Applied Mechanics and Materials Vol 770 (2015) pp 434-438
© (2015) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMM.770.434

Submitted: 2015-03-13
Accepted: 2015-03-18

Stress State of Disk Tool Attachment Points on Tetrahedral Prisms Between Axial Bits

A.A. Khoreshok [1,a], L.E. Mametyev [2,b], A.Yu. Borisov [3,c], A.V. Vorobyov [4,d]

[1,2,3] Department of Mining Machines and Complexes/Mining Institute,

T.F. Gorbachev KuzSTU , Russia, 650000, Kemerovo, Vesennyaya street 28,

[1,4] Department of Mining Equipment, Yurga Institute of Technology, TPU affiliate,

Russia, 652055, Yurga, Leningradskaya street 26

[1] Institute of coal, Siberian branch of Russian Academy of Sciences,

Russia, 650065, Kemerovo, Leningradskiy prospect 10

[a]email: haa.omit@kuzstu.ru, [b,c]email: bau.asp@rambler.ru, [d]email: vorob@tpu.ru

Keywords: Roadheader, working body, axial bits, tetrahedral prism, attachment point, disk tool, cutting, stress state, Finite Element Method.

Abstract. The paper presents results of simulation of stress-strain state of disk tools attachment points on tetrahedral prisms of working bodies of multipurpose roadheaders while cutting of coal and rock faces.

Introduction

Development of technologies in coal mines, increase of coal extraction speed, implementing of complex mechanization and automation of manufacturing methods of coal production by underground methods increases demands to the mining equipment with a view to reduction of a specific energy consumption [1, 2]. Geological and mining conditions of the openings to surface in coal mines of Russia are very diverse and vary not only within a single region, but within a single mine. Differences in thickness and seam inclination, methods of openings and primary mining, host rock physical-mechanical properties, depth of occurrence, abundance of water and gas emission determine the variety of cross-section types, technology and mechanization during opening-to-surface works.

Experience in the design and operation of boom working bodies of multipurpose tunneling machines identified both advantages and disadvantages of numerous engineering solutions and designs used in mining and underground construction [3].

The main advantages of bit boom working bodies include:

- possibility of selective extraction of structurally inhomogeneous rock mass, such as coal rock;
- providing a wide range of excavation shapes and cross-sections that are convenient for the subsequent stabilizing and laying underground utility system;
- widening the scope of roadheading machinery for mechanization of room-and-pillar mining;
- overlapping of cutting and loading of rocks of different physical and mechanical properties;
- ensuring availability of the face and workspace for technical inspection and repair with easy retreat of the roadheader from the face space;
- interaction with a variety of self-propelled machines and mechanisms of floor and overhead monorail types in forming of mechanized mining complexes;
- drilling of technology wells and cutting of side chambers in the walls of excavations, as well as holes for roof supports and drainage grooves.

The main disadvantages of multipurpose tunneling machines are:

- console mounting of the boom working body to the base frame, that leads to a loss of stability if intensive modes of operation;
- sharp decline in performance if coal is replaced by rocks;

- high dynamics, vibration, noise and dust in the workspace; a shorter service life of rock cutting tools, bit housings, loading and conveying elements of different loading machines;
- low loading capacity in working areas;
- low efficiency of lump crushing in the face space on the face ground in the area of the loader feeder desk;
- increased danger when driving mine workings in unstable free-caving rocks and quicksands;
- low efficiency of the bits when cutting into rock on a transverse operating width at the beginning of a next driving.

Working bodies of multipurpose tunneling machines with longitudinal axial bits square face up more accurately, without significant rock discrepancy and mechanize cutting of drainage grooves and drilling holes for roof supports; their shapes and sizes are better adapted to multipurpose excavation.

Working bodies of multipurpose tunneling machines with longitudinal axial bits under prevailing horizontal movements are characterized by increased stability of frame subsystems and electric drive of propulsor subsystems, by decrease in dynamic stress of power subsystem elements especially during the excavation in hard and complex rocks.

A full cycle of arcwall face treatment with axial bits includes a large number of sequential operations: a frontal cut; a vertical cut; a side cut. Excavation by vertical stripes is also possible.

Performing cuts by the working body depends on the boom position: boom advancement into the face performs a frontal cut; boom lift performs a vertical cut up; boom lowering performs a vertical cut down [4].

