GAUGE AND TENSION CONTROL DURING THE ACCELERATION PHASE OF A STECKEL HOT ROLLING MILL

by

Burkhard Heinrich Freyer

Submitted in partial fulfillment of the requirements for the degree
Master of Engineering (Electronic Engineering)
in the
Faculty of Engineering, Built Environment
and Information Technology

UNIVERSITY OF PRETORIA

November 2002

Abstract

Low investment cost and flexibility regarding its products make the Steckel mill an attractive option in steel rolling. A characteristic of this mill is its reversing type of operation, which is its main difference from multi stand mills. A Steckel hot strip rolling mill is considered for controller design purposes in this dissertation.

A nonlinear simulator of this process, modeled in [4], is used for the identification of linear models with a point of linearization during the acceleration phase of the mill. The linear models are identified for different cases simulated with and without gauge meter compensation and controlled tensions as part of the simulator. The system identification is accompanied by a heuristic justification of the data obtained.

A diagonal PID/PI controller as well as diagonal and MIMO H_∞ controllers, based on the linear models, are designed and implemented on the simulator.

From the system identification data for the different linear models it could be seen that gauge meter compensation successfully counteracts the adverse effect of mill stretch and eliminates an oscillatory influence of the tensions on the exit gauge of the strip. The results from simulations of the different controllers in closed loop with the nonlinear plant showed, that the requirements, specified for the controllers, are fulfilled by a diagonal controller and an H_∞ controller scheme designed for a linear model with nonzero transfer functions only on the diagonal. The latter H_∞ controller scheme, which includes gauge meter compensation and an inner loop tension control in the simulator is, among three controller schemes tested, found to be most suited.

Keywords

Steel making, hot strip rolling, Steckel rolling mill, system identification, acceleration phase, tensions, exit gauge, diagonal control, H-infinity control, gauge meter compensation

Opsomming

Lae bestedingskoste en buigbaarheid t.o.v. sy produkte maak die Steckel wals 'n aantreklike opsie onder staalwalsprosesse. 'n Kenmerk van hierdie wals is sy omkeer tipe bedryf, wat die hoof verskil is in vergelyking met walse met meervoudige raamwerke. 'n Steckel warm band wals proses word in hierdie verhandeling beskou met die oog op beheerderontwerp.

'n Nie-lineêre simulator van hierdie proses, soos in [4] gemodelleer, word gebruik vir die identifisering van lineêre modelle met 'n punt van linearisering gedurende die versnellingsfase van die wals. Die lineêre modelle is geïdentifiseer vir verskillende gesimuleerde gevalle, met en sonder diktemeter-kompensering en beheerde bandspannings. Die stelsel-identifikasie word vergesel deur 'n heuristiese motivering van die data wat verkry is.

'n Diagonale PID/PI beheerder sowel as 'n diagonale en 'n MIMO H_∞-beheerder, gebaseer op die lineêre modelle, word ontwerp en op die simulator geïmplementeer.

In die stelsel-identifikasie data kan gesien word dat diktemeter-kompensering die nadelige uitwerking van walsrekking suksesvol teëwerk en die ossillerende invloed van die bandspannings op die uitsetdikte elimineer. Die geslote-lus simulasieresultate met die nie-lineêre gesimuleerde aanleg het gewys, dat 'n diagonale beheerder en 'n H_∞-beheerder, wat ontwerp is vir 'n lineêre model met nie-nul oordragsfunksies slegs op die diagonal, aan die spesifikasies voldoen. Laasgenoemde H_∞-beheerder is onder die drie beheerstelsels, wat getoets is, die meeste geskik.

Sleutelwoorde

staal vervaardiging, warm band wals, Steckel wals, stelsel-identifisering, versnellingsfase, spannings, uitsetdikte, diagonale beheer, H-oneindig-beheer , diktemeter-kompensering

Acknowledgements

During the work on this dissertation Prof. Ian Craig guided me with constructive criticism and positiveness, which helped to focus on the project's essential aspects. I experienced our discussions as stimulating and thank him for this.

The time Prof. Chris Pistorius sacrificed to think through the rolling process and his helpful comments are highly valued. Communication with him was always fruitful.

A significant portion of my thanks I want to express towards Ernst Scholtz for answering numerous questions I had about the simulator. I appreciated that I could use such a detailed program of his.

In the Department of Electrical, Electronic and Computer Engineering there were people such as Prof. Yavin, Prof. Xia, Fernando Camisani and Leon Staphorst who gave me advice and information, I would not easily have found in literature, for which I want to thank them here.

This work will also remind me of the occasions I was given advice by colleagues, Elsa de Klerk, Kobus Oosthuizen, Rademeyer Vermaak, Pieter de Villiers, Paul Rathaba, Jerry Wang and Jacques Steyn.

Many of the personnel of this University, I have asked to help in one or other way, were always prepared to respond positively for which I am so grateful.

My father, brothers and sister supported me everyone in their own personal way during my studies. I am very thankful for this.

In particular I want to thank all friends and people here and in Windhoek that encouraged me and were interested in my work.

CONTENTS