

CONTINUOUS CASTING SEGMENTS SERVICE LIFE IMPROVEMENT

Pedro Stoppani⁽¹⁾

Summary

For many years the main reason for repairing segments in continuous casting machines has been the deterioration of the rolls. In the worst case this results in catastrophic failure. With the development of new technologies and consistent quality improvement of the roll manufacturing process over the last few years, roll life has been significantly improved. The main reason for segment failure today is associated with bearings. This is particularly true with the introduction of new split roll technology. In addition it is important to understand that rotary joints also influence the service segment life.

This report focuses on the concepts, which have led to the development of a new bearing and roll assembly design. This design was introduced in order to obtain the best technical and economical balance between bearings and roll lifetime so that caster downtime, as well as maintenance costs, can be minimised. This continuous casting roll unit with floating, bearing design aims to achieve a longer segment service life with less maintenance and unnecessary expense. This concept is based on the idea of treating the segment as a totally integrated system of:

- rolls
- bearings
- rotary joints
- lubrication
- water cooling circuit (i.e. bearing housings)
- hydraulics (not considered in this study)

In order to accomplish this improvement the following changes have been made:

- ❖ a new bearing assembly design modification
- ❖ a new bearing bracket sealing system
- ❖ a different kind of rotary joint design
- ❖ an economical longer lifetime roll design
- ❖ a better lubrication system

Key words: slab casting, roll design, segment maintenance.

(1) Technical Services Manager - Gustav Wiegand Maschinenfabrik - Germany.
XXXV Steelmaking seminar – May 17th to 19th, 2004 – Salvador – BA – Brazil

INTRODUCTION

In continuous casting machines segment service life is one of the primary concerns of personnel in charge of maintenance, production and quality issues. Segment service life is defined by the quantity of steel tons passing through the segment from installation in the strand until removal for any maintenance, production or quality reason, excluding early termination because of breakout. From the maintenance point of view caster downtime for segment change is one of the major items in loss of production and cost effectiveness because it affects the productivity of the caster due to the reduction of the steel in mould index. Quality is also affected when the geometry of the strand is not within defined tolerances.

Segments generally must be removed from the strand at the onset of the first failure, because this affects the slab quality or caster productivity. In most cases bearing failure or roll deterioration is the primary reason.

In casters with split roll designs these failures occur more with the central bearings compared to the end bearings. The primary reasons and causes of failures are very well known to those involved in the Continuous Casting process and will not be covered in detail in this report.

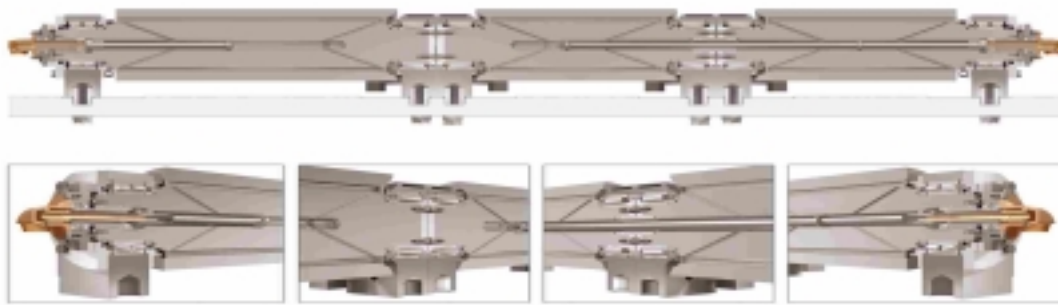
In summary typical origins of bearing failures are:

- load
- contamination
- lubrication
- corrosion

The order of importance of these factors depends on each caster but in most cases all are present. For that reason it is very important to prevent each of these factors from occurring.

