Structural Optimization of a Transversal Rolling Mill Component to Improve Flexional Stiffness

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Summary

Company Overview
Process Cycle Description
Model - Analysis
Optimization scheme
Results
Company Overview - Tenaris (at 31-12-2009)

**Sales:** 8 bilions $

**Employees:** 22,500

**Seamless pipes:** 3,400,000 t

**Welded pipes:** 2,700,000 t

Production and commercial offices in more than **15** Countries
R&D center TenarisDalmine

Tenaris has 4 R&D centers:

**Argentina**  Steel making and OCTG products

**Japan**      High Cromium steel

**Mexico**     Welding processes - linepipe

**Italy**      Rolling processes, mechanical thermal application

**R&D Center Dalmine**

- 25 researchers (40 researcher capacity)
- 68 laboratory technicians
- 2,800 square meters surface
- 1,000 special test every year
- 530 standard tests every day
Expander process cycle

1. Mother pipe
2. Heating furnace
3. Reeler
4. Re-heating furnace
5. Sizer
6. Finished Pipe
Expander mill
Plug bar boundary conditions

Problem description: Reduce displacement of plug under lamination forces (disks action) with all the steadier closed and after the release of the first steadier
Plug bar actual structure - stiffness

In the actual configuration the internal structure (in yellow) is not working for structural purpose. Unfortunately even if all the structure had to work for flexional stiffness it would not be enough to have an improvement. A new structure must be designed.
Structure proposal – Static FEM model

Plug Bar section:

External shell

Internal shell

Longitudinal frames

Plug Bar: Frame panel structure. Red section corresponds to steadier position

In the optimization analysis the thickness of the shell panel (external / internal shell, longitudinal panels) are the optimization variables. The static calculation gives in output the vertical displacement of the plug to minimize and the total mass due to thickness change to constraint for handling problems.
Structural Optimization scheme

OPTIMIZATION INPUT VARIABLES: panel thickness (36 variables)

Abaqus Model input (2 step static calculation: 1. all steadier closed, 2. release of first steadier)

Optimization

OUTPUT VARIABLES (mass, displacement)

CONSTRAINT (mass) & MINIMIZATION (displacement)
Optimization

The DOE consists of 20 random analysis to settle the Design of Experiments space.

The complete bar structure has 36 different thickness as input variables. Genetic algorithm are not very efficient when there are many input variables. It is worth to reduce the input variables as much as possible: two ways.

- Considering the problem physic the important variables are just in the first half of the bar (reduce the variables to 16 variable)

- A Screening Analysis method is used to identify the most important variables among the 16 remaining (by running 10 jobs for each variable)

After the screening phase a Genetic Algorithm (Multi Object Genetic Algorithm - MOGA II) works for the optimized solution.
From Optimization phase it is possible get the correlation matrix between the variables in relation to the objective. The correlation is a measure of the linear association between the variables.

in red the positively correlation and in blue negatively correlation. The value near to 0 indicates low correlation.
**Structural Optimization**

*Tstudent* chart can give a relationship between input and output variables. The effect size (height of the bar) gives the strength of the relationship between input and output. Color red (positive values) is for the direct correlation and blue (negative) for inverse.
Structural Optimization

Design ID History

Genetic optimization

ID 561

random screening
The improvement for the optimized solution is about double the stiffness keeping the mass in the constraint range.
Structural Optimization: Explicit model

Explicit model for mill process: displacement of plug bar \((X,Y,Z)\) with actual bar structure

Explicit model for mill process: displacement of plug bar \((X,Y,Z)\) with optimized bar structure

Video 01

Video 02
This is the end thanks