INCREASING THE HYDROSTATIC CAPACITY OF MORGOIL® BEARINGS IN A TANDEM COLD MILL*

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Resumo

Primetals Technologies obteve sucesso na melhoria do sistema hidrostático dos mancais de encosto de filme de óleo do laminador de tiras a frio para obter uma maior força de laminação especificada com um custo eficiente, introduzindo o sistema de bolsas duplas, mantendo o mesmo sistema de bombas hidrostáticas e o sistema de fornecimento de óleo.

Palavras-chave: Laminação e Frio; Hidrostático; Buchas com duas bolsas; Mancais de Encosto.

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Abstract

Primetals Technologies has successfully upgraded the hydrostatic oil film bearings in a Tandem Cold Mill to achieve a specified higher force capacity in a cost effective manner by introducing custom dual pad bushings while at the same time retaining the existing hydrostatic pump and supply system.

Keywords: Tandem Col Mill; Hydrostatic; Dual Pad Bushing; Back-up Roll Bearing.

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1 INTRODUCTION

Primetals Technologies has provided metal producers a means of providing for higher rolling forces at low speeds by developing new MORGOIL® dual pad hydrostatic bushings. In doing so, the existing hydrostatic pumps and feed lines are retained, resulting in a cost effective solution.

2 Overview of MORGOIL® bearings

2.1 Bearing characteristics

Figure 1 below shows the typical operating envelope for an oil film bearing.

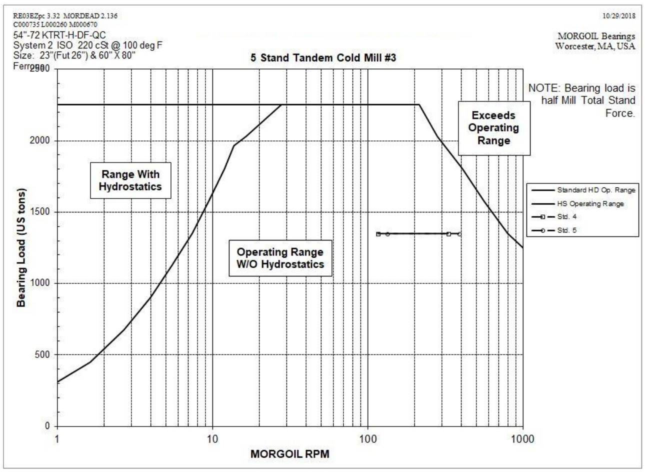

Figure 1 — Bearing operating envelope

The area of particular interest is at the left of the bearing map where either the speed is insufficient and/or the force is high enough that it is not possible to maintain a hydrodynamic oil film. Should it be necessary to roll at a low speed and/or stop and start the mill under rolling load, then it is also necessary to provide an external means of generating the oil film, ie: a hydrostatic system.

2.2 Hydrostatic system components

Figure 2 below shows the components of a hydrostatic system.

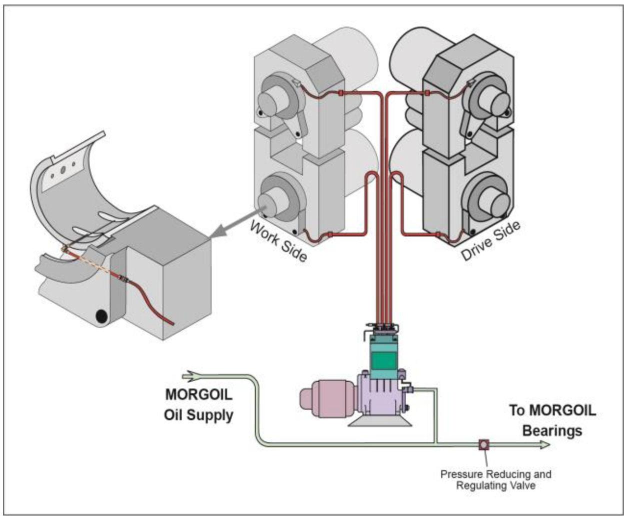

Figure 2 — Hydrostatic system components

Filtered oil is supplied to the hydrostatic pump from the hydrodynamic lubrication system. In this mill, the hydrostatic pump is capable of supplying pressure up to 10,000 psi at a flow rate of 2.6 gpm with a relief valve set to 11,500 psi. From the hydrostatic pump, the oil is separately piped to each of the four chocks.