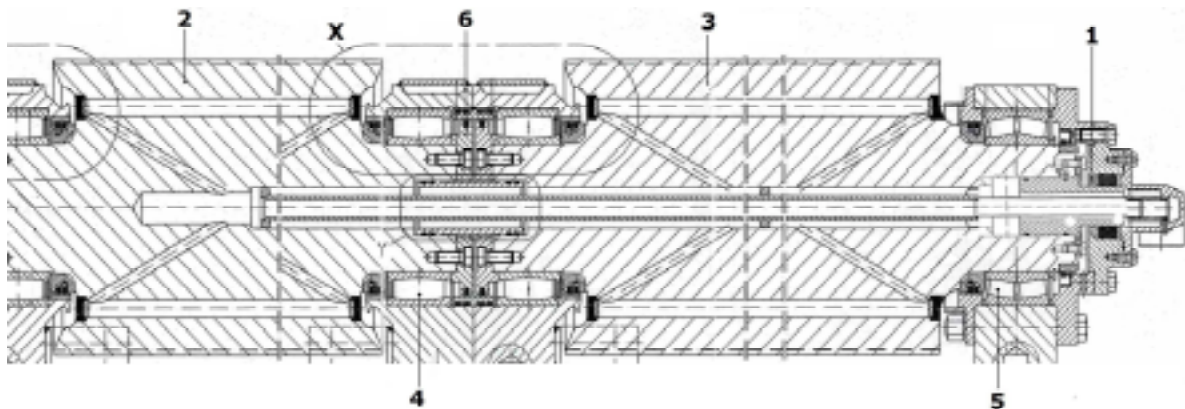
BEARING ASSEMBLY DESIGN

Due to the geometric layout, metallurgic conditions, the mechanical design and the operating conditions of the caster, among other parameters the most critically loaded zone in the segment is the central area. With split roll assemblies one of the main bearing failure mechanisms is high radial load. A second failure mode is created by high axial load. To improve this situation, SKF CARB type bearings have been installed in the central positions. Spherical bearings have also been installed in the end positions of the split roll line (see sketch 1 and sketch 2). With these changes the wear and failure time of all bearings has been balanced as much as possible in the roll assembly.



Patent of 2006 & 2014 / 2007 / 2008 (German, English, French)
 E-mail: bergmans@tk.com
 E-mail: grelewitz@tk.com
 ThyssenKrupp Stahl AG
 47119, Mönchengladbach
 ABB
 ThyssenKrupp Stahl

Sketch 1. New patented design by Thyssen Krupp Stahl AG, invented by E. Bergmans, G. Grelewitz and W. Krume.



Sketch 2.

There are two primary influences on bearing load. Excessive load created by external factors or insufficient load bearing capacity. Excessive external forces, in excess of the designed specifications, mainly come from cold extraction, geometry, which is out of tolerance in the radial direction or cooling inefficiency in the axial direction.

In order to reduce the external force in the axial direction two design concepts are employed. The external roll bodies (3) are fixed by means of their external bearings (5) and the central body (2) is float mounted. These changes absorb as much mechanical load as possible and reduce the axial energy transferred into the bearings.

All of the inner bearings (4) of the internal rolls (2) are essentially movable bearings, and both bearings of the central roll (2) are high load capacity movable CARB bearings. The free axial movement of the float mounted central roll is limited by a stop (6). This is assembled as stop disks and mounted between the opposite front faces of the external and internal rolls. With this design the axial forces influencing the performance of the central bearing (4) are almost eliminated.

The CARB bearings used in the central position offer much higher load capacity and as a result external force resistance is improved and longer lifetime is obtained. Our

experience indicates that 30% larger static load capacity translates to more than 50% longer lifetime.

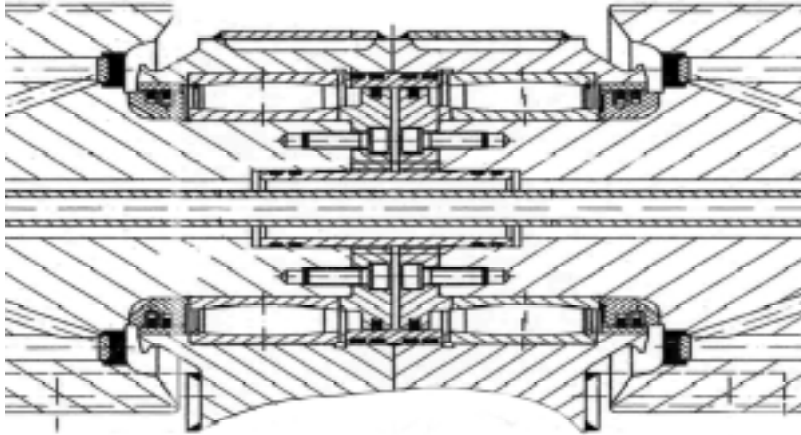
In the next paragraphs the central bearing sealing system (X), the lubrication procedure and a new patented rotary joint (1) are explained in detail.

Bearing bracket sealing and lubrication procedure

Contamination with water and scale is another reason for bearing failure. In order to avoid this failure mode two changes are necessary. Improve the design of the sealing system and the materials used and reduce the incidence of vacuum formation in the bearing case. During non steady state casting conditions when the casting speed is reduced or the caster is stopped the thermal balance changes and the operating temperature of the bearing case is reduced. As a result of this phenomenon a vacuum is created in the bearing case, which allows water, scale or debris to enter into the case. To avoid this, it is necessary to inject grease at precisely the time that these non steady state events occur thus ensuring that the case is always full of lubricant.

