COLUMBUS STEEL – CORRECT TORQUE LIMITATION AND MAINTENANCE[1]

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Abstract
Torque limitation is a crucial part of preventive maintenance as well as productivity. Downtime is expensive both from broken components point of view as well as from lost production. Therefore it is very important that the Safeset torque limiting couplings are overhauled regularly to maintain the extreme accuracy. Voith Group of Companies, develop torque limiting, transmitting and monitoring systems to ensure full productivity and optimized driveline design and torque limit setting. We also make sure that the products are working with their full potential during the whole life time, by performing pro-active maintenance on site, or in one of our Service centres, spread over the world. We can also offer a full scale torque test on your mill, and thereby finding the optimal setting for even more accurate protection of the drive line. By analysing the unique torque dynamics of your drive line, we will ensure that you can work as close as possible to the maximum output of your mill, without exposing the drive line for a torque higher than the design limit. During on-site service we also train your personnel to make sure that their handling of the Safeset is correct and fast, so that the production can be resumed at shortest possible time. In this paper we are going to present the successful intervention hold in the Columbus' plate mill in South Africa in the year 2012.
Key words: Torque limiting; Maintenance; Overhaul; Plate mill; Rolling Mills.

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1 INTRODUCTION

The Safeset ® is one of the most precise and fastest torque limiter on the market.
The Safeset transmits torque by a friction connection created from hydraulic pressure. This gives a variable set range by using different pressure.
But since the torque setting is depending on the friction in the connection surface, it is a high demand that these surfaces are kept in good condition and that they are maintained correctly. This paper will show how a Safeset coupling can be restored to the original performance by making a major overhaul at site.
On this specific mill, the strain gauge measurements[(1)] showed that the set torque was exceeded without a release of the Safeset. And also due to the fact that the couplings has not released since 2006, it was decided to overhaul the couplings to make sure that they will work properly in the future.

2 METHODS

The Safesets were removed from the drive line, stripped and inspected.
The inspection showed that the friction surfaces had a high degree of contamination.
After the inspection, the friction surfaces were cleaned and machine polished to regain the original state.

Figure 1. Disassembly of the Safeset from the motor shaft.

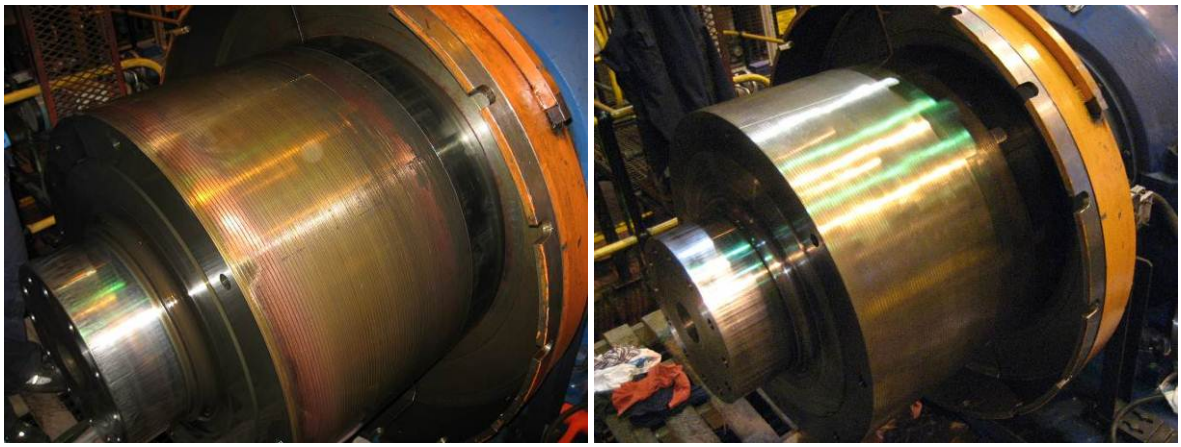

Figure 2. Inner friction surface before and after service.

