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Identification Of Investigation Procedures To Predict Work Roll Fatigue For Developing Machine Learning Applications – A Systematic Literature Review

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Abstract

Machine learning approaches present significant opportunities for optimizing existing machines and production systems. Particularly in hot rolling processes, great potential for optimization can be exploited. Radial-axial ring rolling is a crucial process utilized to manufacture seamless rings. However, the failure of the mandrel represents a defect within the ring rolling process that currently cannot be adequately explained. Mandrel failure is unpredictable, occurs without a directly identifiable reason, and can appear several times a week depending on the ring rolling mill and capacity utilization. Broken rolls lead to unscheduled production downtimes, defective rings and can damage other machine parts. Considering the extensive recording of production data in ring rolling, the implementation of machine learning models for the prediction of such roll breaks offers great potential. To present a comprehensive overview of the potential influencing factors which are possibly relevant to the lifetime of mandrels, a systematic literature review (SLR) focusing on work roll wear in hot rolling processes is conducted. Based on the results of the SLR, a first selection of features and the used investigation procedures are presented. The insights can be used for the prediction of mandrel failure with machine learning models in further work.

Keywords

Radial-Axial Ring Rolling; Work Rolls; Fatigue; Systematic Literature Review; Machine Learning;

1. Introduction

Seamlessly formed, ring-shaped components with high required specifications, such as highly dynamic load capacity and high product variability, are necessary for many machines and systems in all branches of industry. Typical areas of application are rail transport, aerospace, the automotive industry, plant and energy plant engineering, and special machine construction. Radial-axial ring rolling (RARR) (see Figure 1) is an important process for the production of such components.[1] A currently not sufficiently explainable failure in the domain of RARR is the failure of the mandrel, which occurs unpredictably and without a directly identifiable reason. The large amount of influencing factors (e.g. rolling temperature, rolling pressure, rolling material)[2], which also have non-linear interdependencies, hinders the use of proven research methods to identify qualitative and quantitative influences that are related to failure.[3] In this context, machine learning algorithms offer a new approach for identifying and weighting the influencing factors and predicting the remaining lifetime of the mandrel. It has already been demonstrated by Fahle et al. that machine learning models are suitable for applications in the field of RARR.[4] Furthermore, comprehensive data recording is

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already available in many industrial companies, which is a basis requirement for the implementation of machine learning applications.[5]

