technol.&volume=2&issue=40&pages=235-254&publication_year=2018)

11. Zenkin, A.S.A., Kozello, N.L., Oborsky, I.L.: Technological support for accuracy of thermo action assembly of tension fit joints. Bull. Mech. Eng. **10**, 43–45 (1988)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Technological%20support%20for%20accuracy%20of%20thermo%20action%20assembly%20of%20tension%20fit%20joints&author=ASA.%20Zenkin&author=NL.%20Kozello&author=IL.%20Oborsky&journal=Bull.%20Mech.%20Eng.&volume=10&pages=43-45&publication_year=1988)

12. Hintikka, J., Mäntylä, A., Vaara, J., Frondelius, T., Lehtovaara, A.: Stable and unstable friction in fretting contacts. Tribol. Int. **131**, 73–82 (2019)

CrossRef (https://doi.org/10.1016/j.triboint.2018.10.014)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Stable%20and%20unstable%20friction%20in%20fretting%20contacts&author=J.%20Hintikka&author=A.%20M%C3%A4ntyl%C3%A4&author=J.%20Vaara&author=T.%20Frondelius&author=A.%20Lehtovaara&journal=Tribol.%20Int.&volume=131&pages=73-82&publication_year=2019)

13. Putro, E.V. Yurko V.I.: Elastic Couplings with Sets of Annular Metal Membranes of "MCK" type. Modern Energy Efficient Technologies for Implementing Engineering Problems for Dynamic Equipment: Monograph. Tritoria, Sumy, (2017)
Google Scholar (https://scholar.google.com/scholar?q=Putro%2C%20E.V.%20Yurko%20V.I.%3A%20Elastic%20Couplings%20with%20Sets%20of%20Annular%20Metal%20Membranes%20of%20%E2%80%9CMC%D0%9A%E2%80%9D%20type.%20Modern%20Energy%20Efficient%20Technologies%20for%20Implementing%20Engineering%20Problems%20for%20Dynamic%20Equipment%3A%20Monograph.%20Tritoria%2C%20Sumy%2C%20%282017%29)

14. Petukhov, A.N.: Fretting corrosion and fretting fatigue of slow-moving joints for gas turbine engines and power machines. Aerosp. Eng. Technol. **7**(15), 128–134 (2004)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Fretting%20corrosion%20and%20fretting%20fatigue%20of%20slow-moving%20joints%20for%20gas%20turbine%20engines%20and%20power%20machines&author=AN.%20Petukhov&journal=Aerosp.%20Eng.%20Technol.&volume=7&issue=15&pages=128-134&publication_year=2004)

15. Smyslov, A.M., Selivanov, K.S.: Increasing Durability of Machine Parts in Terms of Fretting. Gilem, Ufa (2005)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Increasing%20Durability%20of%20Machine%20Parts%20in%20Terms%20of%20Fretting&author=AM.%20Smyslov&author=KS.%20Selivanov&publication_year=2005)

16. Panova, I.M. Panov, A.D.: Analysis of reliability of tension fit joints on special operating conditions. Naukovedenie 4(9), 26TVN417 (2017)
Google Scholar (https://scholar.google.com/scholar?q=Panova%2C%20I.M.%20Panov%2C%20A.D.%3A%20Analysis%20of%20reliability%20of%20tension%20fit%20joints%20on%20special%20operating%20conditions.%20Naukovedenie%204%289%29%2C%2026TVN417%20%282017%29)

17. Malitsky, I.F., Chernyatina, E.V.: Influence of roughness and processing methods on strength of tension interface. Mech. Eng. **13**, 149–153 (2014)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Influence%20of%20roughness%20and%20processing%20methods%20on%20strength%20of%20tension%20interface&author=IF.%20Malitsky&author=EV.%20Chernyatina&journal=Mech.%20Eng.&volume=13&pages=149-153&publication_year=2014)

18. Lebed, V.T., Kulachenko, A.A.: Technology of thermal assembly of composite large-sized parts. Progressive Technol. Syst. Mech. Eng. **28**, 84–94 (2004)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Technology%20of%20thermal%20assembly%20of%20composite%20large-sized%20parts&author=VT.%20Lebed&author=AA.%20Kulachenko&journal=Progressive%20Technol.%20Syst.%20Mech.%20Eng.&volume=28&pages=84-94&publication_year=2004)

19. Lebed, V.T., Kulachenko, A.A.: Optimization of coating technology for joints of large-sized composite rolls to increase bearing capacity. Reliab. Instrum. Optim. Technol. Syst. Collect. Sci. Works **23**, 240–247 (2008)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Optimization%20of%20coating%20technology%20for%20joints%20of%20large-sized%20composite%20rolls%20to%20increase%20bearing%20capacity&author=VT.%20Lebed&author=AA.%20Kulachenko&journal=Reliab.%20Instrum.%20Optim.%20Technol.%20Syst.%20Collect.%20Sci.%20Works&volume=23&pages=240-247&publication_year=2008)

