STRESS ANALYSIS AND OPTIMISATION OF ROLLING MILL HOUSING USING CAE
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Abstract

Based on Industrial practices, it has found that failure of housings of Cold Rolling Mills affect the cost of production drastically. The forces of rolling, which act on the rolls, are completely transferred on to the Housings. To sustain rolling forces, the housing of rolling stand requires high rigidity, sufficient strength for taking the loads, simplicity of design and minimum cost of production. In papers reviewing the design of rolling mill housing, they explained the load that comes on the rolls during the rolling operations and how it affects the bearing life. The calculations for the power required for rolling operation and the roll dimensions are also discussed. In papers Optimization methods are involved for the optimum design. ESO(Evolutionary Structural Optimization) method removes the elements that have lower design values (stress, strain energy, etc.) from the design domain and attaining the shape and topology of a more fully stressed structure is carried out. Such a process is carried out repeatedly until an optimum design is achieved. Also work on the design optimization of work roll chock and backup Roll chock in cold rolling mill controls the failure of choke in the cold rolling mill to retain the material cost and longer life of the roll chock. An essential aspect of the work is sensitivity analysis, which consists of computing derivatives of the functions which define the optimization problem. Proposed work described procedures for design sensitivity analysis and optimization of nonlinear structural system with the computer program vAdina. General mathematical programming method was described for structural sizing as well as for shape optimal design. The new method to optimize both the structural parameter and time-invariant control gains while including the effects of transient loads. A computer code was developed to solve the resulting equation and simultaneously solve for the optimal control gains and structural parameters.

Keywords: cold rolling, stress analysis, FEA, housing, rolls

1. Introduction

Rolling mill housing as shown in Fig. 1.1 [1] encloses supports and adjusts rolls in the correct position. The backup rolls serve to avoid to strong bending of the work rolls and are itself supported by the transverse and hydraulic backup roll bending (BURB) systems. The rolling mill housing should be so strong that even though the roll may breaks, the housing does not deform plastically as its cost of manufacturing and time of replacement is excessively high. The forces, which act on the rolls during rolling, are completely transferred on to rolling housing through the nut of the adjusting mechanism. In addition, there exists a tendency for the roll stand to turn as a result of the torques acting on the rolls, which get transmitted to the housing in case of bearing seizures or when rolls are unable to pass the metal due to lack of sufficient power. So, the housing of rolling stand requires high rigidity, sufficient strength for taking the loads and minimum cost of production.

Prasad Suresh Parab [1] described the cold rolling has defined as a process which reduces the cross sectional were the metal by forming at approximately at room
temperature with the help of pair of revolving rolls with plain barrels. Based on Industrial practices, it has found that failure of housings of Cold Rolling Mills affect the cost of production drastically. The forces of rolling, which act on the rolls, are completely transferred on to the Housings. To help address the needs of better rolling technology, presented Stress Analysis of Cold Rolling Mill Housing using FEA software (Solidworks). For validate Software’s results, they have made a prototype model of mill housing and strains are actually checked by applying proportional forces on it. Housings are elements in a rolling mill that enclose and support the chock assemblies; the adjusting mechanisms etc. and retain them in their proper position. Their construction and dimensions have to take into account the sizes of various other elements. To sustain rolling forces, the housing of rolling stand requires high rigidity, sufficient strength for taking the loads, simplicity of design and minimum cost of production. The present work involves the stress analysis of rolling mill housing, design for rigidity, to control the deflection of the housing for better gage control of the material being rolled. The Housing stress distribution has been analyzed using analysis software Solidworks from which maximum static stress at critical areas have been calculated, studying structural behavior of housing under the given loading and boundary conditions using analytical method was very difficult. Therefore 3D solid model was chosen to predict the stress and strain response details.

Firoj U. Pathan, Dr. Santosh N. Shelke [2] described the process of plastic deformation of metal by passing it through the rolls called as the metal rolling. Rolling has widely used forming process, which can have high production figures and precise control of final product. Rolling is classified in two major parts the cold rolling and hot rolling. Every part has its own theory, development of rolling process and subsequently the designing of the cold rolling mill components, like rolls and rolling mill housing. The aim of the present paper is to understand the various methodologies which are used to design the cold rolling mill. They have focused on the history of the rolling process; it is understand that the rolling process was adopted since year 1590. Although it was raw method but it initiated the slitting rolling mill and the actual experimentation were started from year 1670. In those days rolling was concerned with rolling of bars only after few years the rolling of bars were started. They also tried to discuss the earlier patents which were granted in 18th century and was related to the tandem mill which were using copper and brass as the rolling materials. In year 1783, after the entry of grooved rolls the rolling production increased up to 15 times and that was the start of modern rolling mill. While reviewing the design of rolling mill components our area of interest is to visit design of rollers and rolling mill housing. They have discussed the different parameters and factors that affect the roll design. The calculations for the power required for rolling operation and the roll dimensions are also discussed. In reviewing the design of rolling mill housing, they explained the load that comes on the rolls during the rolling operations and how it affects the bearing life. The rolling mill housing designed optimization has achieved by using
different Finite Element Analysis techniques and various experimentations for rolling mill housing structural analysis has also reviewed.