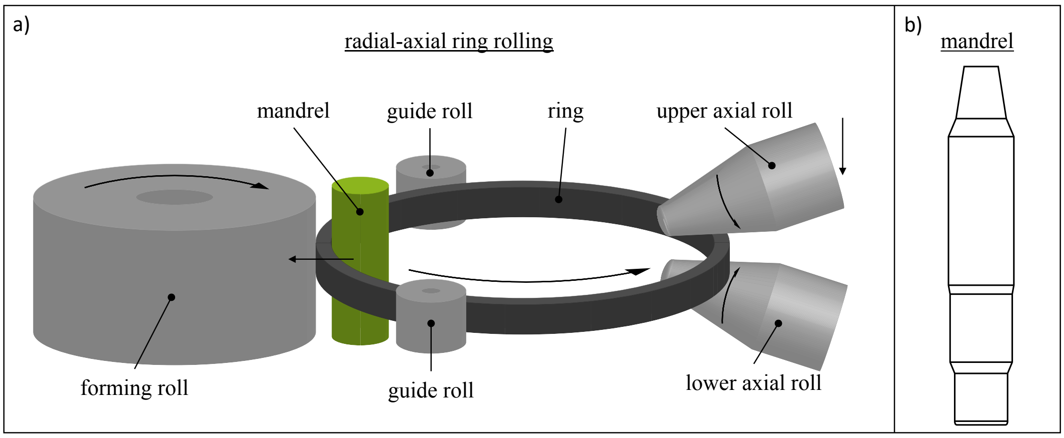

Figure 1: a) Scheme of the RARR process; b) illustration of the mandrel

To exploit the potential of machine learning algorithms effectively, it is beneficial to gain a fundamental domain knowledge about the conventional investigation procedures. However, given the limited availability of publications pertaining to the field of RARR, which were also included in this systematic literature review, it is not feasible to establish a scientifically robust investigation exclusively from the domain of RARR. Consequently, the scope of this study is broadened to encompass the broader domain of work rolls in hot rolling. In this field, it is well known that the service life of work rolls is mainly influenced by thermal stress, mechanical stress and wear. Consequently, the objective of this scientific paper is twofold. Firstly, a systematic literature search will be conducted which aims to classify the used research procedures and their limitation to investigate hot work roll wear. Second, the identified publications will be reviewed for potential capabilities in predicting work roll life. By accomplishing these goals, this study establishes a solid foundation for a well-informed machine learning application.

2. Structured Review Methodology

This chapter describes the literature search phase for the presented literature selection in Appendix 1. The literature selection was conducted using a combined approach by vom Brocke et al. [6] and Cooper [7] with the primary focus of identifying all relevant studies dealing with the investigation of factors affecting the wear and fatigue of work rolls in hot rolling. In addition, the approaches in the selected articles were examined for their ability to predict work roll life.

The Scopus database was used for the literature search as it provides a comprehensive international literature database from different research areas. The search was conducted in July 2023 using the search string shown in Figure 2 with the aim of presenting a literature review that was as comprehensive as possible in terms of the topic while still limiting the number of results to a controllable quantity. Specific filters were used to exclude irrelevant articles. The filters limited the search results to articles written in English or German, to articles from the subject area Engineering or Material Science and the document type Article or Conference Paper. Since many of the articles are dealing with the wear of bearings, rail wheels, gear, or cold rolling, these were also filtered out using keyword limitation.

Working Roll		**Defect**
TITLE(*rolling* OR roller OR "rod mill" OR "working roll*" OR "*strip mill*" OR rarr OR mandrel)	**AND**	TITLE(damage* OR crack* OR defect* OR failure OR fatigue OR wear)

Figure 2: Search string

The search results as well as the outcomes of each filtering stage are shown in Figure 3. After performing all filtering stages, the initial number of 2,566 articles were reduced to 59. The selection of literature was limited to papers in which, firstly, the work rolls themselves are made of metallic material and, secondly, metallic materials are formed. Furthermore, the work rolls must perform forming work. This also includes backup rolls of strip steel mills, as they make an active contribution to the forming of the rolled material. Centering rolls, which mainly have a stabilizing role and do not contribute to the actual forming, are not considered. The effects of applied lubrication are also not considered since they play a minor role in the domain of RARR. Moreover, some studies were not considered, because it was not possible to clearly determine the influence factor for the defect that occurred. In addition, the selection has been reduced by papers where the conditions for increased wear of the work roll are not related to the forming process but to the manufacture of the work roll (e.g., development of internal stresses due to previous heat treatment of the working roll), as well as by papers where only the abstract, but not the full text, is available in English. Furthermore, in the case of a few papers, despite great efforts, it was not possible to gain access to the full paper.