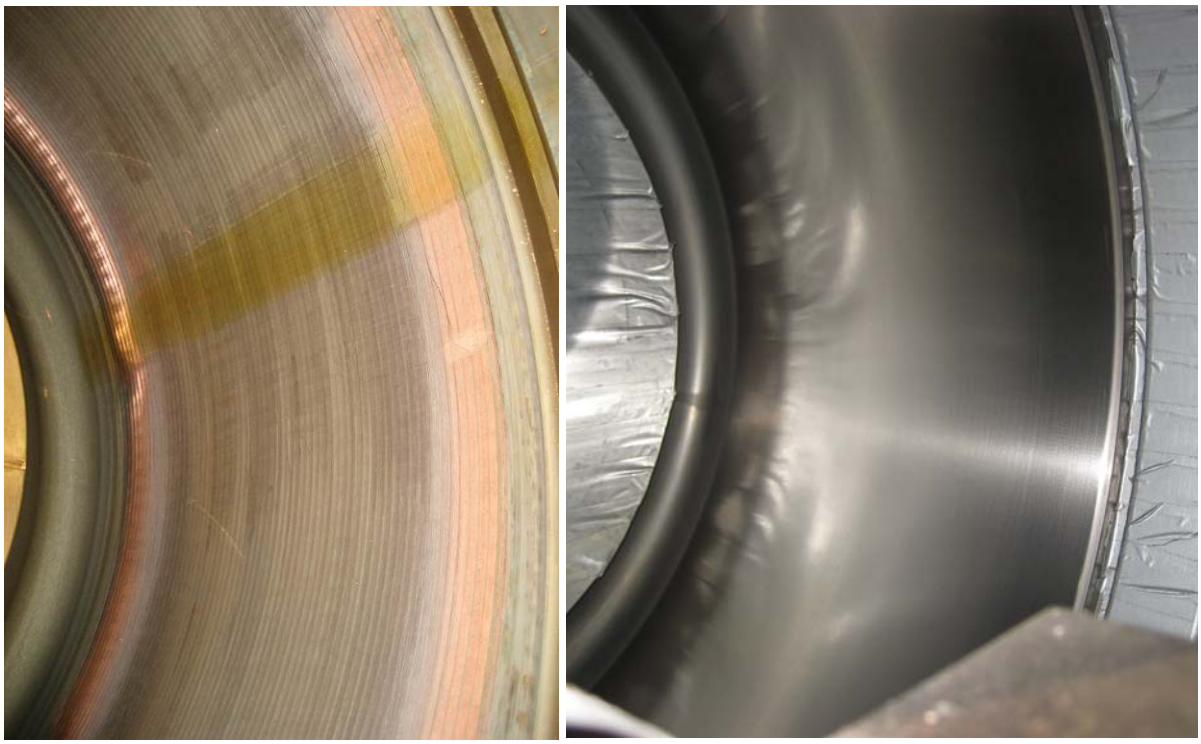

Figure 3.Outer friction surface, before and after service.

After the Safesets were serviced and reinstalled in the driveline, the driveline was equipped with 2 additional strain gauge measure points (Figure 4 blue and grey) to the 2 existing ones (red and green)
The testing of the Safeset release function was then performed under normal rolling conditions and the over torque was induced by making an extra big draft on a normal rolling pass.
As soon as the slab entered the rolls, the Safesets were exposed to an over torque and released (test slab on Figure 5).
The test was performed with following settings:
Test 1: Set pressure was 42MPa which corresponds to a torque value of 1417 kNm
Test 2: Set pressure was 48MPa which corresponds to a torque value of 1785 kNm
Test 3: Set pressure was 60MPa which corresponds to a torque value of 2521 kNm