With these improvements in grease quality, lubrication method, design and modification of seal materials the contamination issue has been essentially eliminated.

Central bearings (CARB type, loose assembly)



Sealing design

- **Geometry**
- **Seals material**
- **Lubrication cycles**
- **Grease quantity**
- **Grease type**

Sketch 3

COOLING SYSTEM

Rotary joint

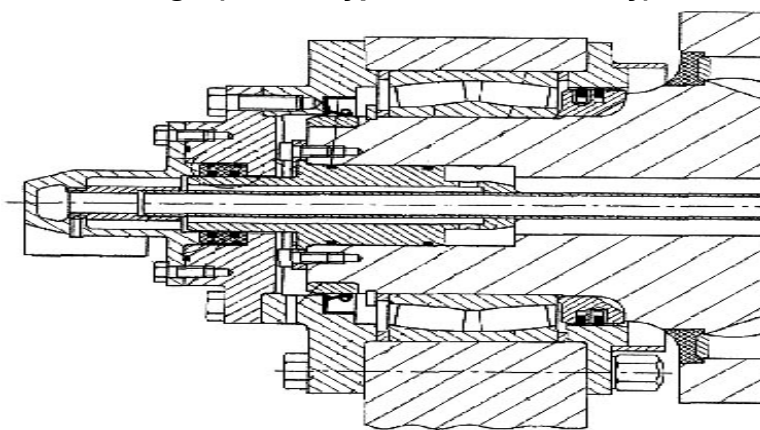
Cooling control is crucial to ensure that high levels of quality are maintained and levels of maintenance are controlled. Higher temperatures lead to larger expansion than the designed values and consequently higher axial forces over the bearings. In addition

this can lead to higher roll bending, larger slab bulging and quality defects such as internal cracks. Higher temperature also introduces detrimental effects on rolls such as thermal cracks and in addition this implies decreasing hardness.

Water must flow through the rolls at all times, per the design parameters, without interruptions. The critical and limiting components in the cooling system are rotary joints and flexible hoses and they are subjected to very severe conditions in a very contaminated environment.

In order to minimise failures in this area a simple mechanism has been employed which relies on as few movable components as possible with low wear rates combined with perfect sealing over long run times. Experience has shown that after the first trials with this new rotary joint design, it is not only much more economical but also a very reliable way to reduce problems in the cooling system. See sketch 4.

End bearings (SPHR Type, fixed assembly)



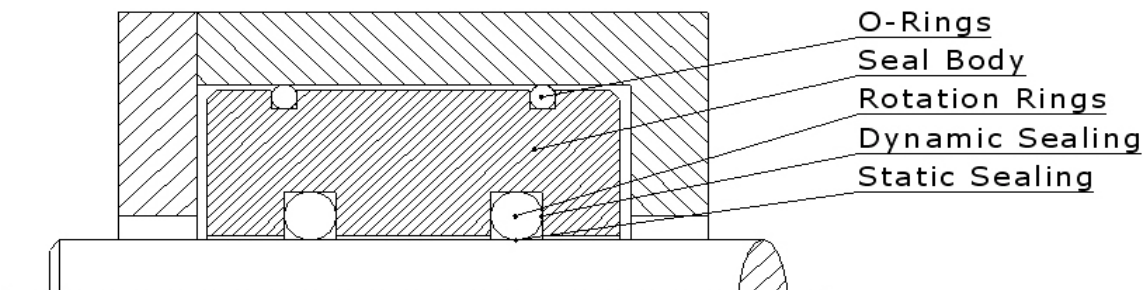
ROTARY JOINT

- Very simple design
- Few movable parts
- Perfect sealing
- Long lifetime

Sketch 4

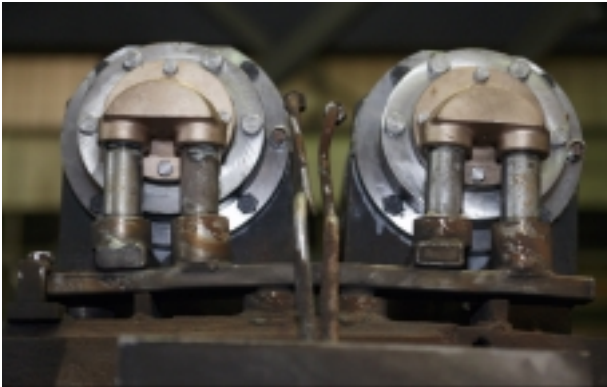
New Patented Rotary Joint. Patented by Thyssen Krupp Stahl AG invented by E. Bergmans, G. Grelewitz and W. Krume

The concept of the rotary joint seal is shown in the sketch 5



Sketch 5

Flexible hoses provide a source of problems for maintenance personnel. This new rotary joint design allows the installation of standpipes instead of hoses with no special connecting devices between the manifold and the rotary joint or between the manifold and the standpipes. See picture 1 as an example.

