Modelling for Control of a Steckel Hot Rolling Mill

by

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Abstract

Steckel hot rolling forms part of the larger steelmaking process. Steckel hot rolling is not the most common type of hot rolling mill, found in the industry. Steckel mills are normally associated with developing countries and are also very similar to cold rolling mills. The modelling aspect of this dissertation focuses on a practical investigated Steckel rolling mill, which is used in the production of stainless steel strip. Various types of rolling mills that can roll various shapes and dimensions of products are found in the industry, but only hot strip rolling is investigated in this dissertation.

In this dissertation models were identified in order to create a mill simulator that can adequately simulate Steckel rolling mill behaviour. The constructed simulator is able to simulate the thickness crown behaviour of the hot strip as well as the tension in the sheet while rolling. The simulator is not able to simulate the temperature, shape and flatness behaviour of the Steckel rolling process.

The mill simulator consists of a roll gap model, stand model, tension model as well as models accounting for the dynamics associated with the hydraulic actuators. The integration of these models in order to form the mill simulator, and the application of this simulator in an investigation of the interactions in the Steckel rolling mill process is considered a substantial contribution to the literature.

This dissertation forms the basis of a continuing research project, which aim is to apply a model based predictive control method, to regulate the centerline gauge and strip tension in the hot rolling mill. Tension control of the strip is normally associated with multistand hot rolling mills and little literature exists concerned with the tension and gauge interactions associated with the Steckel hot rolling mill process. This dissertation addresses this issue and the dynamic interaction is identified.

The nonlinear mill simulator was used to identify a linear model for control system design. The linear model was identified around a certain operating point associated with a certain pass of a multiple pass rolling schedule. Step tests were applied to the manipulated variables of the nonlinear mill simulator, and by doing system identification a linear time invariant multivariable transfer function model was derived.

Open loop simulation results were compared with time responses found in the literature and practical logged data as far as possible, in order to asses the performance of the mill simulator.

This dissertation ends with an initial control problem formulation and a discussion of how to implement the linear model in a Model Predictive Control (MPC) structure.

Keywords

steelmaking, hot rolling, Steckel rolling mill, dynamic modelling, system identification, control problem formulation, nonlinear, mill simulator, centerline gauge, tension, strip crown

Opsomming

Die Steckel warm walsingproses vorm 'n integrale deel in staal-vervaardiging. Dié wals is egter nie die mees algemene warmwals nie en word hoofsaaklik gebruik in ontwikkelende lande. Die wals is baie soortgelyk aan kouewalse. Die modellering in hierdie verhandeling is gebaseer op 'n praktiese Steckel warmbandwals wat gebruik word om vlekvrye staal band te produseer. Verskeie tipes walse wat verskillende vorme en groottes produkte kan rol bestaan; maar slegs warm band walsing word in hierdie verhandeling ondersoek.

Verskeie modelle is ondersoek om 'n wals-simulator op te stel wat die Steckel wals gedrag akkuraat naboots. Die simulator kan die dikte kroon gedrag en die spanning in die band voorspel. Temperatuur variasies, vorm en platheid word nie deur die simulator in ag geneem nie.

Die wals simulator bestaan uit walsgaping-, walsraamwerk-, en spanning modelle, sowel as modelle vir die hidrouliese aktueerders. Die koppeling en verband ondersoek, tussen die voorafgenoemde modelle word beskou as 'n groot bydrae to die literatuur.

Die verhandeling is deel van 'n navorsings projek wat ten einde sal poog om model gebaseerde voorspellings beheer te gebruik om middel dikte en band spanning in die warm wals te reguleer. Spannings beheer word gewoonlik geassosieer met veelvoudige stand warm walse en min literatuur bestaan oor die interaksie tussen spanning en dikte in die Steckel. Hierdie verhandeling beskou die dinamiese interaksie.

Die nie-lineêre simulator is gebruik om 'n lineêre model af te lei wat geskik sou wees om 'n beheerder vir die proses te ontwerp. Die lineêre model was afgelei om 'n werkspunt wat verkty is vanaf 'n tipiese verloop van die veelvoudige verloop wals skedule. Stap toetse is op die gemanipuleerde veranderlikes van die nie-lineêre wals simulator gedoen, en die resultate gebruik om deur middel van stelsel identifikasie 'n linieêre tyd invariante model te verkry. Ope lus tyd simulasie resultate is met die literatuur en praktiese data vergelyk om die doeltreffendheid van die simulator te ondersoek.

Die verhandeling eindig met 'n aanvanklike beheer probleem uiteensetting en bespreek die kwessies omtrent die gebruik van die lineêre model vir die toepassing van model gebaseerde voorspellings beheer.

Sleutelwoorde

staalproses, warmband walsing, Steckel wals, dinamiese modellering, beheerstelsel probleem formulering, nie-lineêre, wals simuleerder, middel plaat uitset dikte, aangelegde plaat spanning, plaat kroon

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