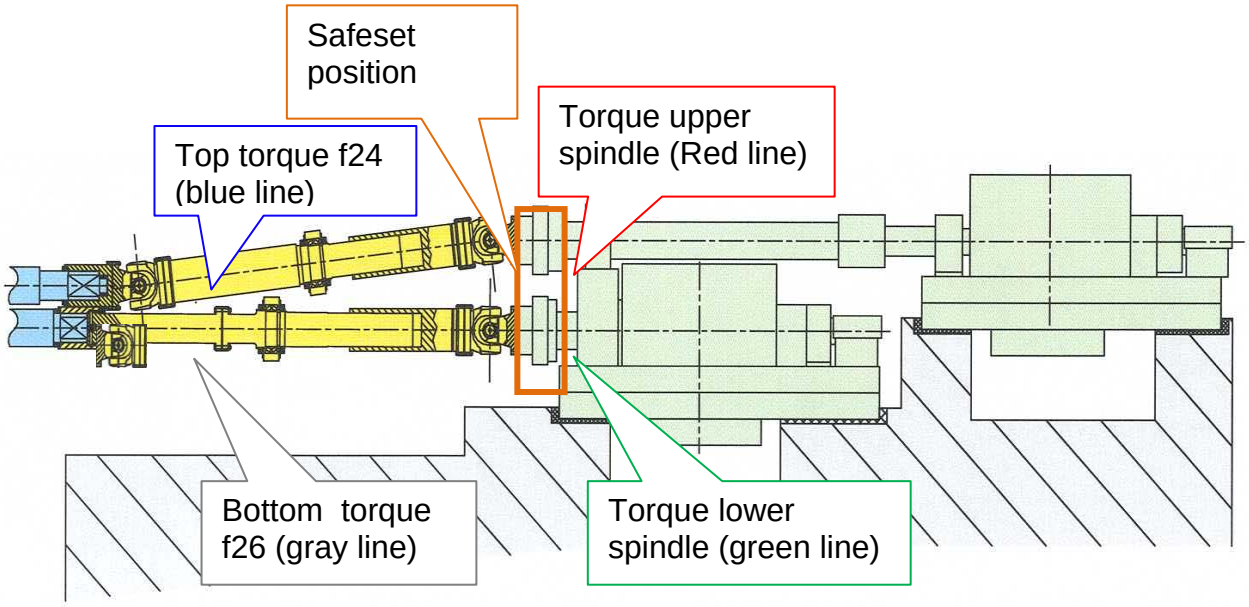

Figure 4: Schematic sketch of the positions of the strain gauges for the measurements.

Figure 5: Test slab after cool down.

3 RESULTS

3.1 Test 1 @ 1417kNm

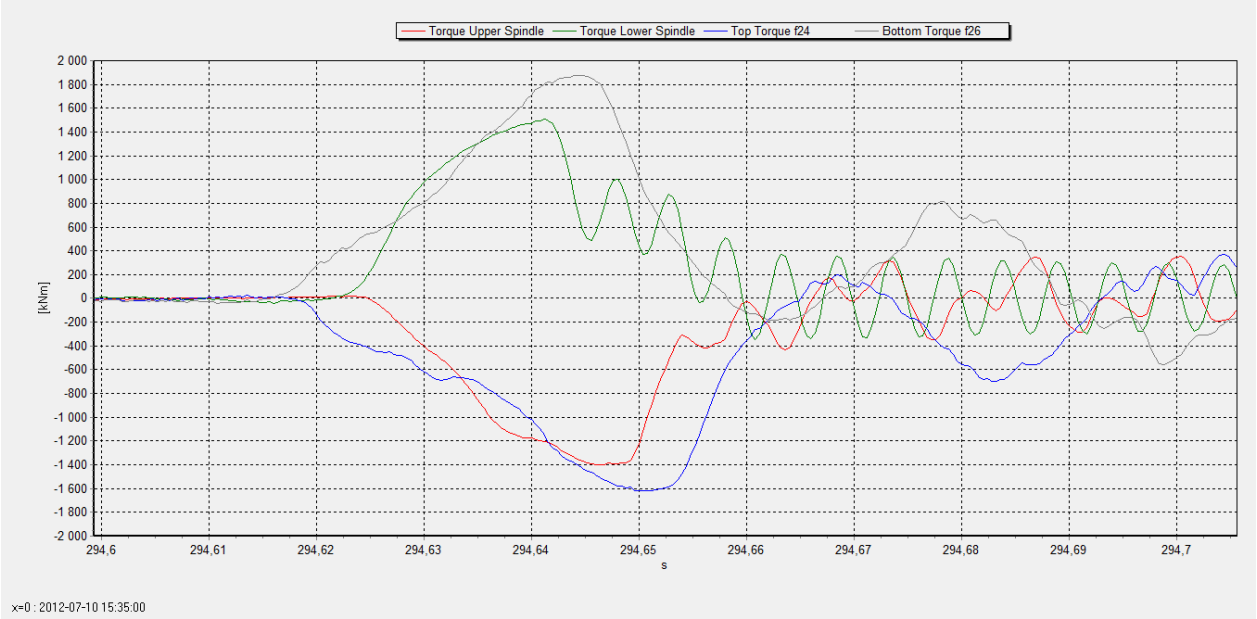

Figure 6: Torque curves from the strain gauge, test 1.