2.3 Characteristics of the hydrostatic system

The system uses a fixed displacement pump which provides a constant flow rate. The pressure loss through the piping to the chocks is constant. Also, the relationship between changes in roll force and hydrostatic pressure are relatively linear. Figure 3 below shows these characteristics with the system relief valve setting.

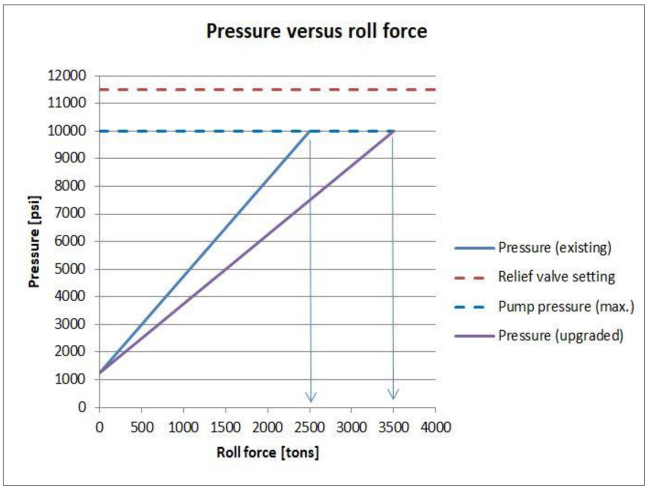

Figure 3 — Hydrostatic system characteristics

Therefore, to provide for higher rolling forces while retaining an existing hydrostatic pump system, it is necessary to change the hydrostatic pressure versus roll force relationship.

2.4 Plant Description

2.4.1 Overall

The Tandem Cold Mill is a part of an integrated steel making facility manufacturing a range of flat products including advanced high strength steels, API pipe grades, steel for electrical lamination applications, exposed automotive panels, martensitic grades and aluminized steels.

2.4.2 Tandem Cold Mill

The 5 stand Tandem Cold Mill was originally built in the mid 1960's. The bearings are the same on all five stands and each stand has its own hydrostatic system.

The mill produces a wide range of cold rolled product, threading at low speed and regularly stopping under load in order to perform coil division.

In line with industry trends, the mill is looking to the future and to the increased production of advanced high strength steels. With this combination of low speed and high force, an upgrade to the hydrostatic system is required in order to maintain optimal bearing performance.

2.5 Hydrostatic upgrade

In order to increase low speed rolling force, the integrated force produced by the hydrostatic pressure field must be increased to compensate. Since the existing pump will be retained, the hydrostatic pressure will be the same, so the volume of the pressure field must be increased by other means. The technique used to do this was to convert from a single pad hydrostatic bushing to a two pad bushing thus producing a wider pressure field, increasing its integrated volume, shown in 2D in Figure 4 and 3D in Figure 5 below.

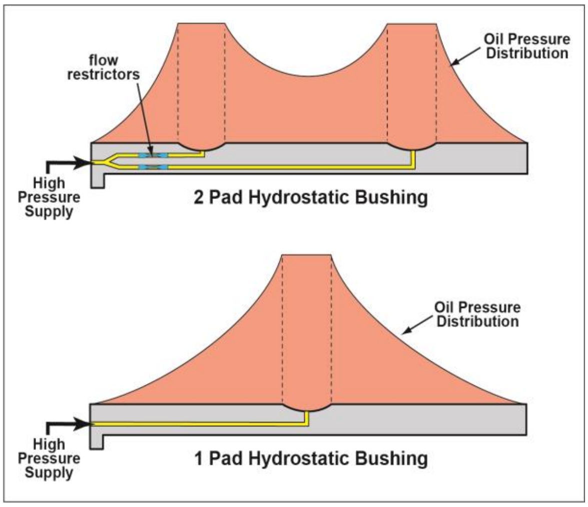

Figure 4 — Two pad versus single pad hydrostatic bushing cross section

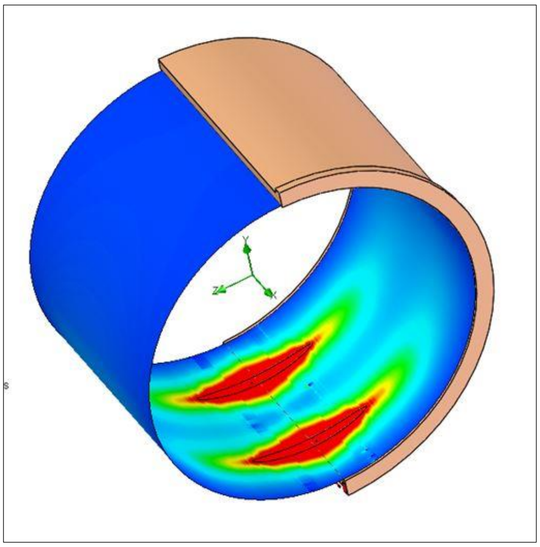

Figure 5— Two pad hydrostatic bushing pressure field 3D view

2.5.1 Key parameters of two pad hydrostatic design

The key design parameters for a hydrostatic bushing are:

- flow resistance in each of the two hydrostatic feeds
- pad spacing from the bearing centerline
- pad width
- pad angle
- pad cross section

The pad geometry along with the oil viscosity, flow rate, and bearing geometry (sleeve diameter, bearing width and bushing clearance) determine the hydrostatic pressure field. Some of the key parameters are shown in Figure 6 below.

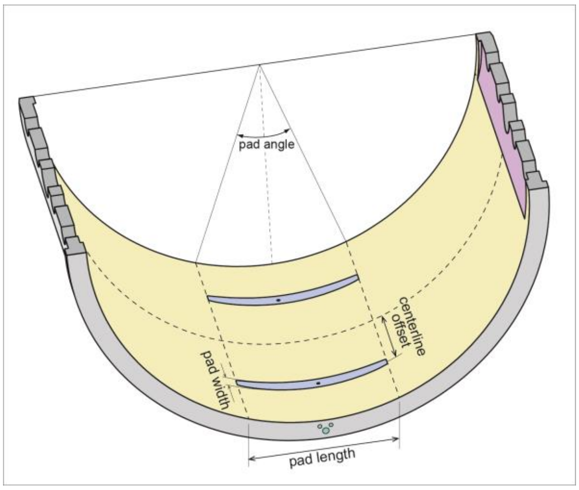

Figure 6 — Two pad hydrostatic bushing geometry

2.5.2 Discussion of parameter optimization

Flow resistance in the bushing feed passages for inboard and outboard pads should ideally be equal. However, when the roll deflects causing the bearing sleeve to tilt in the bushing, the resistance is reduced to the pad with increased clearance, shown in Figure 7. This decreased resistance allows a higher flow through the pad with greater clearance. To prevent this resistance imbalance, flow restrictors are added to the feed passages. Resistance of the flow restrictor increases as flow increases. This causes more oil to flow through the pad with smaller clearance, thus increasing the pad pressure. This helps to realign the sleeve in the bushing to the optimal position.

Pad centerline offset is an important design parameter. If the pads are too close together then the two pads approximate a single pad bushing. If the pads are too far apart, then this places the point of maximum pressure close to the boundary condition of atmospheric pressure at the edge of the bushing. This causes oil pressure to be wasted as it escapes to atmosphere. There is an optimum spacing that lies between the two extremes described.

The width of the pads is also of interest. The pads need to have some practical minimum width but if they are too wide, then this may compromise the hydrodynamic capacity of the bearing.

Ideally the cross section of the hydrostatic pad form is rectangular with a width considering the factors previously mentioned and a depth that does not introduce excessive pressure losses. However, a rectangular pad cross section has sharp corners at the ends of the pads resulting in stress concentrations that can be high enough to bring about babbitt cracking at the corners of the pad.

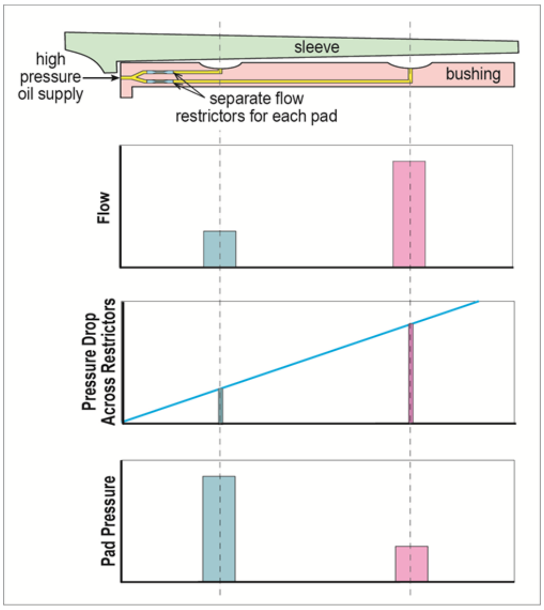

Figure 7 — Adding flow restrictors to reduce imbalance

The pad angle directly affects the pad length as shown in Figure 6. The longer the pad length the better, however this can only be taken so far. Factors that need to be reviewed are the sleeve to bushing diametral clearance, the position of the sleeve in relation to the bushing shown in Figure 8 and the elastic deformation of the two. Should the pad be too long, then oil pressure will be lost though the end of the pad where the gap between the sleeve and bushing opens.