The main advantage of the working bodies with cross-axial bits if compared to that with longitudinal axial bits is the increased stability of the machine when operating.

The main disadvantages of the working body of this type are:
- a lower quality of face treatment, as compared with the longitudinally axial bit, that increases complexity of the roof supporting and reduces the roof stability;
- inability to cut the drain grooves and degradation of selective mining quality.

Thus, for both types of bit working bodies the main disadvantages are: poor surface quality and face contour accuracy, which adversely affect the possibility of roof support mechanization.

The main disadvantage of the working bodies of tunneling machines with cross-axial executive bodies is the low productivity of cutting because of an indestructible rock block in the inter-bits space (fig. 1, 2).

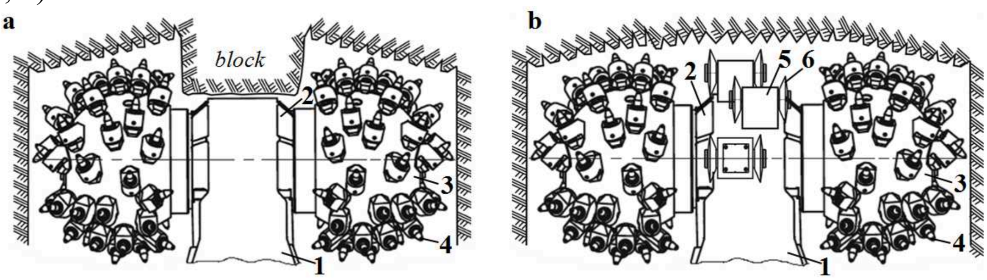


Fig. 1. Working body operation: a – conventional body; b – when using disk tools with tetrahedral prisms on the distributing gear

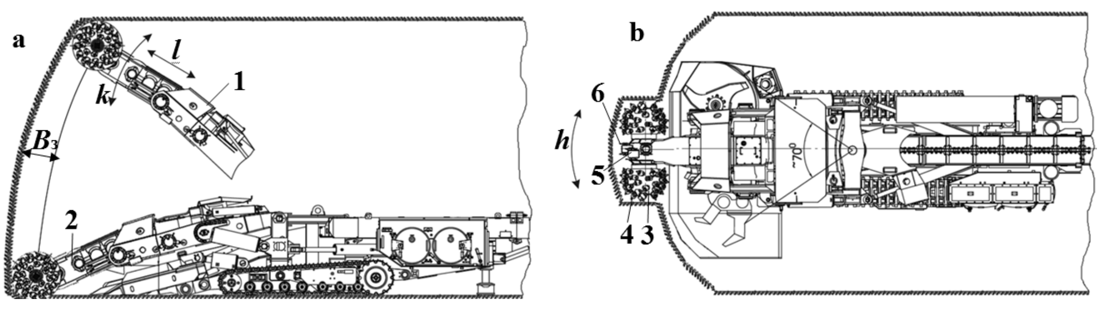


Fig. 2. View of multipurpose roadheader operation: a – side cutting view; b – top view after cutting

Researchers from the Department of Mining Machines and Complexes T.F. Gorbachev KuzSTU introduce disk tools on tetrahedral prisms in inter-bit area for efficiency of operations of the working body with cross-axial bits.

On the basis of this idea, technical solutions are designed [5-7] raising efficiency of operations of mineral and rock cutting with working bodies with axial bits of multipurpose tunneling machines as P110, KP220.

Rock cutting operation goes as follows (Fig. 1 and 2): working body boom 1 with distributing reduction gear 2, axial bits 3, cutters 4 and tetrahedral prisms 5 with disk tools 6 performs vertical-rotary planning-off and simultaneously expands telescopically.

Wherein the block (Fig. 1a), which is formed during the operation of conventional working bodies, is destroyed with disk tools 6 on tetrahedral prisms 5 (Fig. 1b) in inter-bits space.

A part of distributing reduction gear housing 2 of the boom 1 is turned to face surface and is made as a cylindrical sector, on its surface tetrahedral prisms 5 with the disc tools 6 are mounted in chessboard order; these overlap the space between the cutting lines, formed by the outer cutters 4 from the large bases of the axial bits 3 side.

In this case radial tool overhang of disk tool wedge cutting edges 6 does not exceed radial overhang of the outer cutters 4 on large bases of the axial bits 3.