Table 1. Maximum values from test 1

	Set Pressure	Theoretical Value	Measured Value at Safeset	Relative difference from theoretical value, Safeset side	Measured Value at roll side	Relative difference from Safeset value, Roll side
Top	42 MPa	-1417 kNm	-1399 kNm	-1,3%	-1621 kNm	+16%
Bottom	42 MPa	+1417 kNm	+1507 kNm	+6%	+1872 kNm	+24%

3.2Test 2 @ 1785kNm

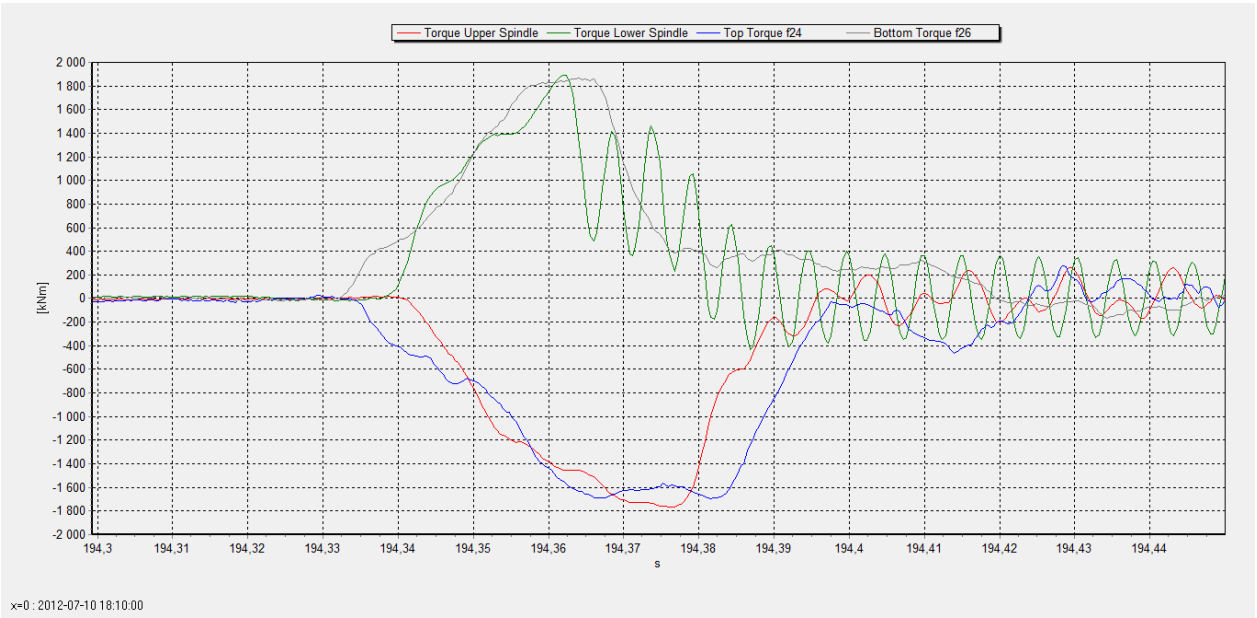

Figure 7: Torque curves from the strain gauge, test 2

Table 2. Maximum values from test 2

	Set Pressure	Theoretical Value	Measured Value at Safeset	Relative difference from theoretical value, Safeset side	Measured Value at roll side	Relative difference from Safeset value, Roll side
Top	48 MPa	-1785 kNm	-1768 kNm	-1%	-1695 kNm	-5%
Bottom	48 MPa	+1785 kNm	+1894 kNm	+6%	+1872 kNm	+4,5%