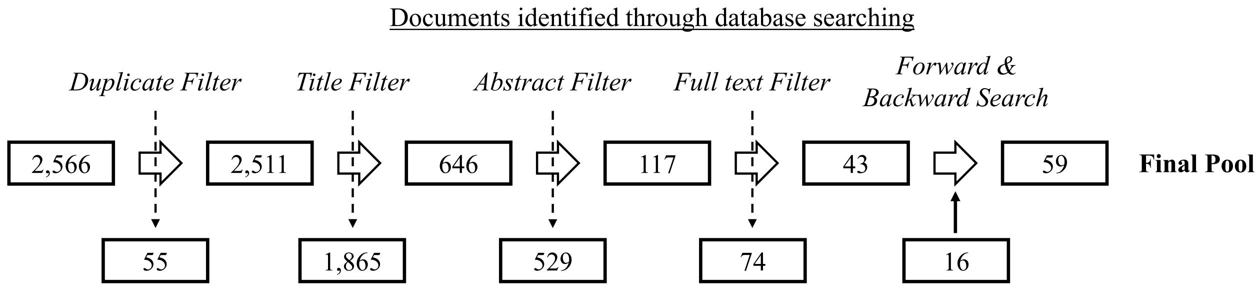

Figure 3: Levels of the systematic literature review

3. Summary of the Literature Review

3.1 Dimensions of the Analysis

In the following, the publications from the final pool are inspected in more detail. A list of the identified articles can be found in Appendix 1. The publications were divided into different categories in the areas of examined *influencing factors,* used *investigation procedure* and *investigation objective*. In the area of investigated *influencing factors,* a distinction is made between the categories *temperature*, which describes the effects on the rolls triggered by the high process temperatures, *material stress*, where the focus is on the forming forces required in the process and the associated stresses on the rolls, *material*, which inspects the material behavior, *process factors*, in which process variables, as well as influences of the system control and product properties are taken into account, and *roll design*, which describes the effects of different roll forms on wear. Within the area of *investigation procedure*, a distinction is made between *Simulation Approach, Experimental Approach, In-situ Analysis and Post process Investigation*. A closer description of the individual areas is given in the subsections of section 3.2. A more detailed look is also taken at the *investigation objective*. A distinction is made between a focus on general *wear* and a focus on the *end of service* of work rolls. End of service in this context means that either the roll has a defect which prevents the roll from being reused or the roll must be reworked within a maintenance. If the article focuses on the end of service, it is also checked whether methods for *predicting the end of service* are considered.

3.2 Publication Metadata Analysis

To identify trends and research priorities, an analysis of the metadata was carried out regarding the areas introduced above. In Figure 4, it is evident that the focus of research efforts is on simulation approaches and the application of an experimental approach, while the integration of in-situ analysis and the category post process investigation remains comparatively limited. In addition, the general importance of the topic is highlighted by the continuously increasing number of publications over the years. The limited number of articles in the years 2020-2023 can be justified by the fact that articles are often entered late in the databases and the year 2023 was not completed at the time of the literature search.

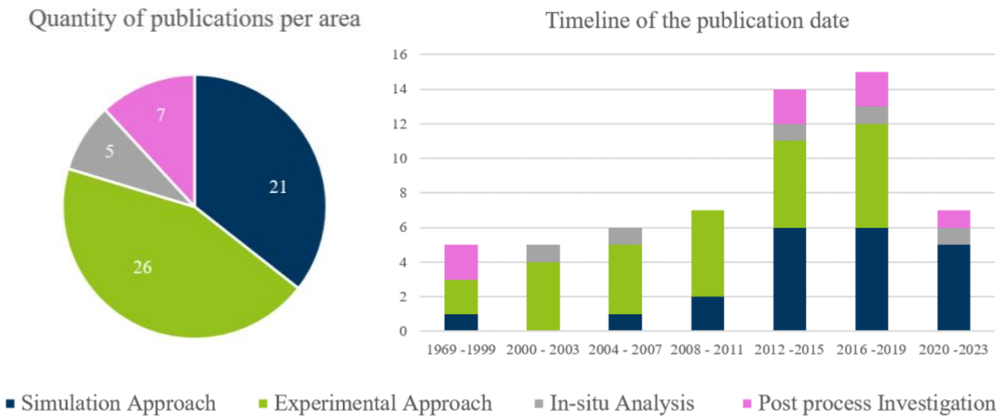

Figure 4: Superficial article analysis

Furthermore, with exception of the influencing factor roll design, all other categories in the articles were investigated with the same frequency (between 22 % and 26 %). The same applies to the investigation objective of the articles. 31 articles focus on the wear of the work rolls while 28 articles focus more on the end of service of the rolls. Six of the 28 articles also introduce new ways to predict end of service.