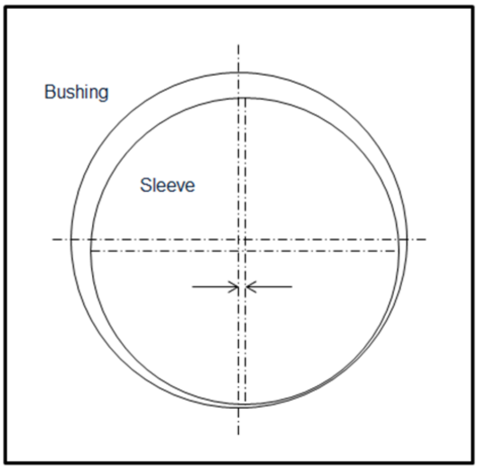

Figure 8 — Position of the sleeve within the bushing

2.6 Analysis, design, manufacturing and implementation

In November 2016 the mill consulted with Primetals Technologies on upgrading the hydrostatic capacity of their bearings. With a maximum hydrostatic pump pressure of 10,000 psi the maximum roll force with the mill stationary was approximately 2,500 US Tons. The aim of the project was to increase the maximum roll force to 3,250 US tons while maintaining the existing hydrostatic pumps and piping.

Existing mill data was supplied by the mill and analyzed by Primetals Technologies. By March 2017 the upgraded bushing design was complete including upgraded hydrostatic fittings. The purchase order for the project was received in June and four bushings were completed and assembled ready for mill testing in November 2017. Figure 9 shows a bushing in final inspection.

The four test bushings were installed in Stand 4 of the Tandem Cold Mill for a planned period of a week after which time they would be removed from service and inspected. During this time data was also gathered and analyzed. Based on the performance, additional improvements were made to the design. Manufacturing of the remaining bushings began in February 2018 and progressively installed during the remainder of that year.

Figure 9 — Final inspection of a dual pad bushing prior to shipping

3 Conclusion

Figure 10 shows the relationship between hydrostatic pump pressure and total force for various backup roll speeds. During the project, data was recorded from the original design and the final configuration. For example in Stand 4 of the original design, when the mill is stationary at the maximum hydrostatic pump pressure, the maximum total roll force is limited to 2500 tons. In the final configuration, the maximum total roll force is increased to 3250 tons, an increase in hydrostatic force capacity of 30%.

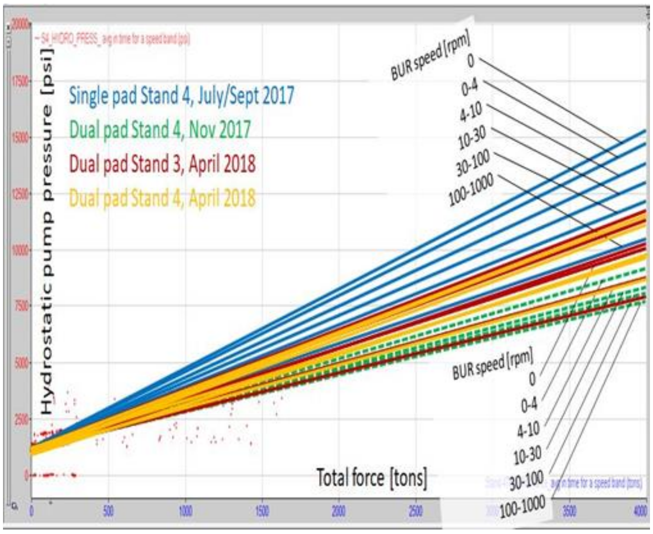

Figure 10 — Dual pad versus single pad hydrostatic pressure

Primetals Technologies has developed a cost effective solution to significantly increase the hydrostatic force capacity of MORGOIL® oil film bearings. This allows mill operators to increase rolling force without the need to upgrade existing hydrostatic pumps and feed lines.