20. Bashkarev, A.V., Kushchenko, AYa.: Control of frictional properties of polyimide coatings in tension fit joints. Sci. Tech. Statements St. Petersburg State Polytech. Univ. **1**(238), 155–162 (2016)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Control%20of%20frictional%20properties%20of%20polyimide%20coatings%20in%20tension%20fit%20joints&author=AV.%20Bashkarev&author=AYa.%20Kushchenko&journal=Sci.%20Tech.%20Statements%20St.%20Petersburg%20State%20Polytech.%20Univ.&volume=1&issue=238&pages=155-162&publication_year=2016)

21. Aslanyan, I.R. Krioni, N.K. Shuster, L.Sh.: Tribological characteristics of electrolytic coatings under different friction conditions. Ufa: UGATU **8**(61), 24–28 (2013)
Google Scholar (https://scholar.google.com/scholar?q=Aslanyan%2C%20I.R.%20Krioni%2C%20N.K.%20Shuster%2C%20L.Sh.%3A%20Tribological%20characteristics%20of%20electrolytic%20coatings%20under%20different%20friction%20conditions.%20Ufa%3A%20UGATU%208%2861%29%2C%2024%E2%80%9328%20%282013%29)

22. Selivanov, K.S., Galiakbarov, R.F.: Increasing fretting-resistance of machine parts by integrated vacuum plasma processing. Aerosp. Eng. Technol. **7**(84), 29–32 (2011)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Increasing%20fretting-resistance%20of%20machine%20parts%20by%20integrated%20vacuum%20plasma%20processing&author=KS.%20Selivanov&author=RF.%20Galiakbarov&journal=Aerosp.%20Eng.%20Technol.&volume=7&issue=84&pages=29-32&publication_year=2011)

23. Balatsky, L.T.: Strength of Press Joints. Tehnika, Kiev (1982)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Strength%20of%20Press%20Joints&author=LT.%20Balatsky&publication_year=1982)

24. Mikhailyuk, A.I., Gitlevich, A.E., Ivanov, A.I., Fomicheva, E.I., Dimitrova, G.I., Gripachevsky, A.N.: Transformation in surface layers of iron alloys at electrospark alloying with graphite. Electron Beam Process. Mater. **4**, 23–27 (1986)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Transformation%20in%20surface%20layers%20of%20iron%20alloys%20at%20electrospark%20alloying%20with%20graphite&author=AI.%20Mikhailyuk&author=AE.%20Gitlevich&author=AI.%20Ivanov&author=EI.%20Fomicheva&author=GI.%20Dimitrova&author=AN.%20Gripachevsky&journal=Electron%20Beam%20Process.%20Mater.&volume=4&pages=23-27&publication_year=1986)

25. Mikhailyuk, A.I., Gitlevich, A.E.: The use of graphite in electrospark technologies. Electron Beam Process. Mater. **5**(46), 37–44 (2010)
Google Scholar (http://scholar.google.com/scholar_lookup?title=The%20use%20of%20graphite%20in%20electrospark%20technologies&author=AI.%20Mikhailyuk&author=AE.%20Gitlevich&journal=Electron%20Beam%20Process.%20Mater.&volume=5&issue=46&pages=37-44&publication_year=2010)

26. Ershov, V.M.: Carburizing steel surface during electrospark treatment by graphite. Collect. Sci. Works Empl. DonSTU **31**, 219–225 (2011)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Carburizing%20steel%20surface%20during%20electrospark%20treatment%20by%20graphite&author=VM.%20Ershov&journal=Collect.%20Sci.%20Works%20Empl.%20DonSTU&volume=31&pages=219-225&publication_year=2011)

27. Wang, J., Yu, H., Fan, Z., Sun, D., Meng, H.: Surface hardening of Fe-based alloy powders by Nd: YAG laser cladding followed by electrospark deposition with WC-Co cemented carbide. Rare Met. **29**(4), 380–384 (2010)
CrossRef (https://doi.org/10.1007/s12598-010-0134-z)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Surface%20hardening%20of%20Fe-based%20alloy%20powders%20by%20Nd%3A%20YAG%20laser%20cladding%20followed%20by%20electrospark%20deposition%20with%20WC-Co%20cemented%20carbide&author=J.%20Wang&author=H.%20Yu&author=Z.%20Fan&author=D.%20Sun&author=H.%20Meng&journal=Rare%20Met.&volume=29&issue=4&pages=380-384&publication_year=2010)