3.3 Summary of the Literature Review

In the following section, the publications identified by the literature review (see table in Appendix 1) are examined regarding the analyzed influencing factors within each publication. The articles are grouped according to the employed investigation approach. If a publication could be assigned to more than one investigation procedure, the one that accounts for the largest part of the paper was chosen. The respective category is highlighted in the table in Appendix 1. The assigned categorization can also be taken from the table. Due to page limitations, the publications are summarized briefly in the assigned categories. Nevertheless, all articles have been analyzed in detail and are referenced for further interested parties.

3.3.1 Simulation Approach

The category Simulation Approach includes all articles that deal with the development of models to replicate the wear and failure behavior of the work rolls without using real world data in the first place to create the model.

For this purpose, Dong and Cao created a finite element method (FEM) model that analyses the contact behavior of asperities in the strip mill. Especially in the asperity areas, increased stresses could be found, which support crack initiation and propagation.[8] Furthermore, Wu et al. developed an edge contact model to account for the time-varying contact strength of the surface of rolls. Through this work, a deeper understanding of the correlation between the vibration characteristics of rolls and roll wear could be generated.[9] A three-dimensional model dealing with the stress behavior of high-chromium work rolls was developed by Masoudi et al. Based on the stress behavior, the crack growth behavior can be modeled and the life of the roll can be predicted.[10] Further research regarding the possibility of calculating the service life of rolls was presented by Hu et al. Here, the thermoelastic and plastic behavior of high-speed steel (HSS) rolls were analyzed. The occurring residual stresses induced by thermal and mechanical influence were investigated by means of a FEM-Model, which allows to calculate the service life up to crack initiation on the rolls.[11] A FEM model for the development of internal fatigue fractures in bimetallic rolls induced by mechanical stresses is presented by Aridi et al.[12] The development of a model for the prediction of elliptically occurring cracks and fatigue phenomena in work rolls in continuous casting processes, which could be evaluated using FEM and experimental data, was presented by Tolcha et al.[13] Negahban Boron et al., on the other hand, investigated the effects and stress development triggered by thermal or mechanical loading or a combination of both types of loading in mandrel and main rolls in the RARR area. For this purpose, a FEM-Model was developed which reflects the stress behavior in the rolls.[14] For the investigation of thermal crack growth, Fedorciuc – Onisa and Farragia performed a FEM analysis, which can estimate roll life in terms of thermal fatigue.[15] Lundberg and Gustafsson developed a heat transfer model to determine thermal stresses based on the wear and friction behavior of rolling materials.[16] A model which is used to predict fatigue damage to backup rolls in strip mills is listed by Yuan et al. Based on the contact stresses that occur and taking into account the non-uniform wear of the rolls, fatigue phenomena can be predicted after the rolled material is fully formed.[17] Traino et al. developed a finite difference method (FDM) approach to predict the wear rate in strip rolling mills considering the friction path and the friction force in the deformation zone.[18] Song et al. developed a wear law by means of theoretical analysis and creation of FEM -Models to calculate the wear behavior of quenched and tempered rolls in the strip mill, which are mainly characterized by increased wear due to lack of lubrication and oxidation. The model was evaluated and verified in practice.[20,19] A development of a FEM-Model to investigate the wear load in hot strip mills for roll shifting strategies and changing rolling schedules was presented by Cao et al.[21] The investigation of rolling force and roll speed with respect to their influence on the wear of mandrel rolls was studied by means of FEM simulation by Behrens et al. In addition, the influence of lubrication was also investigated, although this is estimated to be low.[22] A consideration of roll wear in strip rolling mills, considering existing process factors and roll geometries, was carried out by both Guo et al. and Liu et al. Guo et al. also considered the existing roll geometry, roll material and friction coefficients.[23] Liu et al., on the other hand, considered the prevailing temperatures to calculate the wear rate.[24] An evaluation and comparison of different models for calculating and predicting the wear behavior in hot strip mills was presented by Souto et al. The models consider material hardness, material and roll geometry, and applied forces. Subsequently, the approach with the best results was implemented in an artificial neural network, again resulting in an improvement.[25] Qin et al. developed a theoretical model for damage development on backup rolls, taking into account the periodic reworking of the roll surface after its use.[26] A simulative consideration of abrasive wear caused by an oxidation layer forming on the surface of HSS rolls was developed by Phan et al. using the discrete element method.[27]

3.3.2 Experimental Approach

The Experimental Approach is concerned with the study of publications in which experimental studies were carried out either by means of test setups (e.g., twin disk rolls) or in the actual rolling mill.