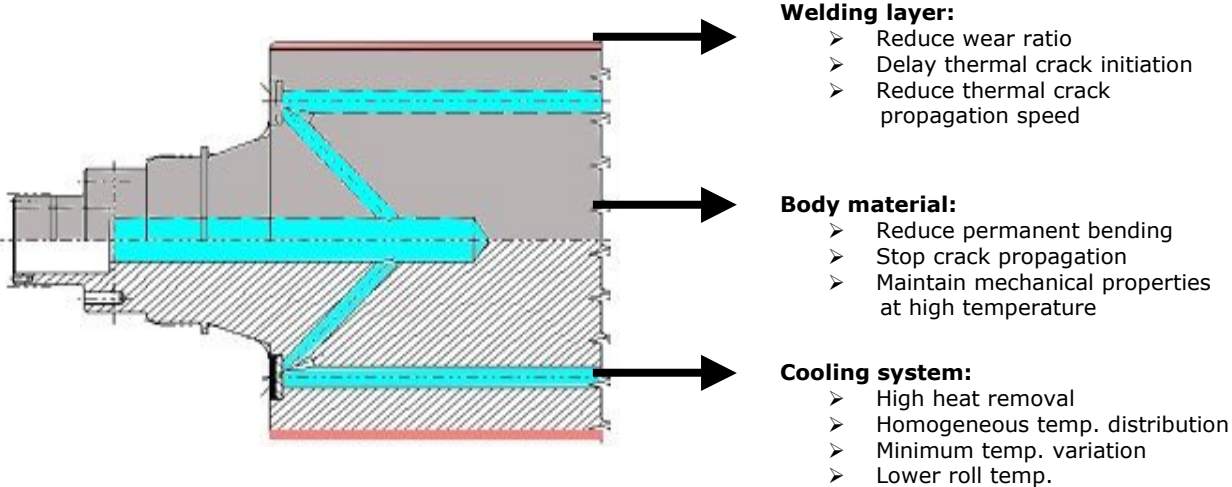


Picture 1

For all the reasons cited previously the lifetime of the cooling components now matches the lifetime of the other components in the segment.

Longer roll lifetime

The new Thyssen Krupp patented technology has been further enhanced with Gustav Wiegard MASCHINENFABRIK revolver type cooling rolls. This roll technology relies on the use of a consistent quality cladding layer and extremely reliable body material. As a result the service life of caster segments has been significantly improved.



Sketch 6

The body material and welding layer specifications are selected according to the roll position in the caster and typical reason for deterioration.

The deterioration of the roll surfaces depends on the position of the roll and the operating and maintenance condition of the strand.

In general the main causes of roll deterioration are listed below:

- catastrophic failure
- wear
- thermal cracks
- permanent bending

Catastrophic failures are created by inappropriate roll quality selection or extreme operating conditions such as cold extraction.

Wear is usually caused by corrosion such as chemical attack in top zone.

Thermal cracks occur primarily in the straightener and withdrawal areas. In straightener area more than 70% of the failures are due to thermal cracks. In the withdrawal area this percentage increases to greater than 90%. Permanent bending is responsible for most of the remaining percentage of failures in the straightener and withdrawal areas. Careful selection of the body material, close control of the welding composition and method and use of the revolver cooling system can prevent these phenomena from occurring.

The rolls are produced using the submerged arc strip-cladded process. In order to significantly extend roll life it is essential to use high quality forged materials with novel welding technology, which has been developed over the years.

A very good alternative for extension of segment life is the use of the so called “**Revolver-roll**” featuring a modified **internal cooling system**. This type of roll design increases the service life significantly when compared to conventional rolls with the central cooling design.

Listed below is an example of the specifications used for rolls in the straightener area.

Body material: 21 CrMoV 5 - 11 QT (Hot forming tool steel highly resistant against crack propagation). This material keeps its properties under severe thermal conditions and the properties match perfectly with the required conditions.

Chemical analysis in %

C	Si	Mn	P+S	Cr	Mo	Ni	V
min. 0,17	0,30	0,30	max.	1,20	1,00	max.	0,25
max. 0,25	0,60	0,60	0,035	1,50	1,20	0,6	0,35

Mechanical characteristics

- Forging rate: min. 400 %
- Tensile strength: 690 - 830 N/mm²
- Yield point: min. 540 N/mm²
- Elongation ($l_0=5 \cdot d_0$): min. 16 %
- Notched bar impact work: min. 55 Joule

Strip-cladding specification

The welding layers have to reduce the wear ratio, delay thermal crack initiation and decrease the thermal crack propagation velocity.