This allows cutting rocks at operating widths B_3 (Fig. 2a) while moving the boom 1 during cutting in the vertical plane (arrowed line *k*) with telescopic expansion (arrowed line *l*). On stepped treatment with axial bits 3 boom 1 moves (arrowed line *h*) to the right or to the left (Fig. 2b) in the horizontal plane.

Together with the Department of Mining Equipment YTI TPU, a procedure for Finite Element Modeling was developed and calculation of load forces P_z, P_y, P_x for disk tools mounted on tetrahedral prisms was tested, which were previously approved in studies of reverse radial bits with disk tools on triangular prisms [8, 9].

Figure 3 shows a Finite Element Model of a tetrahedral prism with disk tools that forming an additional cutting area in the inter-bit space of the road header working body. Baseline characteristics for calculating parameters of stress state of destructible rock masses were chosen: coal ($\sigma_{compress}$ = 12.4; 13.5; 14.8 MPa) and rock ($\sigma_{compress}$ = 51; 60.6; 78.9 MPa). Four design versions of the disk tool with diameter D = 160 mm were used (three biconical with taper angles: $\varphi = \varphi_1 + \varphi_2 = 25° + 5° = 30°$; $20° + 10° = 30°$; $15° + 15° = 30°$ and a conical $\varphi = 30°$).

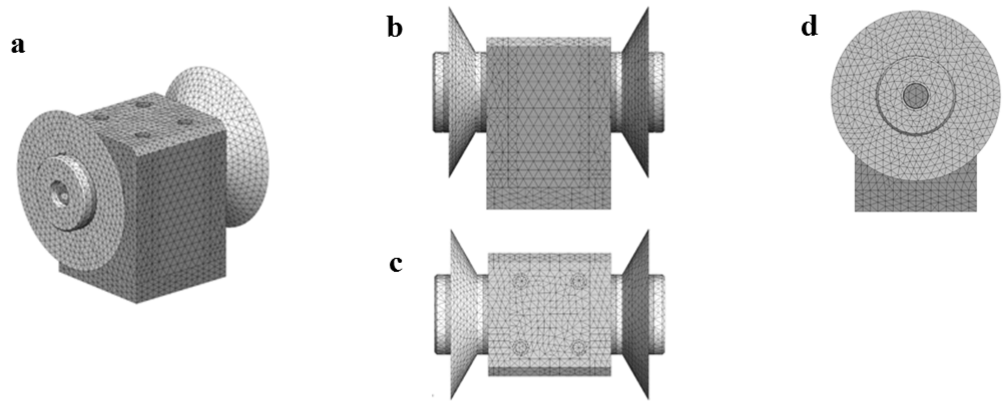


Fig. 3. Finite Element Model of the tetrahedral prism with disk tools

The calculation was made in SolidWorks Simulation. When constructing the grid, parabolic finite elements in the form of triangular pyramids were used. The size of finite elements was selected such that further increase of the grid density would not affect results of calculation significantly. Material for details was 35 HGSA steel and Steel 45. Forces of cutting P_z, sump P_y and lateral P_x were determined considering design of disk tools, mode parameters and characteristics of rock mass $\sigma_{compress}$. Rated load forces P_z, P_y, P_x were applied (Fig. 3) to finite element models of the disc instruments with attachment points on tetrahedral prisms to obtain models of stress-strain states of biconical and conical disk tools (Fig. 4).

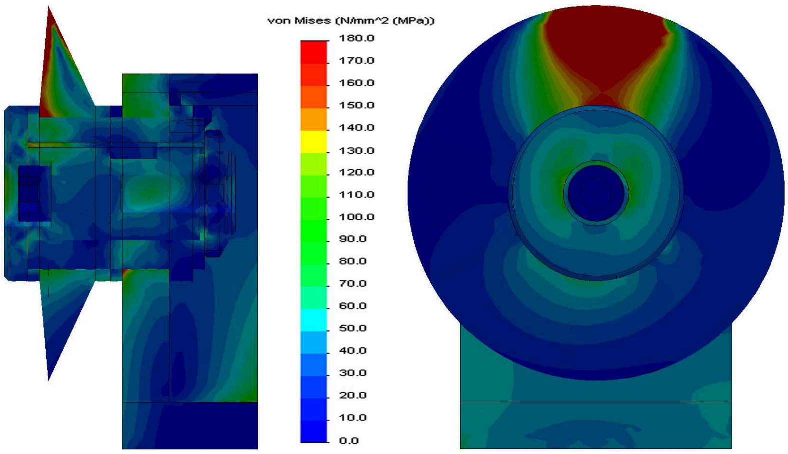


Fig. 4. Distribution of equivalent stresses according to Mises criterion in the attachment point of biconical disk tool (φ = 25°+5° = 30°) when rock mass cutting $\sigma_{compress}$ = 78,9 MPa