Li et al. investigated the effects of temperature, rolling force and slip on the wear rate of HSS rolls used within strip rolling mills. The investigations were carried out by means of a self-developed test setup.[28,29] An investigation of different roll materials with respect to their wear behavior was implemented by Pelizzari et al. Within a twin disk roll test setup, high alloy HSS, cast iron and indefinite chill iron were analyzed. For the evaluability, a disk made of unalloyed C40 steel is heated to 700°C by induction and rolls against the sample with predefined contact pressure. In addition to the wear rate, the surface roughness of the specimens before and after the test run were determined.[30] The wear of HSS and nickel-grain iron based on the thermal fatigue property was analyzed by Ryu and Ryu. HSS showed much better fatigue properties in this case. The investigations were carried out by means of experimental setups as well as in the rolling mill.[31] To check the thermal fatigue and hot wear resistance of HSS materials, Tremea et al. developed two test setups that evaluated the specimens in terms of their correlation between the microstructure and the defects that appear.[32] Garza-Montes-de-Oca et al. studied the effects of the oxide layer on the wear rate on HSS rolls. Several tests were carried out at different temperatures and environmental conditions (water, both gaseous and liquid, and laboratory dry air). Due to the formation of a larger oxide layer, a higher wear rate occurred in the wet tests.[33] Based on the results, further studies were conducted regarding the formation of oxide layers and the emergence of cracks and spalling, taking into account the high-frequency thermal cycling of work rolls.[34]

Optimization of the thermal load was the focus of the research work by Raudensky et al. Temperature sensors were installed inside the roll and a relation was established between increasing roll speed and increasing heat flow. The knowledge gained enabled adjustments to be made in the rolling process, which led to a reduction in the peak temperature within the rolls.[35]

Some studies, which deal with the optimization of the roll material, could also be taken from the literature search. Zhang investigated the influence of deep rolling on the thermal fatigue performance of hot work tool steel.[36] Furthermore, Delaunois et al. examined various iron alloys regarding their suitability in rolling mills. Here, the focus was primarily on the characteristics of the developed oxide layers of the individual alloys. In particular, iron alloys which develop a fine oxide layer are suitable in rolling mills due to their low coefficient of friction.[37] Molinari et al. investigated the influence of matrix hardness in the thermal fatigue behavior of several HSS. The matrix hardness was varied by the tempering temperature.[38] Furthermore, Xiao-Feng et al. investigated the behavior of the hardness of Cr5 backup rollers under cyclic loading, where the hardness of the backup rollers decreases as the number of cycles increases and fatigue occurs.[39] Finally, a study by Flora et al. could be identified, which deals with the material behavior of 55NiCrMoV7, which is used as mandrel roll material in ring rolling mills. Different hardness grades were compared and evaluated with respect to their hot wear and thermal fatigue behavior.[40]