Fatih Mehmet [3] described the evolutionary structural optimization (ESO) method has been presented by Xie and Steven in 1993 to deal with numerical structural topology optimization problems. Although ESO has appeared on a simple foundation, many contributions have been made by many researchers up to now. ESO has an algorithm sometimes defined as intuitive - which has running by removing the elements that have lower design values (stress, strain energy, i.e.) from the design domain and attaining the shape and topology of a more fully stressed structure. Such a process is carried out repeatedly until an optimum design is achieved and final decision is made by evaluating the applicability of the last design formed after the process. That study is based on the general aspects of ESO to give information about the development and a clear explanation of the ESO procedure. Also two examples that have part in the literature have been presented to demonstrate the capability of this method.

Dr. Santosh S. Shelke, Firoj U. Pathan [4] described the Rolling has defined as a process in which metal has formed through a pair of revolving rolls with plain or barrels with different shaped grooves. The metal converts its shape during the period in which it is in contact with the two rolls. Rolling has a major and a most widely used mechanical working technique. A Rolling mill has a complex machine for deforming metal in rotary rolls and performing auxiliary operations such as transportation of the stocks to the rolls, disposal of metal after the rolling operation, cutting the metal strips, metal strip cooling, melting. The problem of failure of Rolling mill housing was there in industry, which can be efficiently solved by using CAE. That present work involves the design optimization of work roll chock and backup Roll chock in cold rolling mill, to control the failure of choke in the cold rolling mill for retain the material cost and longer life of the roll chock. The roll chock had stress distribution has been analysis by software ANSYS from which maximum static stress at critical areas have been calculated. Structural behavior of Roll chock under the given loading and boundary conditions using an analytical model are very difficult. Therefore 3D solid model was chosen in order to predict the stress and strain response detail. They have made a prototype of chock of optimized design of scale so as to verify our results that have been given by the analysis of work roll chocks and backup roll chock on analysis software.

Arif S. Malik [5] presented a new computational method for predicting the static cross-sectional thickness profile of rolled metal strip. Methods to model the strip profile and related flatness with improved efficiency and accuracy remain central for achieving high quality flat-rolled products. The new method involves a novel combination of Timoshenko beam finite elements with multiple coupled Winkler elastic foundations. It applies to simple mill configurations, such as the common 4-high rolling mill, in addition to complex mill types, such as the 20-high Sendzimir mill. The inherent benefits over traditional strip profile models include non-discrete elastic foundations, cubic displacement fields, rapid solution, and mixed boundary conditions. The flexible nature of the model allows it to readily accommodate typical mechanisms used in industry to control strip profile, such as roll crowning, roll bending, roll shifting, and roll crossing. Comparison of the predicted displacement for a 4-high mill with that obtained using a large-scale finite element simulation provides validation of the presented strip profile calculation method for real-time industrial applications.

V. Oduguwa [6] discussed Rapid product development and efficient use of existing resources are key competitive drivers in the steel industry and it is imperative that solution strategies are capable of delivering high quality solutions at low cost. However,
traditional search techniques for Rolling System Design (RSD) are ad hoc and users of them find it very difficult in satisfying the required commercial imperatives. This paper presents a comprehensive review of approaches for dealing with RSD problems over the years in terms of modeling and optimization of both quantitative and qualitative aspects of the process. It critically analyses how such strategies contribute to developing timely low cost optimal solutions for the steel industry. The paper also explores the soft computing based technique as an emerging technology for a more structured RSD optimization. The study has identified challenges posed by RSD for an algorithmic optimization approach, especially for evolutionary computing based techniques.