28. Nezhibetsky, G.N. Shkurko, A.I.: Bushings for Rotor End Seals. Modern Energy Efficient Technologies Intended to Implement Engineering Problems for Dynamic Equipment: Monograph. Tritoria, Sumy (2017)
Google Scholar (https://scholar.google.com/scholar?q=Nezhibetsky%2C%20G.N.%20Shkurko%2C%20A.I.%3A%20Bushings%20for%20Rotor%20End%20Seals.%20Modern%20Energy%20Efficient%20Technologies%20Intended%20to%20Implement%20Engineering%20Problems%20for%20Dynamic%20Equipment%3A%20Monograph.%20Tritoria%2C%20Sumy%20%282017%29)

29. Gitlevich, A.E., Mikhailov, V.V., Parkansky, N.Ya., Revutsky, V.M.: Electrospark Alloying of Metal Surfaces. Stintz, Chisinau (1985)
Google Scholar (https://scholar.google.com/scholar?q=Gitlevich%2C%20A.E.%2C%20Mikhailov%2C%20V.V.%2C%20Parkansky%2C%20N.Ya.%2C%20Revutsky%2C%20V.M.%3A%20Electrospark%20Alloying%20of%20Metal%20Surfaces.%20Stintz%2C%20Chisinau%20%281985%29)

30. Młynarczyk, P., Spadło, S., Bartos, J.: Selected properties of electro-spark deposition on carbon steel using the Alloy 400 electrodes. In: IOP Conference Series: Materials Science and Engineering, vol. 461, p. 012055 (2018)
CrossRef (https://doi.org/10.1088/1757-899X/461/1/012055)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Selected%20properties%20of%20electro-spark%20deposition%20on%20carbon%20steel%20using%20the%20Alloy%20400%20electrodes&author=P..%20M%C5%82ynarczyk&author=S..%20Spad%C5%82o&author=J..%20Bartos%E2%80%99&journal=IOP%20Conference%20Series%3A%20Materials%20Science%20and%20Engineering&volume=461&pages=012055&publication_year=2018)

31. Gostishchev, V., Ri, E., Ri, H., Kim, E., Ermakov, M., Khimukhin, S., Deev, V., Prusov, E.: Synthesis of complex-alloyed nickel aluminides from oxide compounds by aluminothermic method. Metals **8**(6), 439 (2018)
CrossRef (https://doi.org/10.3390/met8060439)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Synthesis%20of%20complex-alloyed%20nickel%20aluminides%20from%20oxide%20compounds%20by%20aluminothermic%20method&author=V.%20Gostishchev&author=E.%20Ri&author=H.%20Ri&author=E.%20Kim&author=M.%20Ermakov&author=S.%20Khimukhin&author=V.%20Deev&author=E.%20Prusov&journal=Metals&volume=8&issue=6&pages=439&publication_year=2018)

32. Heard, D.W., Brochu, M.: Development of a nanostructure microstructure in the Al–Ni system using the electrospark deposition process. J. Mater. Process. Technol. **6–7**(210), 892–898 (2010)
CrossRef (https://doi.org/10.1016/j.jmatprotec.2010.02.001)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Development%20of%20a%20nanostructure%20microstructure%20in%20the%20Al%E2%80%93Ni%20system%20using%20the%20electrospark%20deposition%20process&author=DW.%20Heard&author=M.%20Brochu&journal=J.%20Mater.%20Process.%20Technol.&volume=6%E2%80%937&issue=210&pages=892-898&publication_year=2010)

33. Jing, Q.F., Tan, Y.F., Ji, H.Y., Wang, X.L., Gao, L., Zhao, W.: Microstructure and tribological properties of Stellite21 coating by electro-spark deposition. Appl. Mech. Mater. **423–426**, 939–943 (2013)
CrossRef (https://doi.org/10.4028/www.scientific.net/AMM.423-426.939)
Google Scholar (http://scholar.google.com/scholar_lookup?title=Microstructure%20and%20tribological%20properties%20of%20Stellite21%20coating%20by%20electro-spark%20deposition&author=QF.%20Jing&author=YF.%20Tan&author=HY.%20Ji&author=XL.%20Wang&autho

r=L.%20Gao&author=W.%20Zhao&journal=Appl.%20Mech.%20Mater.&volume=423%E2%80%93426&pages=939-943&publication_year=2013)

Copyright information

About this paper

Cite this paper as:

Martsynkovskyy V., Tarelnyk V., Konoplianchenko I., Gaponova O., Dumanchuk M. (2020) Technology Support for Protecting Contacting Surfaces of Half-Coupling—Shaft Press Joints Against Fretting Wear. In: Ivanov V. et al. (eds) Advances in Design, Simulation and Manufacturing II. DSMIE 2019. Lecture Notes in Mechanical Engineering. Springer, Cham

- First Online 07 June 2019
- DOI https://doi.org/10.1007/978-3-030-22365-6_22
- Publisher Name Springer, Cham
- Print ISBN 978-3-030-22364-9
- Online ISBN 978-3-030-22365-6
- eBook Packages Engineering

Personalised recommendations