On the basis of design solutions stated in [5-7] an original engineering solution [10] was proposed; tetrahedral prisms with dual disk tools are manufactured as single dismountable structural units with possibility of conjoint free rotation on fixed pivot axles. This provides conjoint rotation of two disc tools on each tetrahedral prism, and reduces the risk of blocking and wear when cutting rock masses.

Technical solutions and test results were obtained within the base part of Ministry of Education and Science of Russia state order, project №632 "Investigation of technologies and techniques parameters for selecting and developing innovative designs to improve operating efficiency of multipurpose mining machines in Kuzbass."

Summary

It is established that static load for all tested versions of disk tool attachment points on tetrahedral prisms of distributing gear housings of working bodies with axial bits is distributed so that static load is maximum at the edge of the disc tool in the area of contact with the rock mass; it gradually decreases to a minimum in the area of the fixed pivot axle and the axis with thrust collar.

It is revealed that minimum level of equivalent stress when cutting as coal ($\sigma_{compress}$ = 12,4; 13,5; 14,8 MPa) and rock mass ($\sigma_{compress}$ = 51; 60,6; 78,9 MPa) is observed using biconical disk tools (φ = 25°+5° = 30°; φ = 20°+10° = 30° and φ = 15°+15° = 30°), and maximum level of equivalent stress is observed when using the conical disk tool (φ = 30 °).

It is specified that when changing tapering angle of the biconical disk tool from asymmetric (φ = 25°+5° = 30°; φ = 20°+10° = 30°) to symmetric (φ = 15°+15° = 30°), decrease in the estimated level of the maximum equivalent stress with all versions of the load occurs.

It is proved by the static FEM simulation of coal cutting operations in the range of compressive strength $\sigma_{compress}$ = 12,4÷78,9 MPa that indicators of stress-strain state of structural elements of the disk tools with attachment points, manufactured on the proposed engineering solutions, provide a guaranteed safety margin for steels (35HGSA, St. 45).

The chart of the disk tool layout on the distributing gear housing between the axial bits of the roadheader working body is recommended, with the placement of conical discs in the central zone and biconical disks - across the width of inter-bit space.

References

[1] V.V. Aksenov, A.B. Efremenkov, V.Yu. Beglyakov, The influence of relative distance between ledges on the stress-strain state of the rock at a face, J. Applied Mechanics and Materials. 379 (2013) 16-19.

[2] V.V. Aksenov, A.A. Khoreshok, V.Yu. Beglyakov, Justification of creation of an external propulsor for multipurpose shield-type heading machine – GEO-WALKER, J. Applied Mechanics and Materials. 379 (2013) 20-23.

[3] A.A. Khoreshok, L.E. Mametyev, A.Yu. Borisov, Improvement of destructive-loading ability of multipurpose roadheader, J. Scientific and technical journal «Mining engineer», Moscow. 1 (2013) 102-110.

[4] Information on http://library.stroit.ru/articles/combain2/index.html

[5] L.E. Mametyev, A.A. Khoreshok, A.Yu. Borisov, A.M. Tshehin, RU. Patent 136086 (2013).

[6] A.A. Khoreshok, L.E. Mametyev, A.M. Tshehin, A.Yu. Borisov, Devices for improvement of cutting with effectors of multipurpose roadheaders, J. Mining equipment and electromechanics, Moscow. (2014) 11-16.