Other studies are concerned with the thermal fatigue behavior of work rolls. Ohkomori et al. investigated the occurrence of spalling on back-up rolls used within hot strip mills. The resulting spalling is due, on the one hand, to excessive contact stress at the roll ends and, on the other hand, to the thermal shocks experienced by the rolls.[41] Besides Sonoda et al investigated the cracking of high-speed steels using damaged work rolls. Experimental studies are presented for the identification of influencing factors, in which an independent consideration of mechanical and thermal cyclic loading took place. The main factor for crack initiation could be traced back to thermal stress. Crack growth, on the other hand, is significantly influenced by mechanical stresses.[42] Weidlich et al. calculated a coefficient for determining surface damage, taking into account cross-section reduction, material temperature and rolling speed. The coefficient correlates with the plastic strain of the rolls and can thus be used to determine service life. The design was developed using rolls from a pilot mill as well as industrial data.[43] A quantitative model to study the crack morphology of backup rolls mimicked by a twin-disc rolling machine was presented by Frolish et al.[44] An investigation of the backup roll of a steel strip mill was implemented by Dong et al. using FEM. Heterogeneous stress distributions lead to cracks and accelerate fatigue failure.[45] Based on the results, a more homogeneous distribution of contact stresses was aimed at and the geometry of the backup rolls was adjusted, thus reducing premature crack initiation.[46] Bombač et al. also conducted investigations on crack initiation in rolls due to cyclic heating. The investigation was carried out by means of a self-developed test rig, which heats a specimen conductively. The sample can be cooled in a controlled manner by means of a built-in cooling channel. Different temperature ranges were investigated, as well as different material compositions in a build-up study.[47,48] Drobne et al. investigated the fracture mechanics and fatigue crack growth of high chromium work rolls under thermal loading.[50,49] Belzunce et al. also analyzed the fracture toughness of rolled materials here the research focus was not only on thermal loading but also on mechanical loading.[51] Furthermore, Mercado-Solis et al. investigated the surface deterioration of HSS and carbon containing chromium steels. The study focuses on the progressive surface deterioration triggered by thermal fatigue. The investigation of the behavior of the steels is implemented by a standalone twin-disc simulation machine under conditions that are comparable to those of hot rolling of steel, which also takes into account cyclic thermal heating.[52] In addition, Akiyama et al. investigated the initiation of cracking due to thermal stress in mandrel rolls used to produce seamless rolled tubes. Real mandrel rolls were used for this purpose, but laboratory tests and FDM investigations were also carried out.[53] Further possibilities for the design of mandrel rolls were researched by Musa-Zade et al. The focus here was on adapting the geometry of the mandrel roller to reduce the wear rate.[54]

3.3.3 In-situ Analysis

In-situ Analysis contains publications that deal with the implementation of methodologies that monitor the wear of the work roll based on logger and production data in-situ during the process.

Two of these publications focus on determining the service life of the work rolls. Jiao et al. focused on calculating the remaining duration until the next maintenance of the roll. The prediction was based on neural networks that take into account the process factors of work rolls used in strip rolling mills.[55] Struin et al., on the other hand, dealt with the adjustment of control parameters to optimize the service life of mandrel rolls in tube mills.[56]

Other publications in the field of In-situ Analysis focus on the calculation wear rate of work rolls in different rolling mills. This includes the publication by Mohammed and Widell, which evaluated the possibilities of predicting the wear rate using two models. The focus was on the comparison of the two models regarding different rolling materials and stands in the strip mill. Industrial data as well as test campaigns were used for the investigation.[57] John et al., on the other hand, developed a roll force model which predicts the wear behavior of the work rolls in a strip mill on the basis of the available process factors.[58] Furthermore, a methodology for calculating the average friction wear rate of work rolls in hot strip mills was developed by Servin Castañeda et al. Process variables, the geometries of the rolls, and existing friction coefficients were considered. In addition, an evaluation using real-world data is presented.[59]

3.3.4 Post process Investigation

Post Process Investigation, publications were reviewed which examined the wear behavior of work rolls previously used in the rolling mill.

In this category, Nierkuziak and Kubinska investigated the wear behavior of work rolls in strip mills. Real-world process data and laboratory tests were considered for the analysis. This made it possible to calculate the wear rate of the rolls in use and to optimize the selection of roll materials for different production lines.[60] Investigations focusing on the assessment of the topography of rolls in plate mills were carried out by Bataille et al. Here, the main focus was on abrasive and adhesive wear as a function of rolling time.[61] Dobrik and Moiseenko, on the other hand, investigated under which conditions the treatment of work rolls by means of friction hardening contributes to an increase in service life.[62] Colás et al. investigated wear phenomena in work rolls using a scanning electron microscope. Colás et al. attributes the wear fatigue that occurs here to thermal fatigue and contact stresses that occur. The oxidation inside the cracks accelerates the wear rate.[63]