The strip cladding is produced by three strip-layers in submerged-arc-welded operation of strips with 30, 60, or 90mm width being used, depending on the rolls diameter. Heat treatment procedure before and after welding is essential to reach the required optimised properties in this part of the roll. One of the most important parameters is hardness.

By modification of heat treatment procedures and composition of the welding filler material it is possible to vary the hardness of the surface layer. Experience over the years suggest that 40 ± 2 HRC is the most suitable for this application.

Analysis of the welding material in %

C	Cr	Mo	Ni
Max 0,10	13,5 – 14,5	0,7 – 1,2	3,8 – 4,2

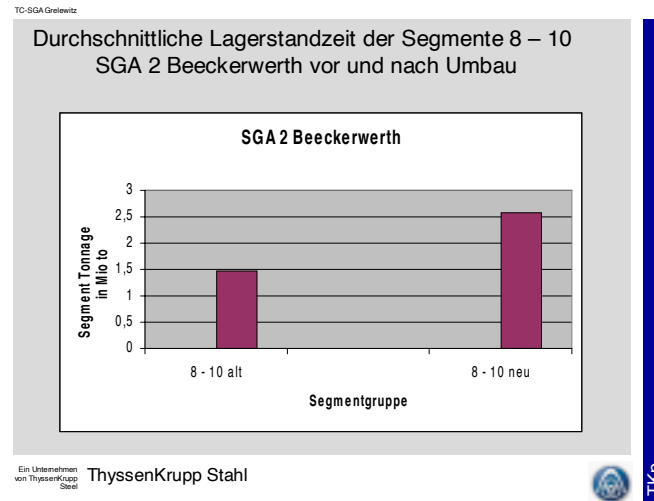
INTERNAL COOLING SYSTEM

The revolver type cooling system is also a way to increase the heat removal, decrease the temperature in the external surface of the rolls and decrease the thermal crack initiation and propagation. In addition this offers the significant advantage of reducing the permanent bending of the roll.

It is important to mention here that it is not necessary to rebuild or modify the segment to install this type of roll, because this system relies on the use of the same cooling system that was previously in service. Experience suggests that it is best to evaluate this type of roll design in the segment which is subjected to the most stress and wear in order to obtain the largest increase in roll life. The rest of the strand segments can then be evaluated afterwards in order to realise the best technical and economical solution.

Summary of infield results

In this case utilising these segment design criteria it has been possible to reach service lifetimes higher than 2.5 million tons. This means an improvement of 150%, from 1 Mt to 2.5 Mt, compared with the old design.



The quantity of segment changes per year has been reduced 30%.
Maintenance costs related to segment repair have been significantly reduced.
Thyssen Krupp Stahl has decided to modify the rest of the strand installing this split roll unit design.

CONTINUOUS CASTING SEGMENTS SERVICE LIFE IMPROVEMENT

Pedro Stoppani⁽¹⁾

Summary

For many years the main reason for repairing segments in continuous casting machines has been the deterioration of the rolls. In the worst case this results in catastrophic failure. With the development of new technologies and consistent quality improvement of the roll manufacturing process over the last few years, roll life has been significantly improved. The main reason for segment failure today is associated with bearings. This is particularly true with the introduction of new split roll technology. In addition it is important to understand that rotary joints also influence the service segment life.

This report focuses on the concepts, which have led to the development of a new bearing and roll assembly design. This design was introduced in order to obtain the best technical and economical balance between bearings and roll lifetime so that caster downtime, as well as maintenance costs, can be minimised. This continuous casting roll unit with floating, bearing design aims to achieve a longer segment service life with less maintenance and unnecessary expense. This concept is based on the idea of treating the segment as a totally integrated system of:

- rolls
- bearings
- rotary joints
- lubrication
- water cooling circuit (i.e. bearing housings)
- hydraulics (not considered in this study)

In order to accomplish this improvement the following changes have been made:

- ❖ a new bearing assembly design modification
- ❖ a new bearing bracket sealing system
- ❖ a different kind of rotary joint design
- ❖ an economical longer lifetime roll design
- ❖ a better lubrication system

Key words: slab casting, roll design, segment maintenance.

(2) Technical Services Manager - Gustav Wiegand Maschinenfabrik - Germany.
XXXV Steelmaking seminar – May 17th to 19th, 2004 – Salvador – BA – Brazil