3.3 Test 3 @ 2521kNm

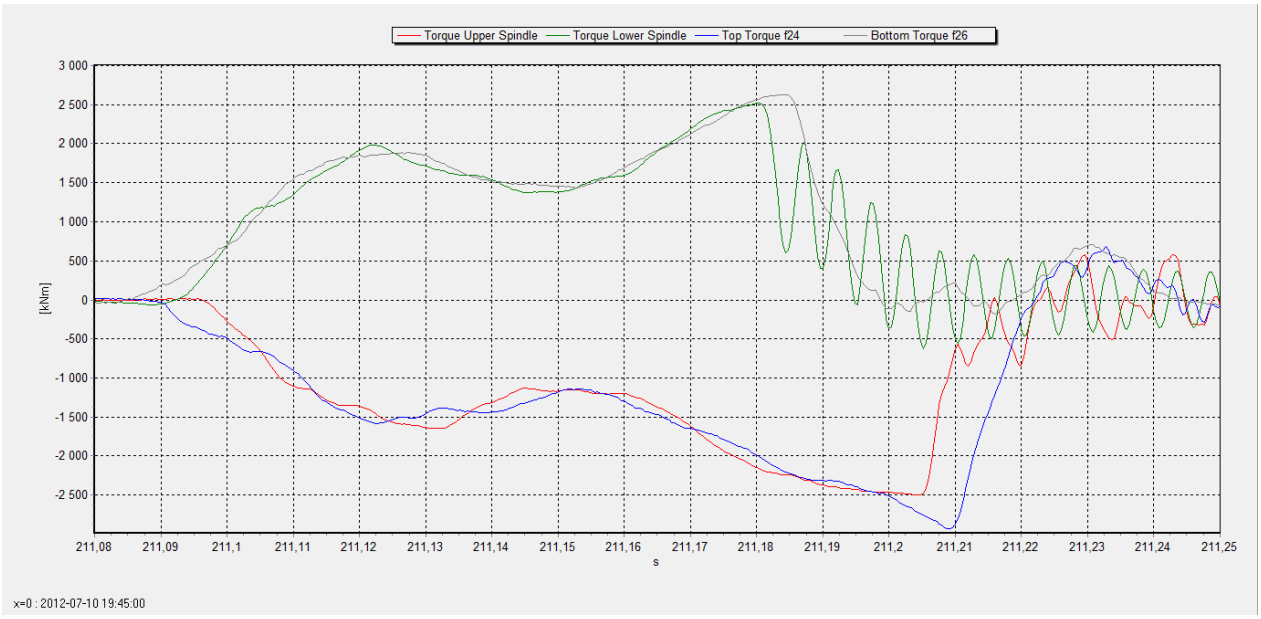

Figure 8: Torque curves from the strain gauge, test 3

Table 3. Maximum values from test 3

	Set Pressure	Theoretical Value	Measured Value at Safeset	Relative difference from theoretical value, Safeset side	Measured Value at roll side	Relative difference from Safeset value, Roll side
Top	60 MPa	-2521 kNm	-2502 kNm	-1%	-2931 kNm	+16%
Bottom	60 MPa	+2521 kNm	+2522 kNm	+0%	+2630 kNm	+4%

3.4 Summary of Test

Table 4. Maximum values, summary of all tests

	Set Pressure	Theoretical Value	Measured Value at Safeset	Relative difference from theoretical value, Safeset side	Measured Value at roll side	Relative difference from Safeset value, Roll side
Top	42 MPa	-1417 kNm	-1399 kNm	-1,3%	-1621 kNm	+16%
Bottom	42 MPa	+1417 kNm	+1507 kNm	+6%	+1872 kNm	+24%
Top	48 MPa	-1785 kNm	-1768 kNm	-1%	-1695 kNm	-5%
Bottom	48 MPa	+1785 kNm	+1894 kNm	+6%	+1872 kNm	+4,5%
Top	60 MPa	-2521 kNm	-2502 kNm	-1%	-2931 kNm	+16%
Bottom	60 MPa	+2521 kNm	+2522 kNm	+0%	+2630 kNm	+4%

The tests show that the Safesets are very accurate after the service done. The maximum deviation between the theoretical value and the measured value is 6% (test 2, Figure 7).
The tests also show the dynamic effects in the driveline.[2] The maximum torque difference at the roll side is 24% higher than at the Safeset side during a release (test 1, Figure 6).. But this is measured at a very low setting and therefor the 16% at the highest test setting should be considered to be a more relevant value (test 3, Figure 8). This dynamic factor must be taken into consideration when deciding the desired setting of the Safeset.

4 CONCLUSIONS

The measurement before this service showed that the Safeset didn't release even though the measured torque exceeded the measure system limit of 4600 kNm and the Safeset was set to 3000 kNm (670 bar). An interpolation of the curve indicates that the torque in the drive line could have been over 5000 kNm.
The factory supplied torque vs. pressure diagram is based on a calculation done with the friction coefficient for a clean and correct lubricated surface.[3] Looking at the measurements before the service, the contaminated surfaces found had probably a friction coefficient that was >70% higher than the normal coefficient that is used for the calibration diagram.
The service performed restored the surfaces to the original state, and thereby the pressure needed can be achieved from the diagram again. The measurements also showed that the dynamic effect during a shock load was max. 16% higher at roll side for this specific drive train.
Recommendations
The maximum allowed torque for this drive train is 4250 kNm, but to avoid any damages to the shafts the maximum torque for the drive line must not be higher than 4150 kNm in worst case scenario. (2.5% safety margin)

Calculation of the Safeset set torque using following test result:

6% max deviation from theoretical value = 1,06
16% max deviation between Safeset and roll side = 1,16
"Setting of Safeset" = 4150 kNm / 1,06 / 1,16 = 3375 kNm.

According to the calibration diagram this torque corresponds to a pressure setting of 74MPa (740 bar).

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