In addition, Palit et al. describes in a case study the breakage of two rolls in use, which can be attributed to different failure cases. Both failures indicate insufficient roll quality. The roll failure was attributed to an unsuitable microstructure and a defect caused in the manufacturing process.[64] Furthermore, broken work rolls were checked by ultrasonic measurement. The crack initiation was caused by exceeding the shear strength.[65] Another case study was carried out by Sinha et al. Here, the failure of an ICDP work roll, which was in use in a strip mill, was investigated. It was found that the extensive spalling that occurred on the roll surface was caused by a weak shell-core bond.[66]

4. Conclusion

Radial-axial ring rolling (RARR) is an important process to produce ring-shaped components across various industries. This study aimed to contribute to the understanding of mandrel failure to develop machine learning based approaches for failure prediction in further research. For this, a systematic literature review examined the current state of the art of publications, which dealt with the identification of influencing factors for determining the fatigue behavior of work rolls in hot forming. The analysis revealed that this field is attaining higher interest in recent years. An overview, of the results as well as the influencing factors analyzed in each publication, can be obtained from the table in Appendix 1.

In conducting this work, two major research gaps were uncovered that offer potential for future research. First, the articles found, mainly focus on optimizing the service life of the work rolls. Here, all influencing factors except for the roll design are equally researched. Optimization is mainly implemented by optimizing material properties and control parameters or avoiding errors in production. Prediction of service life is addressed in only a few research papers. In conjunction with online prediction, there is only one research paper that explores the possibility of predicting maintenance timing in strip mills. Jiao et al. applied neural networks to predict the remaining time until the maintenance of the roll.[55] However, transferability to RARR is not possible due to significant process differences. Hence, suitable methods for the prediction of the service life with consideration of production scheduling are still missing. A reliable prediction of the service life of work rolls in the domain of RARR could optimize the production system as a whole so that the coordination of upstream and downstream production steps can be enhanced while avoiding downtimes.[67] Besides, developing the capability of accurately predicting the lifetime of mandrels could also enable manufacturers of RARR machines to adopt data-based service activities and embrace innovative business models such as Product-Service Systems.[68] Second, our study revealed that there is only one additional article that deals with the field of machine learning algorithms. Souto et al. uses neural networks to improve already existing models for calculating and predicting wear behavior.[25] Nevertheless, none of these machine learning algorithms were specifically focused on the domain of RARR. This indicates that the potential of machine learning algorithms to identify influencing parameters within the RARR domain still remains unexplored, although a sufficient data infrastructure for employing machine learning already exists.[5]

In addition, due to the challenges of measuring various influencing factors in real processes, such as temperature distribution [16,35] or heterogeneous mechanical stress distribution (e.g. [8,45,46]) besides the costly implementation of measurement setups in industrial plants, many studies are using simulations or experimental approaches (see Figure 4). In this context, machine learning algorithms offer a promising approach for industrial research, as they allow the inclusion of significant influencing factors without direct measurements. This is achieved by extracting relevant information from other measurable variables with known correlations and then inferring the non-measurable information.

Based on the research results presented here, in further research, it will be the main focus to investigate the suitability of machine learning algorithms for the prediction of the service life to fracture of mandrels. In particular, the thermal and mechanical influences will be in the foreground. Due to the removal of finished rolled rings and the loading of the line with new blanks, downtimes occur after each rolling operation where the mandrel can cool down. For this reason, emphasis is placed on the number and characteristics of the thermal heating cycles. The machine learning model can acquire knowledge about the mechanical stress of the rolls by incorporating the forming forces, prevailing forming rate, and the material composition of the rings. This integration enables the machine learning algorithms to gain valuable insights into the process factors, thereby minimizing information redundancies right from the outset.