Xing-guo Hu [7] At present, for topological optimization in multiple load cases, many researchers use directly traditional Evolutionary Structural Optimization method to get respectively the inefficient material set that should be removed in each load case, then the intersection of all the sets is just the material that should be removed. This Multiple Load Cases Traditional is difficult to optimize a structure subject to complex load cases, and the optimization result may not be reasonable. Modified Rejection Ratio for Multiple Load Cases Evolutionary Structural Optimization proposed in this paper makes a change based on the Modified Rejection Ratio for Multiple Load Cases Evolutionary Structural Optimization. The major change is to modify the rejection ratio of each load case according to the ratio of the total strain energy of a structure subject to each load case to the total strain energy of a structure subject to all load cases, then optimization for a structure subject to complex multiple load cases can be easily made and the structure obtained from such an optimization has a good undertaking force performance.

Rajkumar Roy [8] Traditional engineering design optimization which is the process of identifying the right combination of product parameters is often done manually, time consuming and involves a step by step approach. This paper identifies recent approaches to automating the manual optimization process and the challenges that it presents to the engineering community. Engineering design optimization is classified based on design evaluation effort and degrees of freedom viewpoints. An overview of different approaches for design optimization is presented. The study identifies scalability as the major challenge for design optimization techniques. Large-scale optimization requires significant computing power and efficient algorithms such as swarm intelligence.

Liyong Tong, Jiangazi Lin [9] described a novel formulation for structural topology optimization in which both cost function and constraints were expressed in terms of an implicit design variable the iso-line/surface threshold of a characteristic response function, such as a strain or mutual strain energy density function. A new material representation model is developed to implicitly describe material usage in a given design domain in terms of one implicit design variable. Based on the Karush Kuhn Tucker(KKT) necessary conditions, optimality criteria for finding solutions are established and then employed to develop a simple algorithm for one-material minimum mean compliance and compliant mechanism problems. The algorithm consists of sequentially moving iso-surface threshold(MIST) of chosen characteristic response function. Numerical examples were then presented to validate the proposed algorithm MIST for the minimum mean compliance, compliant mechanism, and fully stressed design problems.

Rafael Febres [10] described a model of the behavior of metallic structures subjected to flexural effects has proposed. The model focuses on the description of failure due to local buckling. It has assumed that the main inelastic phenomena involved in the process: plasticity and local buckling, can be lumped at inelastic hinges. The model takes into account that in planar...
frames, two local buckling can appear in the plastic hinge region: one due to a positive moment the other
one related to a negative moment. The elastic behavior of frame members with two local buckling has assumed
as unilateral. The plastic behavior is described using the concept of equivalent moment on a damaged plastic
hinge. A new hypothesis, that authors have called ‘‘counter-buckling’’, has introduced. The counter-
buckling concept states that as a consequence of the evolution of one local buckling, the other one results
partially blocked. The notion of counter-buckling has used to describe local buckling evolution during cyclic
loadings. Finally, the model has verified through the numerical simulation of several experimental tests on
frame members and framed structures.

K. G. Mahmoudt [11] described the widely recognized that structural optimization using mathematical
programming techniques can be employed efficiently only in conjunction with explicit approximate
models. In this work an efficient optimization methodology combining a finite element-based
approximate analysis model, a sequential quadratic programming algorithm incorporating an active set
strategy and a direct method of design sensitivity analysis is developed. The methodology involves the
solution of a sequence of explicit high-quality approximate problems subject to given move limits in
the design space. A new technique for constructing approximation functions with a high quality adaptive
capability to the original functions has proposed by using the values of the state variables (displacements
and/or stresses) and their derivatives at points obtained in the process of optimization. Other approximation
techniques have been presented and comp generality of the approximation concepts in structural optimization.

Kurt Maute, Michael Raulli [12] described an interactive method for the selection of design criteria and the
formulation of optimization problems within a computer aided optimization process of engineering systems. The
key component of the proposed method is the formulation of an inverse optimization problem for the
purpose of determining the design preferences of the engineer. These preferences are identified based on an
interactive modification of a preliminary optimization result that has the solution of an initial problem
statement. A formulation of the inverse optimization problem is presented, which has based on a weighted-
sum multi-objective approach and leads to an explicit optimization problem that has computationally
inexpensive to solve. Numerical studies on structural shape optimization problems show that the proposed
method has able to identify the optimization criteria and the formulation of the optimization problem which drive
the interactive user modifications.

Conclusion:
The present paper tries to review on functioning of cold rolling mill housing & history of the rolling process.
There is failure of housing because complete load transfer to the housing from rolls. Stress analysis of
Cold Rolling Mill using FEA software like Solidworks & ANSYS is used to find out results at critical areas. Also
different methods are suggested to optimize the design of work roll chock & backup roll chock by using
software and mathematical programming techniques & ESO method is provided for topology optimization.

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