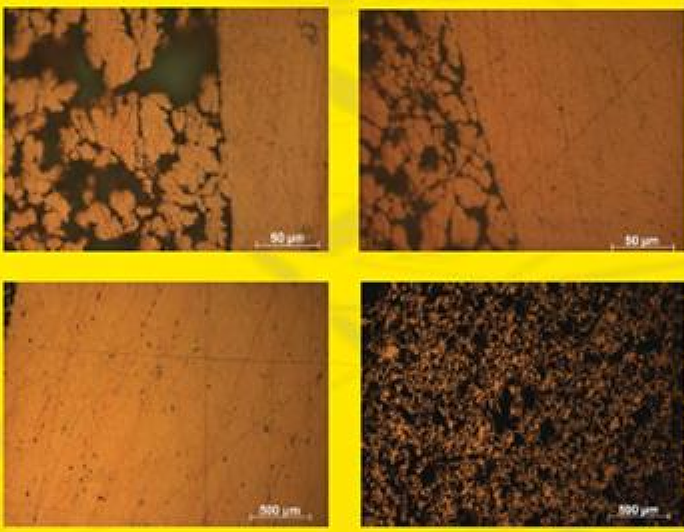
[7] A.A. Khoreshok, L.E. Mametyev, A.M. Tshehin, A.Yu. Borisov, Adjustment of disk tool attachment points of roadheader effectors for mounting and dismounting, J. Mining equipment and electromechanics, Moscow. 7 (2014) 3-8.

[8] L.E. Mametyev, A.A. Khoreshok, A.Yu. Borisov, A.V. Vorobyov, Improvement of designs of disk tool attachment points on radial heads of roadheaders, J. Bulletin of KuzSTU, Kemerovo. 1 (2014) 3-5.

[9] A.A. Khoreshok, L.E. Mametyev, A.Yu. Borisov, S.G. Muhortikov, A.V. Vorobyov, Designing of reversive heads for boom-type roadheaders with disk tool on replaceable trihedral prisms, J. Mining equipment and electromechanics, Moscow. 9 (2013) 40-44.

[10] L.E. Mametyev, A.A. Khoreshok, A.Yu. Borisov, A.V. Vorobyov, RU. Patent 146845 (2014).

Urgent Problems of Up-to-Date Mechanical Engineering



Edited by
D.A. Chinakhov

TTP TRANS TECH PUBLICATIONS

1 item

Registration Log In

Search

Journals

Engineering Research

Advanced Engineering Forum

Applied Mechanics and Materials

Engineering Chemistry

Engineering Innovations

Journal of Biomimetics, Biomaterials and Biomedical Engineering

International Journal of Engineering Research in Africa

Materials Science

Advanced Materials Research

Defect and Diffusion Forum

Diffusion Foundations and Materials Applications

Journal of Metastable and Nanocrystalline Materials

Journal of Nano Research

Key Engineering Materials

Materials Science Forum

Nano Hybrids and Composites

Solid State Phenomena

Engineering Series

Advances in Science and Technology

Construction Technologies and Architecture

Engineering Headway

Books

Special Book Collections

Foundations of Materials Science and Engineering

Scientific Books Collection

Scientific Books of Abstracts

Specialized Collections

Retrospective Collection

Applied Mechanics and Materials - Details

ISSN: 1662-7482

Details

Volumes

Editorial Board

SUBMIT PAPER

About:

Applied Mechanics and Materials (AMM) is a peer-reviewed journal which specializes in the publication of proceedings of international scientific conferences, workshops and symposia as well as special volumes on topics of contemporary interest in all areas which are related to:

1) Research and design of mechanical systems, machines and mechanisms;

2) Materials engineering and technologies for manufacturing and processing;

3) Systems of automation and control in the areas of industrial production;

4) Advanced branches of mechanical engineering such as

RECENT VOLUME

mechatronics, computer engineering and robotics.

Applied Mechanics and Materials" publishes only complete volumes on given topics, proceedings and complete special topic volumes.

Authors retain the right to publish an extended, significantly updated version in another periodical.

All published materials are archived with PORTICO and CLOCKSS.

Presented, Distributed and Abstracted/Indexed in:
Inspec (IET, Institution of Engineering Technology)
Chemical Abstracts Service (CAS)
Google Scholar
NASA Astrophysics Data System (ADS)
ProQuest
Ulrichsweb
EBSCOhost Research Databases
Zetoc
Index Copernicus Journals Master List
WorldCat (OCLC) www.worldcat.org.
CEABA
Polymer Library
ESTEC

ISSN print 1660-9336 ISSN cd 2297-8941 ISSN web 1662-7482

Additional Information:

Please ask for additional information: amm@scientific.net
Publication schedule: 7 volumes per year.

Subscription

WEB ACCESS 2024: Volumes 918-924 (7 Vols.)
Access January - December 2024
The Journal published as of 2004 - Dec 2023: 917 Vols.