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Appendix

Appendix 1 Results of the systematic literature review

Legend:
- ● : Contains elements of the category
- ○ : Contains elements of the investigation procedure though it is not the main focus
- ✓ : Contains elements of predicting end of service

	Influencing Factors					Investigation Procedure				Investigation Objective		
Author	Temperature	Mechanical Stress	Material	Process factors	Roll design	Simulation Approach	Experimental Approach	In-situ Analysis	Post process Investigation	Wear	End of service life	Predict end of service
Akiyama et al. (2000) [53]	●		●			○	●		○		●	
Aridi et al. (2022) [12]		●	●			●			○		●	
Bataille et al. (2016) [61]			●						●	●		
Behrens et al. (2014) [22]		●		●		●				●		
Belzunce et al. (2004) [51]	●	●	●				●			●		
Bombač et al. (2017) [48]	●						●				●	
Bombač et al. (2019) [47]	●		●				●				●	
Cao et al. (2011) [21]			●	●		●				●		
Colás et al. (1999) [63]	●	●	●						●		●	
Delaunois et al. (2018) [37]			●				●			●		
Dobrik and Moiseenko (1984) [62]									●		●	
Dong et al. (2015) [45]		●					●				●	
Dong et al. (2015) [46]		●			●		●				●	
Dong and Cao (2015) [8]		●		●		●				●		
Drobne et al. (2014) [50]		●					●				●	✓
Drobne et al. (2017) [49]		●					●				●	
Fedorciuc - Onisa and Farragia (2008) [15]	●					●						
Flora et al. (2009) [40]	●			●			●				●	
Frolish et al. (2002) [44]		●	●	●			●			●		
Garza-Montes-de-Oca and Rainforth (2009) [33]	●		●				●			●		
Garza-Montes-de-Oca et al. (2011) [34]	●		●				●			●		
Guo et al. (2012) [23]				●		●				●		
Hu et al. (2019) [11]	●	●	●			●				●	●	✓
Jiao et al. (2021) [55]	●	●		●				●			●	✓
John et al. (2006) [58]				●				●			●	✓
Li et al. (2002) [28]	●			●			●			●		
Li et al. (2008) [29]	●			●			●			●		
Liu et al. (2017) [24]	●			●	●	●				●		
Lundberg and Gustafsson (1994) [16]	●		●			●	○			●		
Masoudi Nejad et al. (2021) [10]		●				●	○				●	✓
Mercado-Solis et al. (2005) [52]	●		●	●			●			●		
Mohammed and Widell (2003) [57]				●				●	○	●		
Molinari et al. (2005) [38]	●		●				●			●		
Musa-Zade et al. (1969) [54]					●		●				●	
Negahban Boron et al. (2022) [14]	●	●	●			●					●	
Niekurzak and Kubinska (2022) [60]				●					●		●	
Ohkomori et al. (1988) [41]	●	●					●				●	
Palit et al. (2015) [64]			●						●		●	
Palit et al. (2019) [65]				●					●		●	
Pellizzari et al. (2005) [30]	●			●			●			●		
Phan et al. (2017) [27]			●			●				●		
Qin et al. (2014) [26]		●	●			●					●	
Raudensky et al. (2013) [35]	●			●			●			●		
Ryu and Ryu (2003) [31]	●						●			●		
Servin Castañeda et al. (2014) [59]		●	●	●				●		●		
Sinha et al. (2014) [66]			●						●		●	
Song et al. (2018) [20]		●		●		●				●		
Song et al. (2018) [19]		●		●		●	○			●		
Sonoda et al. (2009) [42]	●	●					●		○		●	
Souto et al. (2022) [25]		●	●	●		●			○	●		
Struin et al. (2019) [56]				●				●		●		
Tolcha et al. (2019) [13]	●	●				●	○				●	
Traino et al. (2013) [18]		●				●				●		
Tremea et al. (2006) [32]	●		●				●			●		
Weidlich et al. (2019) [43]	●	●		●			●				●	
Wu et al. (2014) [9]		●		●		●				●		
Xiao-Feng et al. (2016) [39]		●	●	●			●				●	
Yuan et al. (2023) [17]				●		●					●	✓
Zhang et al. (2013) [36]	●						●			●		

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