Online Subscription Price 2024: EUR 1’300 / US$ 1’490 (Option 1)

Online Subscription Price 2024 with access to all Back Volumes: EUR 1’875 / USD 2’140 (Option 2)

Online Subscription Price 2024 with access to all Back Volumes (perpetual): EUR 48'530 / USD 52'020 (Option 3)

Online Subscription Price 2024 with perpetual access to the last 10 Back Volume years (vols. 239-910): EUR 35'840 / USD 38'420 (Option 4)

Benefits to libraries: • Outright purchase • Perpetual access rights • Multiple concurrent users • Long-time preservation • COUNTER-compliant usage statistics • Pick & Choose licensing options as well as

Share:

Package options. • 24/7 access on www.scientific.net • Freedom to use offline or print • Advanced search options

Please contact us for all subscription options, including access to backvolumes, multisite & archival licensing at subscriptions@scientific.net

DISTRIBUTION & ACCESS

FOR PUBLICATION

INSIGHTS

DOWNLOADS

ABOUT US

POLICY & ETHICS

CONTACT US

IMPRINT

PRIVACY POLICY

SITEMAP

ALL CONFERENCES

ALL SPECIAL ISSUES

ALL NEWS

1 item

Registration Log In

Search

Journals

Books

Topics

All Books

Materials Science

Building Materials

General Engineering

Mechanical Engineering

Bioscience and Medicine

Manufacturing

Electronics

Construction

Civil Engineering

Mechanics

Nanoscience

Computers

Information Technologies

Transportation

Industrial Engineering

Environmental Engineering

Special Book Collections

Foundations of Materials Science and Engineering

Scientific Books Collection

Scientific Books of Abstracts

Specialized Collections

Retrospective Collection

Urgent Problems of Up-to-Date Mechanical Engineering

Description:

Collection of selected, peer reviewed papers from the International Conference “Urgent Problems of Up-to-Date Mechanical Engineering”, UTI TPU, December 11-12, 2014, Yurga, Russia.
The 133 papers are grouped as follows:
Chapter 1: Materials Science in Mechanical Engineering;
Chapter 2: Metal Processing in Mechanical Engineering;
Chapter 3: Designing and Modelling of Machines and Mechanisms;
Chapter 4: Mechatronics, Automation and Control;
Chapter 5: Industrial Engineering and Environmental Research

Access through your institution

Purchase this book:

eBook 978-3-03826-949-6	198,00 €
Print 978-3-03835-483-3	347,00 €
eBook+Print 978-3-03835-483-3	436,00 €

*** 1-User Access (Single User-Price). For Multi-User-Price please fill a contact form**

Info:

eBook:	**View eBook preview**
ToC:	**Table of contents**
Editors:	**Dr. Dmitry A. Chinakhov**
DOI:	**https://doi.org/10.4028/b-NlpP3r**
BIC:	**TBC**
BISAC:	**TEC000000**
Keywords:	**Automation, Control, Designing, Environmental Research, Industrial Engineering, Materials Science, Mechanisms, Mechatronics, Metal Processing, Modelling of Machines**
Details:	**Selected, peer reviewed papers from the International Conference “Urgent Problems of Up-to-Date Mechanical Engineering”, UTI TPU, December 11-12, 2014, Yurga, Russia**
Pages:	**776**
Year:	**2015**

ISBN-13 (softcover): 9783038354833

ISBN-13 (CD): 9783038592648

ISBN-13 (eBook): 9783038269496

Permissions: Request Permissions

Share:

Review from Ringgold Inc., ProtoView: The 133 papers discuss materials science in mechanical engineering; metal processing in mechanical engineering; designing and modeling machines and mechanisms; mechatronics, automation, and control; and industrial engineering and environmental research. Specific topics include electrochemical research on multi-layer corrosion resistant material, the influence of melting technology and out-of-furnace treatment on the composition of non-metallic impurities in rail electric steel, the mathematical modeling of the dynamics of a two-mass gear system with considerations of shaft compliances, and using information systems for socio-economic management applications in mechanical engineering enterprises.

Ringgold Subjects:

— Engineering
— Materials science
— Mechanical engineering

ALL NEWS

ISBN(softcover): 978-3-03835-483-3 ISBN(eBook): 978-3-03826-949-6

Table of Contents

Chapter 2: Metal Processing in Mechanical Engineering

Chapter 4: Mechatronics, Automation and Control

Chapter 5: Industrial Engineering and Environmental Research